Managing Water in the face of Growing Scarcity, Inequity and Declinging Returns: Exploring Fresh Approaches

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The program aims at evolving new perspectives and practical solutions derived from the wealth of research done in India on water resources management. The objective of ITP is to help policy makers at the central, state and local levels to address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations.

ITP engages Indian scientific/academic institutions in addition to in-house researchers in a practical agenda to identify, analyze and document relevant water-management approaches and current practices. This program is seen to fill critical gaps in India's water sector research by bringing in multi-disciplinary perspectives in the analysis of water related problems.

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Theme 3: Water Policies and Legal Framework in India: Are We Creating Paper Tigers?

Theme 4: Water Harvesting and Groundwater Recharging in India from Local and Basin Perspectives: Equity and Productivity

Theme 5: Water, Economic Growth and Human Wellbeing

ARE SECTOR REFORMS WORKING? ASSESSING IMPLEMENTATION OF IRRIGATION MANAGEMENT ACT OF MADHYA PRADESH

Nitin Bassi[1]

Abstract

The irrigation sector plays a vital role in food production and rural economy. Realizing the importance various reforms are carried out world over to modernize irrigation systems and make them more efficient. One such approach is the decentralization of irrigation management from the government agencies to the end users. This paper looks into the implementation of Irrigation Management Act in the Indian state of Madhya Pradesh where partial responsibility of irrigation management was transferred to the end users. Emphasis is given on the administrative, governance, institutional and financial reforms carried out as per the act and the impact these reforms had on the irrigation management. The success of such programs is highly dependent on effectiveness of the execution and the financial resources available with the government which are often limited. Such programs will reap desired benefits, if the end users are involved in more effective manner with greater autonomy and delegation of authority. Also in view of financial scarcity with governments to carry out such large programs, the idea of involving private sector investors in irrigation management may be a good option. Such alternative institutional models can be considered to further improve the overall efficiency and management of the irrigation systems.

1. INTRODUCTION

Agriculture and irrigation sectors have always been a prime focus world over for reforms because of their importance in world economy and farmers' livelihoods (also employs 41% of world total labour). The World Bank has lent some 35 billion dollars for irrigation development or an equivalent seven percent of all its lending since 1950s (Plusquellec, 1999). In spite of such huge investments, irrigation sector continued to be trapped in a vicious circle. It has been observed worldwide that lack of basic infrastructure for irrigation, poor maintenance of existing systems, and reducing government investments on repair and rehabilitation (R&R) of systems have been the major precursors for the irrigation reforms (Vermillion 2001; Gulati et al. 2005; Madhav 2007). Irrigation reforms stated as early as 1960s in Bangladesh and USA, 1970s in Mali, New Zealand and Colombia and to 1980s in the Philippines, Tunisia and Dominican Republic. The new century interventions have taken place in Sudan and Pakistan (2000), India (2001), China (2002) and more recently in some of the central Asian countries. Presently more than 60 countries in the world have undergone some type of irrigation sector reforms (Munoz et al., 2007). These countries constitute around 75% of the world population and represent some 80% of the irrigated area of the world (FAOSTAT, 2003).

In India, various policy reforms have been carried out over the past decade in water sector including irrigation. This is primarily because: a) water is becoming increasingly scarce in many regions, and requires judicious management and b) country's surface irrigation systems are deteriorating. As per estimates, of all the uses of water in India, irrigation is a major consumer. Figures indicate (Source: Indiastat) that annual requirement of water for irrigation in India will go up from 541 BCM (85% of the total annual water requirement) from the 2000 levels to 910 BCM by 2025 at the current levels of efficiency (20-50%). Major problems facing Indian irrigation sector include: a) declining investment on maintenance; b) low levels of system efficiency; c) poor financial working; and, d) low quality, reliability, and system-wide equity. Further, there is a competing demand for water from other sectors. In this light, our ability to address future water scarcity problems and conflicts over the use of water would depend heavily on how we manage irrigation sector (Kumar, 2007).

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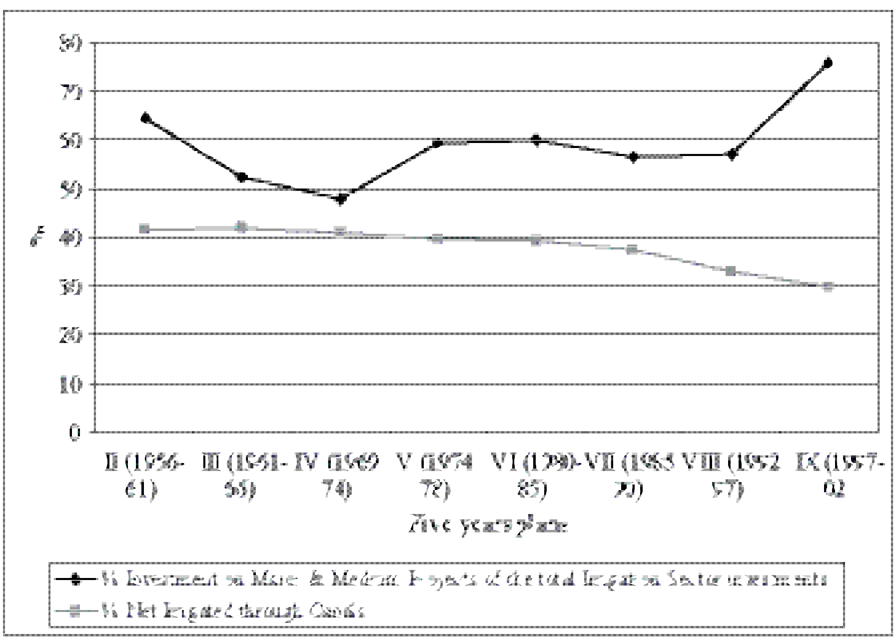
To improve the overall situation in irrigation management, it is important to involve end user groups or farmers in the operation and maintenance of the conveyance system, which can improve irrigation efficiency, generate a sense of ownership among farmers towards canal system and improve the irrigation charge recovery rate. This laid the foundation for irrigation management transfer (IMT) in India. IMT started mainly as a Participatory Irrigation Management (PIM) movement[2]. As a result, various state governments enacted PIM legislations. These states include: Andhra Pradesh, Chattisgarh, Gujarat, Madhya Pradesh, Maharashtra, Orissa, and Tamil Nadu.

However, mere enactment of legislation does not assure solutions to the problems circumscribing the country's irrigation sector. Even after the completion of the eighth and ninth five year plans, there was no pronounced effect in the net irrigated area through canals (Figure 1). Similar trends were noticeable for quality of maintenance of conveyance systems, timeliness and equity of water delivery (DSC 2003), and efficiency of water fee collection. This was the situation despite emphasis for both government investments in irrigation and involvement of end users in irrigation management. Research studies have also shown that even after the enactment of IMT act in various states, performance of transferred systems has improved only marginally (van Koppen et al., 2002; Parthasarathy, 2000). Some of the reasons for this are: a) haste in creating WUAs without any capacity building of farmers as in Andhra Pradesh, b) transfer of systems without complete R&R work as in Gujarat, or c) lack of appropriate legal back up for end user organizations as in Punjab and West Bengal. In the past, researchers have focused on the performance of farmers' organizations but not much on the act or policy, which shaped the organizations. In order to understand the factors that lead to success or failure, it is critical to look into formulation and implementation of PIM acts. Often people who formulate acts and those who implement them consider themselves to be unrelated (Sutton, 1999). In case of PIM act, this perceived dichotomy may lead to ineffective act implementation and working of the whole irrigation system. Thus, it becomes more important to know about the status of implementation of these acts in the respective states and the expected success they are able to achieve.

Figure 1: Investments on Surface sources (only canals) and Net Irrigated Area, India



Source: Indiastat

[2] Participatory Irrigation Management (PIM) refers to the involvement of irrigation users in all aspects and all levels of irrigation management. "All aspects" includes the initial planning and design of new irrigation projects or improvements, as well as the construction, supervision, and financing, decision rules, operation, maintenance, monitoring, and evaluation of the system (Source: World Bank).

2. EXPERIENCES OF IMT IMPLEMENTATION

International experiences with IMT suggest mixed results. In some countries it has reaped benefits in terms of improved system performance and increase in irrigated area, whereas in other countries not much success is achieved (Table 1). Pant (2007) based on his experience of working across India short listed conditions of success for PIM, which included: a) criticality of water; b) able local leadership; c) provision of incentives; d) democratic functioning of WUAs and e) close involvement of key stakeholders. Two action research projects in seven irrigation schemes across India, Nepal and Kyrgyzstan demonstrated that to improve irrigation governance and water distribution by end users, provision of appropriate legal, financial and political environment is must (Howarth et al., 2007). Hodgson (2007) in his findings on government of Iran/World Bank funded Alborz integrated land and water management project also emphasized the need for proper legislation for the sustainability of WUAs.

Table 1: Results of IMT In some Regions of the World

Regions	Parameters	Cost of Irrigationfor Farmers	Efficiency of Fee Collection	Quality of Maintenance	Timeliness of water delivery	Equity of water delivery	Area Irrigated	Crop Yields	Farm income
	Argentina (Mendoza)	Increased	Increased	Increased	Increased	Decreased	Same	Same	Same
	Colombia	Increased	Currently Decreasing	Increased	Change Unknown	Same	Increased	Same	Same
	Dominican Republic	Increased slightly	Improved	Improved	Improved	Improved	Increased	Increased	Increased
	Ecuador	Increased	Same	Declined	Same	Same	Decreased Slightly	Same	Decreased
	Mexico	Increased	Increased in most districts	Improved	Improved	Unchanged	Same	Same	Increased
Latin America	Peru	Change Unknown	Same	Improved	Improved	Decreased	Same	Increased	Same
	Armenia	Increased	Decreased	Same	Same	Increased	Increased	Increased	Increased
	Bangladesh	Unchanged	Same	Increased	Increased	Increased	Increased	Change Unknown	Change Unknown
	India (Andhra Pradesh)	Decreased	Decreased	Increased	Increased	Increased	Increased	Increased	Increased
Asia	India (Karnataka)	Same for farmers	Increased	Increased	Increased	Increased	Increased	Increased	Increased
	Nepal	Increased	Increased	Improved	Improved	Improved	Increased	Same	Same
	Pakistan	Change Unknown	Change Unknown	Change Unknown	Improved	Improved	Change Unknown	Change Unknown	Change Unknown
	Srilanka	Change Unknown	Same	Same	Improved	Improved	Same	Same	Change Unknown
Africa	Zimbabwe	Change Unknown	Increased	Decreased	Improved	Decreased	Decreased	Same	Same
	Albania	Decreased	Increased	Increased	Increased	Increased	Increased	Increased	Increased
Europe	Bulgaria	Decreased	Decreased	Increased	Increased	Increased	Decreased	Increased	Increased
Australia		Increased	Improved	Improved	Improved	Same	Increased	Same	Same

Source: International e-mail conference on Irrigation Management Transfer, 2001

Lesson learned from the survey on 44 IMT programs worldwide suggested that the future IMT programs should concentrate on the following aspects: a) WUAs and irrigation agencies need substantial capacity development; b) IMT programs need systematic public awareness campaigns, consultations and involvement of all key stakeholders; c) IMT should be tailor made and flexible and d) Checks and balances should be created to ensure that WUAs act according to the members' interests (Munoz et al., 2007). IMT experiences in the Indus Basin irrigation system of Pakistan has demonstrated that lack of role clarity between different organizations after transfer, insufficient experience and resources for water users mobilization, lack of democratic approach for establishing water users associations, political involvement and fear of loss of authority of government departments have been the major factors for poor participatory irrigation management progress (Khan et al. 2007).

Results listed in Table 1 do not give clear indication on whether IMT to end users should be promoted or not. In recent times there have been lots of voices in favor of involving private service providers in the irrigation management. Few countries like Niger and Senegal in West Africa (Hermiteau et al., 2001), and some parts of Chile and Mexico (Turral, 1995) have even gone ahead with public-private (involving service provider) irrigation management mode. But it was just impossible to replicate this arrangement at many other places mainly because of the political economy associated with irrigation and agriculture. The bigger question, which remains unanswered is whether transfer of irrigation systems to the end users is the only solution or involvement of private agencies or a combination of both can also work.

Often the success of any irrigation management transfer depends upon how effectively it is implemented. In this regards, role of legislation and people who implement those laws becomes important. Act and policies will always be effective if they are formulated and implemented as per the local needs and problems. Therefore it is important to keep in mind that for what purpose the act is being designed? Who will be the stakeholders? Who will implement it? What will be the role of policy makers in its implementation? As discussed earlier, often the act formulation and implementation are considered as unrelated activity. But this notion does not hold true in practicality. This dichotomy can actually impact the policy outcome in significant way. May be the policy gets implemented in a way which was not thought of originally.

3. OBJECTIVES AND METHODOLOGY

The focus of this research is to search for answers at policy level itself. These include what are the driving forces and original idea behind policy formulation for IMT? How does the policy get implemented and what are the administrative/governance reforms carried out during the implementation? The major objective of the study is to understand the process of PIM act formulation and its implementation. For the implementation aspect, major emphasis was given on the administrative, governance, institutional and financial reforms carried out under the act in Madhya Pradesh.

The selection was based on the researcher discretion with the broader view of expanding the study at the national level if possible. Purposive sampling was followed for the selection of respondents, which included government officials, academicians, NGO personnel and farmer's representatives from the WUA. Two different kinds of schedules were developed. One was used for the selected government officials (irrigation department officials)/academicians/NGO people involved with PIM policy development and other for the selected farmers from a WUA. Focus group discussions were carried out with selected WUA representatives to have their views on the PIM act formulation and implementation in the state. Government records, research papers and other working papers and articles were also used for reference and secondary data.

4. IRRIGATION MANAGEMENT TRANSFER IN MADHYA PRADESH

Madhya Pradesh has a total irrigation potential of 6.72 mha. Of this, a potential of 2.15 million hectare has already been created. However, the potential utilized is only 46%, i.e., 1 mha (as per 2003-04 figures). The main reasons for such heavy underutilization were system deficiencies, deferred maintenance of the system, insufficient revenue to meet O&M cost and non-involvement of farmers in irrigation management (Agrawal

2005; Pandey, 2006). Hence, to improve the overall situation, policy reforms were conceived and PIM act was enacted in 1999. The dual purpose was to improve system condition and involve end users in irrigation management. However, even after 8 years of its existence, little literature is available on the progress and achievements of IMT in MP. Some reference was made to the PIM act, that it was implemented in full capacity in Samarat Ashok Sagar Project, Vidisha district, MP (Pangare et al., 2003; Pandey, 2006).

The assessment study brings out some unstated and interesting facts, which were unknown before. These are discussed under the following sections.

4.1 Reforms in the Past

Before formulation of PIM act, MP government took several other initiatives to have farmers' involvement in irrigation management. They established the Irrigation Panchayats (IPs) in early 1984-85 under MP Irrigation Act, 1931. The functions of these IPs, their rights and duties were not clearly defined under the then existing MP Irrigation Rules, 1974. Consequently these IP's became defunct.

In 1994-95, Farmers Management Committees (FMCs) were formed on pilot basis. Their design principles were very much similar to the farmers' cooperatives in the state of Gujarat and Maharashtra. These FMCs were registered under the cooperative society Act of the MP state. But these FMC's were not able to deliver goods as desired of them and did little to involve farmers in irrigation management. The success of farmer's irrigation management committees in Gujarat and Maharshtra was because of history of strong cooperative movement in these two sates i.e. the Milk Cooperatives in Gujarat and the sugarcane cooperatives in Maharashtra. But in MP there was no such initiative in past and consequently these FMCs became obsolete.

4.2 Coming up of MP PIM act, 1999

Drawing on the experiences from two earlier attempts of involving farmers in irrigation management, it was important to create an enabling legal framework before going ahead with IMT. IMT legislation received major thrust because of the then chief minster Shri Dig Vijay Singh's inclination towards participatory approach for natural resource management. During his regime, Joint Forest Management (JFM)[3] act was launched with a success in the state. For accomplishing the formulation of the irrigation management act, necessary environment was created in the state by discussions and interactions between beneficiaries' farmers and public representatives. This formed the foundation for PIM act formulation. There was no involvement of civil society organizations in these initial stages of policy formulation. The irrigation department (now water resources department) was given complete responsibility to provide suggestions for the formulation of PIM act by looking at the procedure followed worldwide and within the country. Examples of implementation of farmers managed irrigation systems in Mexico, Philippines, and India (Andhra Pradesh, Gujarat and Maharashtra) were examined. Finally, the government decided to formulate an act similar to Andhra Pradesh PIM act with modifications as per the regional settings of MP (Source: As told in various meetings with WRD and PIM directorate officials, MP).

Detailed institutional processes were initiated before coming up with the initial draft of MP PIM act. A core committee consisting a) officials from Water Resources Department (WRD), b) officials from all line departments such as Water and Land Management Institute (WALMI), Agriculture Department, Rural Department, and c) academicians was made. This committee was empowered with providing inputs and suggestions at the various stages of act formulation. Several meetings and discussions were held with the progressive farmers (full time involved in agriculture) about the need and importance of PIM act for the state. Farmers had mixed notion about IMT. Some supported the idea whereas majority of them expressed concerned about their capacity to manage irrigation systems, which WRD has not been able to manage for last 50 years. Because of political will of the ruling party, PIM act formulation was supported equally by the bureaucratic lobby in the state.

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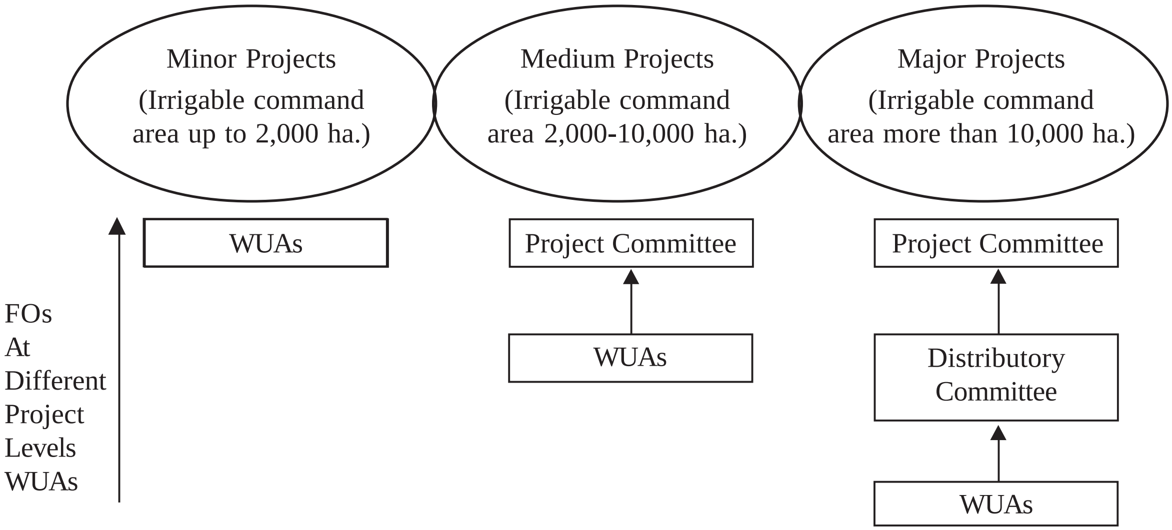
[3] The practice of management of forest resources jointly by the Forest Department and the local communities which would entitle them in sharing of usufructs in lieu of their participation in protection and management of forest resources (Source: Forest Department, Madhya Pradesh).

4.3 Enactment of PIM Act and its Implementation

Finally in 1999 MP PIM act called as "Madhya Pradesh Sinchai Prabandhan Mein Krishkonka Bhagidhari Adhiniyam 1999" was brought into force for the entire state. The rules for act implementation were passed in the same year (Madhya Pradesh Farmers Organization Rules, 1999) by the state government. The Act provides for a three-tier farmers' organizations (FO's) for irrigation management. The lowest tier in the institutional hierarchy is Water Users' Association (WUA) at minor canal level of the irrigation system, secondary unit is

Figure 2: Farmers Organizations at different Irrigation Project/Schemes levels



Note: District collector was empowered for the delineation of command area of WUAs and state government was empowered for the delineation of command areas of DCs and PCs)

Table 2: Constituted Farmers Organization in Madhya Pradesh

	In 2000-01 Total number of farmers' organization (FOs')	Total elected Person	Area under FOs (million ha.)	Total Members (in lac)	In 2006* Total number of farmers' organization (FOs')	Total elected Person	Area under FOs (million ha.)	Total members (in lac)
WUAs								
Minor	850				936			
Medium	153				209			
Major	467				542			
Sub-Total	1470	11752			1687	12877		
Distributory Committees (for major Projects only)	90	300	1.5	11.75	90	300	1.69	Not available (NA)
Project Committees								
Medium	57	398			57	398		
Major	19	151			19	151		
Sub-Total	76	549			76	549		
Total	1636	12601	1.5	11.75	1853	13726	1.69	NA

* Only elections for WUAs are held, figures for DCs and PCs are of 2000-01 elections only

Distributory Committee (DC) at distributory canal of the irrigation system and tertiary unit is Project Committee (PC) at the whole irrigation project level. All minor irrigation schemes had only one tier i.e. WUA, medium irrigation schemes had two tiers (WUA & PC) and the major irrigation schemes all three tiers (figure 2). By default, all farmers having irrigable land in the jurisdiction of the WUA has to be its member. Each WUA area was divided into territorial constituencies (4-10), depending upon the command area under them.

Structurally each WUA was supposed to have a management committee (comprising of elected president and one representative from the each territorial constituencies) and a general body of all the members. Similarly, each DC is comprised of a general body (which consists of the Presidents of all the WUAs in the distributory command) and management committee of not more than five members headed by president. Each PC constitutes a general body (of all presidents of DCs in the project area) and management committee of not more than nine members headed by chairperson, to be elected from the general body members. The term of office of the chairperson, president and members of management committee was five years. By the year 2000-01, management committees of 1470 WUAs, 90 DCs and 57 PCs were formed through the election process. Election for the second term of WUA management committee were held in 2006 (Table 2). However, election for the second tenure for the management committees of DCs and PCs were still to be held.

4.4 Financial Support for the PIM Implementation

During the early stages of PIM implementation, all the financial support was provided by the MP government. After the first FOs election in 2000, an operation and maintenance grant (O&M) at the rate of Rs. 40/ha was provided to each WUA to make them functional. From 2004-05 this grant was doubled. At present Rs. 90/ha O&M grant is given to the WUAs at major and minor irrigation projects and Rs. 80/ha is given to the WUAs at minor irrigation project. In addition to this, a sum of Rs. 5000/annum is being provided to the WUAs for their administrative expenses. A daily wage staff at the rate of 1 person per 200 ha is also provided to WUAs to assist them in repair and maintenance of minor canal.

In 2002, MP government received financial support from the Indo-Canada Environment Facility (ICEF) to speed up the process of implementation of PIM in the state. This support was for the duration of four and half years to assist in the physical work on the transferred irrigation systems and capacity building of both WRD officials and farmers. Under the project, 1 major (Samrat Ashok Sagar), 3 medium (Koncha, Chappi & Satak) and 3 minor irrigation schemes (Gora, Birsagar & Segwal) were selected. Noticeable clause in the project was related to the total expenditure on the execution. Under the clause, 50% of the total expenditure was contributed by ICEF, 20% by state government and 30% by the farmers. However, because of farmers' inability to contribute the 30%, the proportion was later changed to the ratio of 50:30:20 and again to 60:30:10. In total of about Rs. 111.3 million was spent over four and half year of ICEF project execution.

After the completion of ICEF project, state government has now received a World Bank support under the MP Water Sector Restructuring Project. This project has a financial support of Rs. 19.19 billion and will cover the five river basins in the northern part of the state. This project is for period of seven years (2005-2011) and has a major focus on modernization of irrigation system and effective implementation of PIM act in the state.

5. REFORMS CARRIED OUT FOR THE ACT IMPLEMENTATION

For effective implementation of the act, various administrative, governance, institutional, and financial reforms were carried out by the state government. In addition, necessary amendments were made to the act. For capacity building of newly formed FOs several trainings and workshops were organized. We will discuss these in the next half of the paper.

5.1 Administrative Reforms

Major reforms were carried out at the administrative level. For efficient monitoring and evaluation of PIM activities, a separate PIM directorate was formed within the WRD in the year 2000. The directorate comprises of Director, two Deputy Director, two Assistant Director and about 15 junior staff members. In addition to this, one superintending engineer from the office of Chief Engineer and one Assistant Engineer (AE) from the office of Executive Engineer (EE) were nominated as nodal officers of PIM. The main responsibility of the nodal officers is to collect information regarding various WUA activities and compiling a progress report. District collector was responsible to oversee the monthly progress of each WUA. For each district, one executive engineer was made the nodal officer to assist district collector for review meetings.

In accordance with the PIM act, competent authorities were deputed to different farmers' organizations i.e. sub engineers for WUAs, Assistant Engineers for DCs & medium project PCs and executive engineer for Major projects PCs. The main responsibility of the competent authorities is to act as a coordinator between the government departments and the farmer's organizations. Sub Engineers were also responsible to assist WUA in preparation of detailed list of work to be undertaken by them and in preparation of estimates for the same. However powers of giving technical clearance for the works to be undertaken by the WUAs dependent on higher authorities, and was based upon the scale of work identified by WUAs (Table 3).

Table 3: Competent Authority to grant Technical Sanctions for Canal Repair Works

Scale of Project	Competent Authority
a) Ordinary Repairs	Executive engineer (within the funds provided to farmers organization)
b) Special Repairs	
Repairs up to Rs. 5,000/-	Executive engineer
Repairs up to Rs. 50,000/-	Superintending engineer
Repairs up to Rs. 5,00,000/-	Chief engineer

5.2 Governance Reforms

Complete authority for monitoring all the PIM activities in the state was given to PIM directorate formed within WRD. The PIM directorate headed by superintending engineer was also made the nodal agency for carrying out various trainings to FOs members and WRD functionaries involved with PIM implementation. These trainings were targeted to equip key stakeholders to perform their roles effectively under the new regime of irrigation management transfer. District collector was empowered to delineate the command area under each of the irrigation system in the district to be transferred to the WUAs. This delineation was done on hydraulic basis. Similarly delineation of command areas for DCs and PCs was done by the state government in consultation with district collector. District collector was also made responsible for the election of management committee members of FOs.

A sub engineer was appointed as a competent authority for each WUA and as an ex-officio member of the WUA (AE for DCs and medium project; EE for Major Projects PCs). In addition to the sub-engineer, one WRD staff from administrative cadre and one staff from agriculture department was also made ex-officio member of the WUA. For the collection of water charges, a staff from WRD called as Amin (a lower official who collects water revenue in villages) was made responsible. Thus, control over collection of irrigation charges from farmers still remained in the hands of WRD.

5.3 Institutional Reforms

The major Institutional reform was the formation of farmers' organizations itself. A three tier structure of WUA formation was followed. The detail about their institutional structure are already presented in section 4.3. Major responsibilities given to farmers organization included: a) preparation and implementation of Warabandi[4]

[4] Warabandi is a system of rotational turns through which each shareholder in a watercourse obtains his or her water supply.

schedule for each irrigation season; b) preparation of plan and carrying out maintenance of irrigation system in the area of its operation; c) monitoring flow of water for irrigation; d) resolving disputes arising in between the members and the water users in its area of operation; e) maintaining accounts; and f) assisting in the conduct of elections , and g) conducting various meetings at appropriate time intervals. At present Warabandi system is not followed in any of WUAs in MP but as per WRD officials it will soon be implemented.

In past, MP Irrigation Act of 1931 envisaged the formation of irrigation panchayats to carry out similar functions. However, the subsequent rules (Irrigation Rules, 1974) were not able to clearly define the rights, duties and responsibility of these IPs. As a result, these IPs mainly remained as paper organizations and contributed little to improve canal system management.

5.4 Financial Reforms

Financial assistance provided to the WUAs has been already discussed in section 4.4. In addition, irrigation rates were revised after the PIM act. First revision after the act was done in the year 1999, followed by in 2002 and again in 2005. Revisions in 1999 and 2002 resulted in tremendous increase in irrigation charge (water rates) for different crops (Table 4). For some of the crops irrigation charge increased by as high as 850% (for paddy crop grown in rabi season in 2002 as compared to in 1992). In 2005, state government decided to keep irrigation charges as per number of waterings given to different crops. Before that, the charges were based on irrigated area, and were irrespective of number of waterings. Thus financial reforms of 2005 increased pressure on farmers in relation to the irrigation charges they have to bear. Although state government is continuously making changes in the irrigation rates, it does not support irrigation revenue recovery. At the beginning of the financial year 2006-07, arrears for the recovery amounted to Rs. 42,000 lacs.

Table 4: Water Charges for different crops through flow & lift irrigation

Crops		Water Rate (Rs./ha)			% change in 2002 over 1992	Rates for each watering (Rs./ha)
		1992	1999	2002		2005
Paddy	Kharif	60	202.5	215	258.33	85
	Rabi	55	500	525	854.55	155
Cotton	Ordinary	60	175	185	208.33	70
	Hybrid	93.75	375	400	326.67	
Wheat	For land preparation (including 3 watering)	62.5	202.5	105	68.00	125
	For extra watering	15	62.5	65	333.33	75
Gram		42.5	250	105	147.06	75
Groundnut, Moong,	Kharif	45	125	130	188.89	50
Soyabean & Tuar	Rabi	60	250	265	341.67	75
Green fodder Crops		45	125	130	188.89	50

5.5 Capacity Building

Capacity building of the WRD officials at various ranks and WUAs representatives was the major activity carried out during the act implementation. In the first phase (March, 2000), training of 120 Assistant Engineers (AE) was conducted by WALMI. The main purpose was to enable AEs to educate lower functionaries of WRD and office bearers of WUAs regarding the objectives and provisions of MP PIM Act and rules. In the next phase (May, 2000), capacity building program for the WUA presidents/members and lower functionaries of WRD were conducted by WALMI to directly educate these people regarding the implementation of the PIM act. In addition, regular workshops were organized at district head quarters between WUAs presidents/members and the competent authorities i.e. sub engineers concerned for the WUA. The main agenda of these workshops was to discuss and solve any problem arising in implementation of PIM program.

In November 2000, regional workshop of Presidents, TC members and competent authorities was organized which was chaired by then honorable CM of MP. An exploratory visit for the experts of PIM in the country was also organized in October 2001 to assess the progress in PIM implementation in the state. During the period 2002-03, a total of 100 training courses were organized at RCVP Naronha Academy of Administration and Management, Bhopal. These trainings were mainly organized under ICEF funded project. Under each batch 15 WUAs president and 15 competent authorities (sub engineers for WUAs) were trained to enable them to implement PIM in effective way. On similar lines 9 trainings were also organized for the EE's and AE's of WRD. As a part of making PIM effort popular, a quarterly magazine called as MP Sinchai Sandesh was used to be published by PIM directorate. Now it is no longer published.

5.6 Amendments to the Act

In the initial phases of implementing PIM, no civil society organization or NGOs were involved in the capacity building or implementation. But after the ICEF project, involvement of four NGOs namely ASA, BAIF, VIKALP and SRIJAN was mandated under the project. These NGOs played a significant role in increasing community awareness and focus towards the importance of PIM. Besides this, they facilitated bringing about as many as 6 amendments to the existing act for the benefit of community and PIM. Some of the key amendments include:

a) Provision for voting right to the presidents and TC members of medium projects for the election of chairperson and managing committee of PC.

b) Provision for voting rights to the wife of valid landholder in the area for the selection of office bearers of WUAs.

6. INSIGHT ON PIM IMPLEMENTATION IN ONE OF THE IRRIGATION PROJECTS

Satak irrigation project located in Khargone district, MP was selected to understand the actual working of PIM in the field. Selection was broadly based on the recommendation by PIM experts in the state.

6.1 Satak Irrigation Project: Brief Profile

Satak Irrigation Project is a medium tank project constructed during 1955-66 on Satak River in Narmada basin. The tank is located in Bamandi village of Kasrawad tehsil, in Khargone district of MP. The project has 2706 ha of culturable command area, out of which 1800 hectares is irrigable command area. The tank has a total distribution network of 53 km and covers 17 villages comprising 1750 water user families. The canal system of Satak tank project consists of 1 main canal, 1 main distributory and 13 minor canals. Crops in the command area include soyabean, chilies, cotton in kharif (monsoon season) and wheat, gram in rabi (winter season). There is large-scale use of well water in the command area.

6.2 Implementation of PIM on Satak Project

Only one WUA was formed in the entire command area of Satak project in the year 2000. The canal distribution network was transferred to WUA without the necessary R&R works. Until the early part of year 2003, the major role of WUA was restricted to only annual maintenance of the canal structure. In the later half of 2003, Satak project was included in the ICEF project for the renovation of whole canal network and Rs. 128.05 lac was assigned for the purpose. Under this project 30% of the cost (i.e. Rs. 38.41 lac) was to be borne by the farmers of the command area, which was later reduced to 20% and finally 10%. A NGO named ASA was involved as a facilitating agency to mainly: a) promote local institution building at grassroots level, b) motivate farmers to pay their contribution and c) to provide guidance to the farmers for the execution of the physical works. WRD was also equally involved in conducting meetings with farmers and providing guidance for the canal renovation. After a number of meetings and three years of dedicated work by ASA, both quantitative and qualitative change was visible in the community participation for both cost sharing and management of canal system. It was one of the few projects where community made full contribution from their side as a requirement under the ICEF project. However, as a rule under the PIM act, all the money was deposited in the joint bank account of the EE and divisional accountant, WRD, Kasrawat. Release of fund from this account is subjected to technical clearance of physical works from the WRD.

Before finalizing on the repair work on the canal, a participatory walk through (PWT) on canal was carried out jointly by WRD, farmers and NGO members with the aim of deciding priority work to be undertaken first. After the participatory walk through, WUA undertook the canal restoration work under the guidance of WRD and NGO.

6.3 Current progress

As per the PIM directorate record (June 2007), physical work on the Satak project has been executed as per the cost estimates (128.05 lac rupees). Our visit to the Satak project area (23-27 September, 2007) presented the different story. The physical works were still in progress and only initial part of the main canal was renovated.

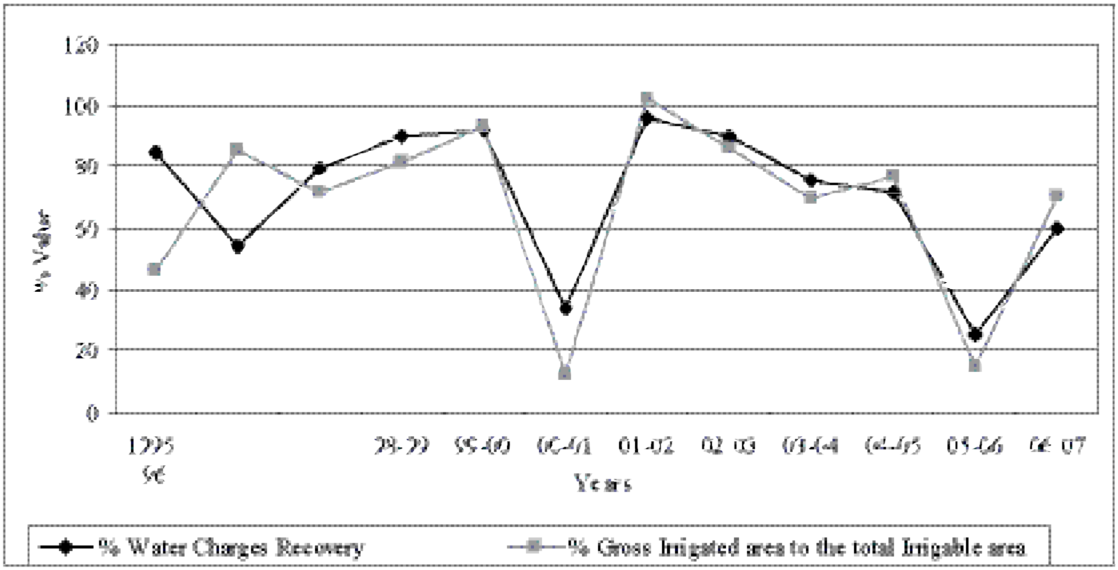
6.4 Performance of Satak WUA

Satak tank is considered one of the best schemes under the ICEF project and it is being promoted as a successful PIM model across the state. Under the PIM Act, role and responsibility of WUAs is only restricted to maintenance of canal system and motivating farmers to pay their water charges on time. However, collection of water charges is still under the WRD representative (called as Amin). Also, WUAs as per the act are not totally independent. An officer of the rank of sub-engineer is the secretary of WUA (does not have any voting right) and the competent authority to oversee the implementation and execution of the decisions taken by WUAs.

Considering the limited role offered to WUAs, what was looked in the performance of Satak WUA was the improvement in the irrigation in the command area and water charges recovery from the farmers. It was found that there was a strong correlation between the gross irrigated area and the water charges recovered after the formation of WUA (i.e. 2000) and more especially after Satak tank was made part of ICEF project i.e. 2003-04 (Figure 3). It can be inferred that the work carried out by WRD and NGO with the farmers under the ICEF project is paying rich dividend at least in terms of water charges recovery. One significant feature to note is very less gross irrigated area in the year 2000-01 and 2005-06. It has to do with poor rainfall during these years leading to less storage of water in reservoir and hence less irrigation.

Once the ICEF project was completed, the NGO has also withdrawn support from the command area. It is quite prominent from the limited information that WUA was able to work when some kind of financial and organizational support was provided to them. But how this WUA will perform in future is not clear. However, one thing was quite evident, WUA office bearers feel that the limited role they have been offered under the PIM act should be expanded. They should be given right to collect their water charges, to have their operator looking after the canal system and greater freedom in their administrative working. It seems that competent authorities of WRD officials still have a bigger say in the day to day management of canal water and also in sanctioning funds to WUA for the maintenance activities. Because of the limited role of WUAs, they are not able to achieve what they actually desire i.e. equitable and timely supply of irrigation water across the command.

Figure 3: Water Charges recovery and Gross Irrigated Area over the years, Satak Project



There was one more source of concern for the WUA. After the second term of WUA elections in the state, earlier office bearers have changed. The new office bearers also need to be trained as was done for the earlier office bearers. But, who will do that? Who will provide financial support for that? The newly formed management committee of WUA at Satak project was not confused about there future course of action. Discussions with farmers revealed that they are not very comfortable with the limited role offered to them under the PIM act and also with the larger involvement of WRD officials in their working.

7. DISCUSSION

Quite often policies are made to resurrect the situation or in response to the problems faced by the communities at large. In the context of the paper, we are looking at the IMT policy adopted by the state to bring back the poorly performing irrigation infrastructure in line. In this section, we will attempt to use literature from different sciences to discuss the IMT policy process followed in the state of MP.

7.1 Model adopted for policy formulation

Discussions with the key respondents involved with PIM process and the way in which act was formulated, it seems incrementalist model of policy formulation was followed in the state. Incremental model simply refers to change “by small steps”. Under the approach, small number of alternatives are looked into for dealing with the problem and finally an option is selected which differs only marginally from the existing policy (Lindblom, 1980; Sutton, 1999). Development of PIM act in MP followed the same route. In response to the problem of poor irrigation system performance, state decided to go for some policy reforms. In the event, IMT as made operational worldwide and in Indian states of Gujarat, Maharashtra and Andhra Pradesh were also looked into. Finally MP PIM act was drafted in close line with AP PIM act with little modifications as per the state socio-political environment, nature of hydraulic systems, investment need and agriculture pattern. This kind of policy making phenomenon is generally “less rational” with actors (refer to policy makers) taking into consideration only limited analysis and factors. Lindblom (1980) bring forth this type of policy making process but often the approach is criticized because of its focus on the short-run period and pessimistic decision-making not bold enough to venture into the distance.

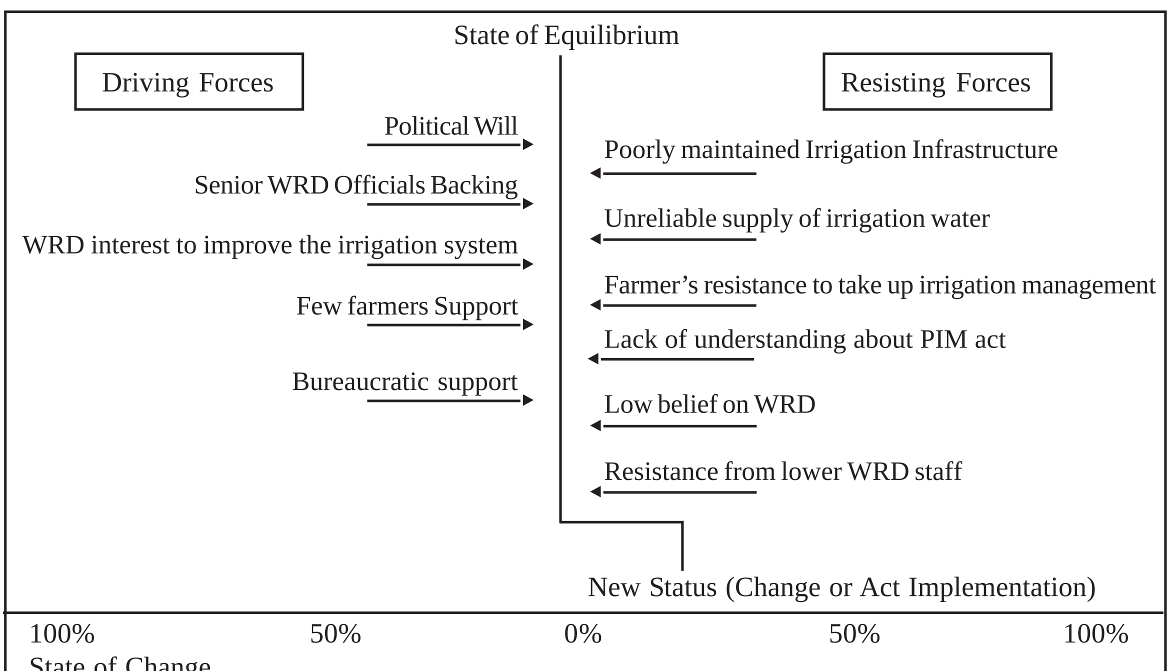
7.2. The Epistemic Community

Epistemic community, also called as policy community, is a group of technical experts who have access to privileged information and ideas. Others do not have such privileges and are excluded. These individuals can be from research communities, NGO's etc. These communities have powerful influence on policy making process. In the course of PIM act formulation in MP, senior experts from WRD played the all important role of epistemic community. These senior experts were the one's, who actually looked into the IMT process worldwide and finally guided the PIM policy drafting for the state. They also enjoyed full support of the then Chief Minister who had an interest in participatory and decentralized resource management. This created a favorable environment in the state for the sound relationship between the WRD experts and bureaucrats in coming up with the PIM act. Some meetings were carried out with the selected farmers before the finalization of the act mainly to understand how they will take the new change. These meetings were few and only with selected individuals. It can be inferred that the policy formulation process did not pay attention to the perception of majority of stakeholders. Views of NGOs and any other civil society organizations were not taken into account during this stage. NGOs were only involved in later stages (ICEF funded project) and that too as a necessity under the funded project.

7.3. Implementation of change

One of the most important aspects after policy formulation is how the change will be implemented. The change has to go through various stakeholders i.e. WRD officials and farmers in this particular case. As per the force field analysis theory[5], for any change to be brought in there are driving forces, which push for change and resistance forces that act against change. For any change to be successful, either, driving forces needs to be increased or resistance forces should be decreased. In the case of PIM act implementation in MP, we tried to identify the nature of both these forces (Figure 4).

Figure 4: Force Field Analyses for MP PIM Act



[5] Force field analysis is a systematic method of understanding competing forces that increase or decrease the likelihood of successfully implementing change.

It was observed that government was able to implement the act because of driving forces created through the political will of the then chief minister, backing of senior WRD officials mainly to improve the irrigation system and bureaucratic backing because of political support. These driving forces outweighed the resistance forces of the majority farmers reluctance to take up the system management because of its poor infrastructure and unreliable supply. These driving forces also outweighed the resistance within the lower WRD staff, which was mainly on account of their fear of losing power and control over the system once act will be implemented.

Opposition to any change may be because of wide range of reasons. In the implementation of PIM act, majority of farmers opposed it because of their low trust on WRD works and their fear of how they will manage the irrigation system which WRD has failed to do in past 50 years. Lack of understanding and information about the benefit of PIM among farmers initially was also a major constraint. Whereas fear of lower level staff of WRD was more because of threat to their status i.e. what will be there role once the system would be handed over. But, since the act implementation was done more in top down approach, government was able to overcome this resistance. However, it took nearly 5-6 years to make farmers fully understand about their role in the irrigation management. This became possible more because of external funding provided by ICEF for capacity building during 2002 - 07. After the second election in 2006, new WUA management committee again looked confused about their role, and their capacity building has becomes necessary. How WRD will address these issues in future, needs to be seen.

The best thing observed in the PIM act implementation was no dichotomy between the act formulators and implementers. This means the experts or the officials who were involved in the act formulation made sure that its implementation is done under their guidance.

7.4 Are Reforms carried under the act Rational?

We will restrict our discussions here to the administrative, governance and financial reforms carried under the act. Various administrative and governance reforms carried out under the Act, suggested significant involvement of WRD officials within the WUA working, be it Amin collecting water tax from the irrigators, WRD canal operator regulating water use, ex-officio members from WRD and agriculture department in the managing committee of WUAs and other higher ranks WRD officials in charge of granting technical sanctions to the WUAs, WRD has a big presence in WUA functioning. As per the World Bank definition, “PIM refers to the involvement of irrigation users in all aspects and all levels of irrigation management. ‘All aspects’ includes the initial planning and design of new irrigation projects or improvements, as well as the construction, supervision, and financing, decision rules, operation, maintenance, monitoring, and evaluation of the system”. But the way MP state has gone about implementing PIM, most of these functions still remain with WRD. WUA role is only restricted to maintaining the irrigation system and motivating farmers to pay irrigation tax.

But, the WUAs role in functions such as operation of the existing irrigation systems, making of irrigation schedules for the different crops, and collection of water tax remains open to question. At present, these roles are not given to them. Discussions with WRD officials suggest that they want to gradually transfer complete irrigation management to the WUAs. However, now has been good eight years of PIM act existence in the state and the situation remains more or less same. Can we call it a PIM? If yes, then is MP government going for IMT just to recover the irrigation charges and with a greater objective of reducing their costs on system maintenance.

Financial reforms (mainly relating to irrigation fee) in 2005 hint at government initiative to restrict excess use of water for irrigation. These reforms were also a step towards charging farmers on the volumetric basis and making them realize about the importance of judicial use of water. But, the irrigation charge recovery in the state is in an abysmal state, and the average rate of recovery for the past 19 years is only 19%. Therefore, the success of such kind of financial reforms is highly questionable. One can infer from the above discussion, that although the administrative and governance reforms were carried out to affect changes in bureaucracy, institutional reforms were not complete for WUAs to have autonomy, greater responsibility and incentive for irrigation management.

7.5 Can we do it without External Aid?

External aid driven projects are often found to have limited success. It is mainly because at one stage, the aid will stop and the process will get back to zero. At that stage, either community take the responsibility or people look for more funding or rely on government funds or just move as per the original pace of things. Although the author is not a critic of external aid, being driven into the implementation of community welfare programs but there should be some crafted rules and procedures, which keep established system in working condition even after the aid ends. Looking at the progress of PIM in MP, apart from creation of farmer's organization at three levels, nothing substantial came out in the first 3-4 years of implementation. Only with the ICEF funding and involvement of NGOs alongside WRD, we saw some positive results. But, that is also restricted to just seven projects. Now again we presume that with the World Bank funding for MP state water restructuring project, some break through will be achieved. This fund is also restricted for the projects located in the northern river basins of the state. The question is for how long we will continue to depend on external support. If state government is not able to generate funds within the system, and continues to depend on external aids, will the system survive? Do we have to find some other way of proceeding with IMT, may be by involving some private operators. The alternative institutional models like public-private partnership mode in irrigation management as experimented in some parts of China, Senegal, Egypt and Saudi Arabia (World Bank 2007) need to be explored by the policy makers.

7.6 Outcomes of the Eight years of PIM existence in MP

We would like to discuss the PIM outcomes dividing the implementation period into pre (1999-2003) and post (i.e. 2003 onwards) ICEF project. We are dividing the implementation process in two phases because the implementation moved on fast track at least for the seven irrigation schemes after they were made part of ICEF project. In terms of number of farmers' organizations formed and irrigable command area (ICA) transferred to them, no significant increase was observed in the pre and post external aid phase. Number of farmers organization increased by 13% in 2006 over 2000-01 and ICA under FOs' increased by only 12.5% for the same period (Table 2). This was quite expected, as focus of PIM during this phase was only on the improvement on the seven selected irrigation schemes.

Out of the total created irrigation potential of 24.88 lac ha (2006-07) only 16.9 lac ha have been transferred to farmers' organization. These are the figures when government claims to have implemented PIM in the entire state. Further, the net surface irrigated area in state remains only at 11.3 lac ha (2004-05). So, there is an obvious gap between the potential utilization even after the large scale reforms in the state. In the discussed case study (section 6) we observed a correlation between the irrigation and water revenue collected. The same relation holds true for the entire state. In 2003-04 and 2004-05 when there was improvement in the net canal irrigated area, irrigation revenue collected was higher compared to previous years. But, overall irrigation revenue recovery remains in abysmal state, averaging 43% for last 10 years (from 1997-98 to 2006-07) with arrears of Rs. 34,000 lac at the beginning of financial year 2007-08.

These numbers may not provide the reader with the entire insight into the outcome of PIM process in MP. But, one can infer that success of PIM in MP is still very far away from reality. Although state government is busy with implementing various PIM schemes but farmers are not satisfied under the current format. They want to have more role in decision making and maintenance of canal system. Farmers believe that unless there is complete involvement, they wont be able to improve the system performance or for that matter equity across the command area. WRD on the other hand feels that if farmers are given all the responsibilities, things will become messier and complicated. For them it is necessary to have WRD involvement in the functioning of WUAs if positive results are to be seen. WRD also fears that if complete transfer is done including the irrigation revenue collection power to WUAs, they may start behaving like a political entity (like panchayat) and then it will become much difficult to monitor and supervise their work.

8. IMPLICATIONS

Policy implementation is a continuously changing process requiring consensus building, participation of key stakeholders, contingency planning, resource mobilization and adaptation, which must be managed in a proper way. Newly formulated laws, acts or policies often bring about changes in roles, structures and incentives of implementers, direct beneficiaries and other stakeholders. Thus, any policy implementation should proceed in a very careful way. Looking at the MP PIM Act formulation and implementation, we see that more of a "top down approach" was followed, especially during the initial years (1999-03). This approach created number of resistance forces both within and outside the policy process system and resulted in little success in terms of benefits to community. Although the model adopted for policy formulation, the incrementalist model, was not rational but surely one, which was politically feasible under the system.

It appears from the foregoing analysis that the administrative, governance and institutional reforms for promoting effective farmer involvement in irrigation management were not adequate. Partial delegation of power and responsibilities to the WUAs are one of the major factors for success of the PIM process. From the discussions with the farmers, it was quite clear that the limited role offered to them and greater involvement of WRD officials in their functioning is not creating much of an impact in the improvement of the irrigation system as a whole. Further, the success of PIM seems to be in the grip of external aid. If there is financial support, stakeholders are sure of positive results but without it, no one seems to be confident. Even the financial reforms (related to revision of irrigation charges) carried out as per the act look out of place and irrelevant.

Effective management of irrigation system requires going beyond the single policy solution to a more refined approach that takes into account the local physical, social and economic conditions (Meinzen-Dick 2007). Thus, the present MP PIM act needs to incorporate a few changes, which are more suitable for the end users. Other ways for promoting farmer management can also be considered. At present private sector involvement in irrigation management is being given due consideration in many parts of the world. In India too, corporate involvement in telecommunications, retail segment, electricity, agro-forestry etc. have shown tremendous success. This success is not only in the quantity but also in the quality of services provided by them. May be we can think of having private sector involvement in irrigation, atleast at the main system level. But, this will only happen if there are less political bottlenecks and favourable policy environment for the private operators. In these privately managed irrigation systems, may be farmers have to pay more for the offered services. But, these can be made up from the increase in the net returns to farmers on account of improved delivery of irrigation water. This can be one of the ways of doing IMT differently. Some incremental thoughts can be given to current reforms and policies to make them more effective and acceptable by the beneficiaries.

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KEY ISSUES IN PARTICIPATORY IRRIGATION MANAGEMENT♣

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Abstract

The recent developments in irrigation sector in the developing world are dominated by PIM/IMT concept. Although the conditions of success and the impediments discussed in this paper concerning the concept are in the context of India, the same are applicable to all countries that are aspiring to achieve success in this respect. Therefore, the aspiring countries, including India must be cautious of the financial allurements of donor agencies because PIM seems to suffer from a number of infirmities that cannot be overridden but in exceptional cases. This is borne out of the fact that although the concept of PIM is being tried in India for over last thirty years, it has yet to achieve even a semblance of acceptability and replicability, not to talk of scaling up. Large canal systems in India contain nearly 40 percent of country's total irrigation potential of 94 million ha, a substantial part of which, remains unutilised. The main reason behind the lack of utilisation is the ill maintenance of irrigation systems, particularly micro systems at lower levels and those at the farm level. Faced on the one hand, by the near collapse of such irrigation systems and on the other, utter financial crunch, administrators are susceptible to donors like World Bank and Asian Development Bank, who are currently coming forward with funds with the conditionality of PIM. Coupled with this alluring prospect is India's experience of the last three decades with the concept of PIM. The scenario that exists in India provides both an opportunity and challenge. The paper based on the author's experience as a researcher/consultant cutting across country's cultural and geographical boundaries, short lists conditions of success of PIM/IMT along with a close scrutiny and analysis of the impediments that impinge on its path.

1. INTRODUCTION

Recent developments in the irrigation sector in Asia, Latin America and Africa are dominated to a large extent by Participatory Irrigation Management (PIM)/ Irrigation Management Transfer (IMT).The paper, based on the author's experience of the last thirty years as a researcher/consultant in respect of PIM/IMT cutting across the country's cultural and geographical boundaries, examines the key issues in PIM/IMT and shortlists conditions of success along with a close scrutiny and in depth examination of the impediments that impinge on its path of success. For some, the concept of PIM seeks to strengthen the water user government relationship by adding farmer participation to government management, while IMT intends to replace the role of the government (Munoz et al., 2007). In this paper, PIM and IMT, however, have been used interchangeably because the author believes like Herve Plusquellec that PIM and IMT often have the stated objectives of providing sustainable and adequate financing for operation and maintenance of irrigation and drainage services and of facilitating investment in the required rehabilitation or upgrading of irrigation systems (2002).[1] Although the review takes into consideration all the Indian states where PIM is being implemented, the major illustrations have been drawn from the state of Maharashtra and Uttar Pradesh on account of two reasons. One, the Maharashtra strategy appears to be most pragmatic and sustainable and two, the author has studied the Maharashtra and Uttar Pradesh experiences in far greater detail than any other state. Although the conditions of success and the impediments discussed in this paper are in the context of India, the same are applicable to all countries that are aspiring to achieve success in this respect. Although the paper does not overtly state that the conditions of success are of ideal types and are

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[1] INPIM differentiates between PIM and IMT and refers to the former as participation of irrigation users - the farmers - in the management of irrigation system and IMT as turning over the authority and responsibility to manage irrigation systems from government agencies to WUAs. (ICID Newsletter 2007) The author as pointed out in the text, however, does not draw this finer distinction and regards that these represent two stages of the same phenomenon.

difficult to be obtained in the prevailing environment, it argues that the aspiring countries, including India must be cautious of the financial allurements of donor agencies because PIM/IMT seems to suffer from a number of infirmities that cannot be overridden but in exceptional cases.

Looking back at antiquity, the evidence of advanced water harvesting systems in India can be traced even to prehistoric times in various Vedic, Buddhist and Jain texts. However, the most vivid and detailed description of irrigation structures and practices is found in the Arthasastra – a politico administrative treatise of Kautilya/Chanakya who was a mentor to and minister of Chandragupta Maurya (321-297 BC), the first emperor of India (Agarwal and Narain, 1997). In India, large irrigation systems were built as early as the second century AD, and their maintenance by water users also dates back to antiquity (Pant and Verma, 1983).

The British colonial rulers were hardly oblivious to the role of local community in the operation of works for irrigation.[2] On the contrary, a long series of 19th century British administrators saw local organisations as central to the success of virtually all irrigation works. But they also saw local community within a distinctive framework and that had critical implications for the future of irrigation. British ideas about the proper relationship between the local community and the state – ideas that developed in the period before construction of large scale irrigation works – had ultimately a profound impact on shaping and constraining the emergence of a ‘public’ voice in irrigation as did the local variables that encouraged and constrained collective action and irrigator cooperation in ‘village republics’ independently of the state (Gilmartin, 1999).

The Northern Canal and Drainage Act, 1873 conferred the rights of distribution of water with beneficiaries who were supposed to fix and apportion their shares of water by mutual agreements. Only in case of disputes the beneficiaries were required to apply to the Executive Engineer for an Osrabandi.[3] As far as back in the year 1990, cultivators started submitting written mutual agreements to the Executive Engineers. These agreements were for sharing of water amongst them day-wise. Subsequently where these agreements did not work, the cultivators insisted that the Executive Engineer to record the agreements on stamp papers. Three types of Osrabandi, namely, thok-wise, chak-wise and village-wise could be prepared according to the convenience of cultivators. Presently chak-wise osrabandi is said to be in vogue in western parts of Uttar Pradesh (Pant and Verma 1983, 26).

1.1 Present Scenario

Large canal systems in India contain nearly 40% of country’s total irrigation potential of 94 million ha. The staggering rise in the cost of creation of irrigation potential can be gauged by the fact that in comparative nominal terms, the public sector outlay has risen from an average of Rs. 90 crores per annum during the First Plan to over Rs. 65000 crores in the Eighth Plan (Vaidyanathan, 1999). Despite the overwhelming increase in the outlay all these years, the management of canals has remained highly inefficient leading to ever-increasing gap between the created potential and its utilisation. The main reason behind the lack of utilisation of irrigation potential is the non / ill maintenance of irrigation systems, particularly micro systems at lower levels and those at the farm level.

Faced on the one hand, by the near collapse of such irrigation systems and on the other, non-availability of funds leading to utter financial crunch, the panacea is once again being found in PIM. International donors like the World Bank, Asian Development Bank and other donor funding agencies are currently going out of their way and coming forward with funds and the conditionality of PIM/IMT. Coupled with this alluring prospect is India’s experience of last three decades during which the concept of PIM has traversed through a number of distinct phases. The scenario that exists in India, no doubt, provides state governments with an opportunity to tide over the financial crunch but at the same time it also sets a utopian challenge to meet the demands of PIM.

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[2] Control over water although did not fit fully in to the structure of local community shares (hissa), and rights (haq), the village papers prepared by the British at each settlement usually included shares and rights in water as well as in land.

[3] The word osrabadi is made of two words – osra (turn)+ bandi (fixation), which means fixation of turn for getting water.

1.2 Evolution of PIM

During the last three decades, the concept of PIM[4] in India has passed through four distinct phases. Starting from around 1975 and for about a decade until 1985, the emphasis initially was on creating outlet based water user organisations and later on research leading to support for PIM as a pragmatic solution for equitable distribution of water among the irrigators, maintenance of water conveyance micro structures and resolution of conflicts amongst the water users. During the second phase (1985-90), the emphasis shifted from research on PIM to experimentation with PIM. Therefore, a number of pilot projects were started and developed all over the country during this period. Ministry of Water Resources, GoI, World Bank and USAID aided and assisted in the establishments of pilots, while NGO's played a catalytic role in mobilizing farmers and sustaining the pilots. The third phase starting from early 1990s has seen the emergence and propagation of the idea of hand over/turn over of irrigation systems in case of smaller systems and hand over of management of sub-systems, particularly at the level of distributaries/minors in case of larger systems to the irrigating farmers. This was started in Maharashtra in the early 90s, followed with India's first "Farmer Management of Irrigation (FMIS) Act" in Andhra Pradesh in 1997. At least seven states (Andhra Pradesh, Madhya Pradesh, Chattisgarh[5], Rajasthan Karnataka, Orissa and Maharashtra) have now enacted legislation that makes PIM a statutory requirement to get access to irrigation water. WUAs (Water User Associations) have grown up in almost all other states and many of the states (like Maharashtra) are in the process of enactment of similar legislation. The fourth phase starting from 1997 marks the emergence of donor funding as bait for restructuring India's irrigation sector with PIM/IMT as a core programme.

1.3 The Legislative Strategy and the Motivational Strategy

One of the first and the foremost issues that one needs to consider is the issue of the strategy that is being adopted for PIM. Two broad strategies may be identified as the legislative strategy and the motivational strategy. The Andhra Pradesh, Madhya Pradesh, Chattisgarh, Rajasthan Karnataka and Orissa experience broadly exemplifies the legislative strategy, which concentrates on a rapid and extensive introduction of PIM through legislative measures. In contrast, the Maharashtra and Gujarat experience mainly exemplify the motivational strategy. The emphasis is on first building up awareness, creating motivation and then introducing PIM. These strategies could also be contrasted as top-down and bottom-up strategies respectively. The former is also called the 'big bang'.

In AP some time in 2005 elections to WUAs were withheld and all the WUAs were superseded and administrators were appointed. The entire process of democratic functioning was in a way aborted by the government. In contrast, the Maharashtra and Gujarat strategy has achieved considerable success. Mula Minor 7, Katepurna and Ozar in Maharashtra and societies formed by the Development Support System (DSC) and Aga Khan Rural Support Program (AKRSP) in Gujarat and the like have provided inspiration and guidance to many PIM efforts. However, in this strategy, the rate of expansion of PIM has been meagre and the proportionate area covered by PIM is small in relation to the total irrigated area in these states.

Thus, the two available models in India are AP model and Maharashtra model. The former represents a top town approach where an Act was passed in a relatively short time and a large number of WUAs were established with the bang. However, the autonomy and sustainability of WUAs is being questioned both by academics and activists. On the other hand is Maharashtra, where establishment of WUAs was going on since late 1980s the Act was passed much later in 2005 after a great deal of deliberations, debates and discussions.[6]

[4] The man behind the of the present-day PIM and irrigation co-operatives in Maharashtra was the legendary civil engineer M. Visvesvaraya, who as early as 1902-03 had advocated establishment of such co-operatives in respect of Khadakwasla canals while working as Assistant Engineer in the then Bombay state. The two earliest water user co-operatives were established in the 1930s. The first one, Saswad Mali Society, was established in 1932 in Pune district. The second, Samvastar Vibhag Water Supply Co-operative Society was established in 1936 in Ahmednagar district.

[5] The state has retained the PIM Act that was passed in 1999 when it was part of M.P.

[6] Although the Government of Maharashtra in its resolution dated July 23, 2001 had indicated that no water permission would be given to individual farmers and that only WUAs would be eligible for water entitlements, the resolution could not be executed.

The State Government was keen to have a comprehensive legislation governing the WUAs in the State. The draft Act entitled “Farmer’s Management of Irrigation System” along with drafts of other complementary legislation had been widely circulated and discussed for over two years before the Act Maharashtra Management of Irrigation Systems by Farmers Act - 2005 (MMISF) was passed.

1.4 Enabling Environment

In all important discussions, debates and formulations one issue that is always discussed in the national and international forums is the necessity of enabling environment. However the author has found that the concept is invariably used in a very marrow sense to include legal and other prerequisites for the successful execution of PIM/IMT programme. The more important political component of the concept is rarely discussed. Even in one of the latest papers based on the large scale survey on the subject that talks of the global scenario mentions that the information collected shows that there is a tendency to grant WUA responsibilities without sufficient, legally recognized authority, while the issue of lager enabling environment is ignored (Munoz et al. 2007).This larger environment refers to the prevailing political scenario, which is more of a stumbling block in the countries where a democratically elected person heads the region/state/country. This aspect can be better understood if we take the case of states like, A.P. and U.P. in India where under the World Bank projects PIM/IMT was taken up. In case of the former state, the one Chief Minister takes it up in a big way but when the other comes to power after the election he finds that the big benefit had gone to the supporters of one political party and he virtually stops the IMT component.

In case of U.P., like in most of the other areas globally, the project is taken up as a pilot in a small area and the World Bank expects that the water charges to be enhanced as part of the implementation process. This is not feasible because while a neighbour where the World Bank project is not in operation pays meagre water charges his neighbour, where PIM/IMT is in operation is expected to pay an exorbitant water charges. Further, an elected Chief Minister never likes to enhance rates of any public services on account of vote bank politics. It is for this reason the prevalent water charges structure in India has no relationship either to income from irrigated land or to the prevailing supply and demand conditions. In most of irrigation projects, water charges are normally assessed on per ha basis. The same is true of all public irrigation systems in case of most of the states of India. This does not provide any incentive to the farmers to use water in the most efficient way, as he is required to pay the same amount of money in irrespective of the fact whether he took little water or more water.

The water charges levied by various state governments are very low and have not been revised periodically to reflect even normal changes in price conditions not to talk of scarcity value of water. In case of Uttar Pradesh, in respect of public surface irrigation systems, the water charges have not been revised since September 1995. The main reasons behind keeping water rates low and not revising the same from time to time are two fold. The one is that politician do not want to annoy farmers who constitute largest segment of their vote bank. The second, the quality of irrigation service is so poor that there is not enough justification to raise water charges because the service is grossly inadequate. In case of U.P.the basic survey carried out for the World Bank PIM/IMT pilot project had found that in 29% of surveyed villages, canal water had not reached at all and in 71 % of the cases the families were not receiving adequate/timely supply of canal water. A number of researchers have carried out studies and have found that the water charges collected by various states do not even meet the cost of the bureaucratic apparatus employed for the collection of water charges. In fact, the present dispensation hits the socio-economically deprived sections of the rural society the hardest. It is so, because the assessment/collection functionaries of the government are not in a position to take action against the big well to do farmers but collect water charges from vulnerable and poor farmers using pressure tactics even in cases where water is not given to them adequately or not given at all. In fact, there is evidence to show that the highest proportion of water charges come from the marginal and poor farmers, while in case of larger farmers and those who wield power and influence the arrears go on mounting year after year. It was, therefore, not uncommon for the author to find the names of big and influential farmers in the defaulters list which was being prominently displayed publicly in various offices in Uttar Pradesh during 2006 when the author was doing his study field visits (Pant, 2006).

However, the issue of discrimination in realization of water charges and enforcement of a system to rectify the problems cannot be dealt in isolation and is closely linked to the larger socio-political and cultural ethos that governs backward societies in general and the society in Uttar Pradesh in particular. In a society where the actions of the central and state governments and those of the Governors and Chief Ministers are set aside by the judiciary and yet such actions are repeated again and again without any shame and fear, the blame cannot be put on a particular mechanism and machinery.

In respect of realization of water charges, the field level functionaries are quite vulnerable. They cannot realize the water charges from the rich and influential farmers because if they attempt to do so, they face all kinds of harassment. They, therefore, find it easier to approach the poor and powerless so that they can safeguard their personal interests at the same time perform their duties. The solution of the problem is two-fold. First, there is a need of restructuring of the system and replacement of many of the procedures emanating from the British laws including the Northern Canal and Drainage Act of 1873. Second, effective and impartial execution of existing provisions such as execution of Kurkee (distress warrant, which enables confiscation of movable property of the warrantee) against rich and influential. This brings in to fore the question of "real politic". In respect of reform process in respect of electricity, lot of restructuring has taken place and inspite of all kinds of pressure from GOI and international agencies, the provisions remain to a large extent on paper when it comes to doing away the financial losses of State Electricity Boards including disconnecting electric lines of influential defaulters (Pant, 2006).

2. CONDITIONS OF SUCCESS

The detailed analysis provided here is not confined to the stereotype examination of "enabling environment", where analysis usually does not go beyond the internal environment in a narrow sense. The sequencing of conditions of success and later that of impediments has been done in terms of their importance and/or logical occurrence in the process PIM/IMT.

2.1 Criticalness of Canal Water

The most important factor found by us in making farmers to come together and work for the common good was the critical necessity of canal water for the survival of the crops grown and even farmers' own survival. This means that they come together and work collectively when they have no other workable economically viable alternative to available public canal water. The author found the earliest example of this in 1984, when he was working with USAID, New Delhi and had visited Gambhiri irrigation project in Chittorgarh district to enhance PIM component in the project. It was found that the farmers were engaged in deep rock cutting, including blasting, high filling up to 0.75 meters, and much excavation work, in one case over 2 km long. Further discussions revealed that the canal water was very critical for the survival of their mustard crop[7]. As a matter of fact, if farmers find that by coming together and forming a WUA they may enhance and optimise their water supply in a situation where they do not have any other feasible option, they would go out of their way and work physically by offering volunteer labour, paid labour or by contributing machinery to do earthen work for improving their water delivery. In a large number of cases, the minors/distributaries on which WUAs were formed were located towards the tail of the system and they were not getting any water worth the name, the farmers contributed their voluntary labour to construct several check dams across the nalas flowing through the commands of WUAs to improve the ground water level and to apply conjunctive use of ground and surface water. In fact, in some cases the WUAs had evolved a very appropriate system of charging for the use of well water from their members. In one case farmers had to launch a movement and subsequently 400-500 farmers gathered together and broke the canal gate to force the ID to sign the (Memorandum of Association) with the WUA and hand over the management to the WUA. In another case the WUA dug a large and deep well in the village temple land by voluntary contributions to save Kharif excess water to utilise during the Rabi season. All

[7] All this was communicated to Robert Chambers, who incorporated it later in his book (Chambers 1988 : 165).

these illustrations reinforce the point that if canal water is critical for the lives of farmers and they do not have any other feasible and economically viable means; they would come forward, form a WUA and then try to sustain it (Pant, 1995; Pant, 2000).

2.2 Right Kind of Multiple Local Leadership

One common feature of all the successful WUAs was found to be the right kind of local leadership. By right kind, we do not mean “selfless commitment”. In most of the cases, it was found that the local leadership, consisting of the main driving force as well as the management committee members had a vested interest in the WUAs. It was found their average land holdings were higher compared to the average land holdings of the members. By right kind, we mean such rural elites who had local influence, high socio-economic status but who had a propensity to come forward to work for a common good where they could derive advantage for themselves also in some common good. The type of leadership that works in harmony with others without jeopardising the interest of others. These were the local leaders who believed in the maxim, “when I serve others’ interest, I serve my interest also because my interest is a part and parcel of others” interest.” According to them it is a matter of coincidence that their interest (land holdings) happened to be bigger (Pant, 1983, 1986 and 2000).

If the WUA has to sustain, the right kind of multiple local leadership must emerge. The local organizations when initiated by committee members or by the members of the general bodies have greater chances of sustainability. Further, those organisations are likely to have greater sustainability, which depend on multiple local leaders, in comparison to organizations, which depend on an individual leader. This is what distinguishes between institutionalization and non institutionalization of the leadership and in the latter case the organization collapses with the disappearance of the leader from the scene, while in the former case even if the leader is no more in the scene, the local organisation continues to flourish (Pant and Pant, 1996).

2.3 Provision of Incentives

One conclusion from our various studies whether from Bihar (Pant and Verma 1983) or from Maharashtra (Pant, 1999, 2000) or from Uttar Pradesh (Pant, 2006) comes out conclusively that incentives must be built around the programme of PIM/IMT if it has to succeed at least in the initial stage. As the organization grows and stabilises, such incentives can be reduced and ultimately withdrawn completely.

The IMT programme in India involves a number of incentives, which attract farmers towards establishing WUAs. In case of Maharashtra, for instance, a number of concessions/incentives are available for the IMT programme. First, there is a management grant at the rate of Rs. 100 per ha for the first and the second years and at the rate Rs. 75 per ha for the third year. Since the 50% matching grant from GoI under this component is available only for the CADA (Command Area Development Agency) projects, in case of non-CADA projects, the matching portion is also provided by the GoM.[8] Second, GoM provides maintenance grants to WUAs at the rate of Rs. 20 per ha per year. Third, 5% concession is given to WUAs on timely payment of water charges. Fourth, the WUAs are provided water on a volumetric basis, which comes much cheaper to water calculated on area basis. Fifth, the WUAs do not have to face any crop restriction. The WUAs are given an allocated quota of water and within this quota they can grow any crop they like. Sixth, IMT involves rehabilitation of the irrigation sub-system to its designed level or at least to a workable operation level. The rehabilitation work involves repairs of about Rs. 8 to 10 lac per WUA, which goes along with IMT. Seventh, non-members can be charged 30% more than members’ water charges, therefore, it is an incentive to form and join a WUA.

One of the reasons that there is so much enthusiasm among farmers for IMT in Maharashtra is that, against 774 WUAs where IMT has taken place covering an area of 250,521 ha, there are 3277 WUAs involving an area of 1.29 mha, which are in various stages of completion of IMT (GoM, 2005).

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[8] As per the financing pattern w.e.f. 01.04.1996 a functional grant in lieu of management subsidy is to be given to the WUA at the rate of Rs. 500 per ha. to be shared between the GOI, the state Government and the WUAs in the proportion of Rs.225: 225:50 respectively.

2.4 Close Involvement of the ID (Irrigation Department) Officials

Based on past and current research it has been found that the most successful WUAs were the ones where greater interaction and most frequent contacts between the ID officials and WUAs were obtained. WUAs have succeeded and sustained only in such projects where top irrigation bureaucracy took a keen interest and the field staff genuinely worked in close collaboration with farmers. In the initial stage, WUAs need assistance for registration, accounting system, and development of internal structures that are conducive to high-level participation. In cases where this close interaction and collaboration was lacking and the WUA was created to fulfil the target requirement, the association collapsed as soon as management subsidy ended. An intervention by senior bureaucracy of ID in meeting the genuine demands helps in strengthening WUAs. On the contrary, hollow promises reduce the legitimacy of the WUA considerably and the beneficiary farmers tend to lose faith in the existence of WUA. (Pant, 1983, 1993, 1999 and 2000).

In the Indian setting the EE (Executive Engineer) is the most important person in establishing WUAs. 3 to 6 Assistant Engineers and about10 to 14 JEs work under him. Besides them, supporting staff like Sinchpals and Khalasis) and labourers also work in the Division. No doubt, higher officials like the SE and CE's support and encouragement are also necessary but the success at the field level depends on the interest of the EE. It has been found that WUAs have succeeded and sustained only in such projects where top irrigation bureaucracy took keen interest and field staff genuinely worked in close collaboration with farmers. Interventions by senior bureaucracy of ID in meeting the genuine demands help in strengthening WUAs. On the contrary, hollow promises reduce the legitimacy of the WUA considerably and the beneficiary farmers tend to lose faith in the existence of WUA.The burden of success of PIM in general and that of WUA in particular lies mainly on the leadership of the EEs who can transform WUAs in to living institutions or can mar them to oblivion even before they are born.

The assessment of the author in respect of the on going World Bank Project in Uttar Pradesh is that no care has been taken in the placement of Divisional Engineers and other staff in critical positions. Anywhere in the developing world where PIM experiment has succeeded, lot of care has been taken in the placement of staff in critical positions.

One of the most important factors responsible for the failure of the government initiated WUAs is the attitude of the implementing staff, towards the members of new organizations. It has often been found a relationship of unequal or unbalanced, kind of relationship. The attitude of the staff is frequently of superiority towards these members (Abernathy, 2004).

2.5 Establishment of PIM Cadre/Core team

It should be clearly understood that the kind of mindset, attitude and approach required for attaining participatory objectives under projects require a cadre of individuals who have confidence in the capabilities of farmers and who genuinely believe that with proper advice, guidance, aid and assistance farmers are capable of managing irrigation systems. The reality of the situation is that such individuals are in short supply. However, there are a small number of individuals at various levels of irrigation bureaucracy who are "field oriented" and are willing to interact and learn from the wisdom of farmers. The necessity of the occasion demands that all such individuals are sorted out from the irrigation agency implementing PIM and brought over in the project. As a first step all such officials (most senior to most junior) who have commitment to PIM and hold sympathetic attitude to the beneficiary farmers in general and on the viability of the WUA as an institution in particular, must be identified at various levels of bureaucracy. Once such officials are identified, they can then be short listed and placed in strategic positions then only chances of success of PIM in general and WUA in particular enhance.

The easiest and the most practical manner of putting this idea in to practice is that the head of the Irrigation Agency issues an official order where all chief engineers of Major and Medium Irrigation projects are asked to identify 15 staff each from their project. The selection would be required to be done from all levels within the project in a pyramidical manner. Thus, each chief engineer may be asked to select 10-15 PIM oriented personnel, which may be drawn fro the lowest to the highest level. The only condition that they may be laid in their selection is in respect of their age. It would be desirable that they should not be over 50 years of age so that they could give substantial contribution in attaining, consolidating and institutionalizing PIM first in the area where PIM is being implemented and subsequently in rest of the regions/states/country. The only exception that can be made in respect of age would relate to senior level staff starting from EE in whose case the age limit could be raised to 55 or even 60 years in exceptional cases. To expedite the matter without any undue delay, the chief engineers may be asked to furnish the lists within a month along with name, designation, age, and the reason behind the selection of such a person in the list. Once the list is obtained in the office of the unit responsible with project implementation may be entrusted with the task of further short listing of the list in his office as per the requirement. It is also possible that the short listed persons are called for an interview in the office of the unit and further short-listing of the list is done (Pant, 2006).

It should be kept in mind that building WUAs in backward states like Uttar Pradesh, Madhya Pradesh, Chattisgarh and Rajasthan that do not have a good record in collective /co-operative affairs is a process of technical refinements and long drawn social processes and thus cannot be attained by issuing orders. Persons who could contact farmers and motivate them should consist of individuals who are oriented to the idea of "farmers first". Even persons so short listed and eventually selected would need training to be given to reorient them if PIM related task is assigned to them.

2.6 Assistance from NGO or from others

Considering the fact irrigation agencies all over the world consist of mainly engineers who generally do not have the expertise in motivating farmers for collective action in solving their water related problems. Therefore, it is accepted that NGO can play a very important role in motivating farmers to form WUAs. It is pointed out that NGO can be catalysts and facilitators in identification of forward looking and progressive farmers, in helping farmers getting their association registered, including getting their rules and regulations formulated, helping the WUAs initially in smooth transaction of their business, including maintenance of record and accounts etc. Such NGOs can work as a liaison between various implementation agencies and farmers groups.

Based on detailed case studies of Maharashtra, it can be said that wherever, the WUA was established by local leaders with the guidance of NGOs like SPK (Samaj Parivartan Kendra), Nasik or SOPPECOM (Society for Promotion of Participatory Ecosystem Management), Pune the WUAs have been working quite satisfactorily. Therefore, what is important is the need of committed NGOs and not just NGOs. Even two NGOs could bring Maharashtra in top position in India in respect of PIM/IMT programme. The main reason was the individuals associated with the two NGOs were highly committed and highly competent professionals, who were working for the programme with missionary zeal

2.7 Democratic Functioning

One of the preconditions that need to be set for the registration of WUAs is that 51% of the beneficiaries and beneficiaries with 51% of the land in the CCA (Cultural Command Area) must be agreeable to form the WUA[9]. This is necessary so that such a condition may prohibit a few big farmers who hold 51% of CCA to form WUAs for their vested interest disregarding the interest of small and marginal farmers

As regards other components of legitimate democratic functioning, these include periodic elections, defined rights, including safeguards to protect the interests of small farmers, minorities and women, a written constitution and bylaws, and regular meetings of the executive and the general body. Of these, the foremost is a written constitution with a general body and an executive committee and the regulative mechanism of the same. The important question is to what extent the WUAs observe these requirements in a true spirit. In all cases where the functioning of such PIM was successful and sustainable it was found that in all such WUAs, the proceedings were duly recorded, elections took place at regular intervals and in a large majority of cases the minutes/decisions of the organs of WUAs were typed/printed and widely circulated. Although elections often

[9] In Maharashtra both the conditions need not be met and even if one of the two conditions is met a WUA becomes eligible for registration.

extended the continuation in office of the same old guards who formed the WUAs, membership circulated among varied individuals. In fact, in some cases complete overhauling of the executive committee took place. However, what was significant, in none of these cases, the smooth functioning of the WUA was affected (Pant, 1999, 2000).

The world-wide survey finds that democratic selection of WUA leaders is a problematic aspect and is often not achieved. Further, in some cases internal rules and regulations of WUAs do not provide enough safeguards for small farmers to be adequately represented (Munoz et al., 2007).

2.8 The Memorandum of Understanding (MOU)

According to the world-wide survey, there is a widespread need for clearer water rights to be given to WUAs. It is found that in many parts of Asia and Africa water rights do not exist or they are not functional. It is felt that farmers may need greater confidence in their water rights before they will be willing to take responsibility and make investments to ensure the productive and sustainable use of the infrastructure as well as of agricultural inputs (Munoz et al., 2007). This is essential because the sustainability of the WUAs largely depend on their capacity to provide an adequate water delivery service and control and to allocate water and to provide an improved service to farmers to enable them to obtain gains in agricultural productivity (Facon 2000).

The following three points, which constitute the core components, must be reflected in the MOU. One, farmers would get right in water[10] allocation through the agreement and would therefore get sustainability and assurance in getting a predetermined quantity of water at a predetermined time. Two, they would get right of information and thereby hope to get at least on demand the information related to water availability. Three, PIM would create a sense of ownership in respect of the irrigation system, which would eventually be scaled up in the form of higher levels of federations of water users.

When a farmer receives a supply on an area basis, he receives a service for his field. He is not interested in the water that flows out of his field (in the losses) because his stake does not cover that portion of the water. In that sense, the water that flows out of his field is not water that he has paid for or has to pay for. When he is delivered water on a volumetric basis, the water that flows away is water that he has paid for, it is water in which he has a stake and there is a possibility of getting him motivated to save that water, to increase his stake. Volumetric supply is, therefore, necessary to make him a stakeholder in the quantum of water delivered (SOPPECOM, 2004).

In Maharashtra the agreement/MOU between the WUA and the ID is the instrument, which secures provision of water quota to the WUA season-wise. This quota varies from one WUA to another. In some cases the quota is only for rabi and kharif, while in others it is to spread to all the three seasons, including the hot weather. However, when the quantity of water in reservoir itself was below the normal, the water quota of the WUA was accordingly reduced. This reduction in abnormal circumstances is provided in the MOU of all WUAs. In Maharashtra, each WUA is entitled to save Rabi quota for the summer after a deduction of 30% (on account of conveyance losses). This means each WUA is entitled to utilise 70% of its Rabi saved water from its “Water Bank” during summer.

The ID provides the agreed amount of water at the minor head, where measuring devices are installed before the MOU. The responsibility of the maintenance rests with the WUA. In view of this, the WUA gets maintenance grants @ Rs.20 per ha per year from the ID. The WUA also collects the water charges from the water users and deposits the same season-wise with the ID. In case of timely payment, the WUA gets a concession of 5% from the amount collected by the WUA. Thus, all rights and responsibilities of the ID and WUAs are clearly specified in each and every MOU that the ID enter with a WUA. It was found, except proper maintenance of minor and the micro conveyance structure related to it, all other terms and conditions are fully adhered to by the two parties. In respect of proper maintenance of the minor the WUAs complain that first, the rehabilitation of the system is generally not done as per the joint inspection report and the systems are generally transferred to WUAs with a promise of completion of full repairs “soon”. In reality, these incomplete works are

[10] Right to water assumes volumetric supply of water to WUAs. One of the important lesions of the Mahrashtra experience is the importance of volumetric supply of water, about which a consensus seems to have arrived in respect IMT everywhere.

never completed. The second, the WUAs feel the amount provided for the maintenance is quite inadequate. During 1992 when the guidelines were issued it was agreed by the GOM to revise the Rs. 20 per ha rate after every two years. In reality, no revision was done even after a lapse of seven years.

The WUAs have to often accept the take-over of the systems even though the rehabilitation work is incomplete. In reality, a reasonably sound physical system seems to be acceptable to farmers. This in realistic terms means the system with a measuring device at the off-taking point of the minor, selective lining and even 50 to 60 per cent of designed discharge is considered as a comparatively sound physical system. Majority of the successful WUAs in Maharashtra have this type of physical system. This leads to two suggestions. First, formation of WUAs in all new projects should be made a compulsory condition so that the question of rehabilitation is not raised. Second, in case of on-going projects, a mutually acceptable physical system should be handed over to the WUAs without waiting for its complete rehabilitation or renovation.

2.9 Legitimacy of WUAs

Legitimacy is different from the legality and it need not follow legality. In respect of WUAs, two instruments provide the legal basis. The one, registration of the WUA and the second, the signing of the MOU/ agreement between the ID and the WUA. However, in reality what is important is the acquisition of legitimacy of the authority of the WUA not only in the eyes of group members and of neighbouring villages, but also in the eyes of the officials of government institutions and agencies of financial institutions etc. Here lies the success of the WUA. However, it does not come overnight but is the result of a continuous process of consolidation/ stabilisation and institutionalisation. In all the cases, where we found the WUAs had obtained a high level of legitimacy in respect to its existence, the rise in legitimacy was a sequential process resulting from the following. Initial success in the management of irrigation functions dealing with distribution of water among users, maintenance and upkeep of water conveyance structures and resolution of conflicts among users and between users and the ID gave a boost to WUAs in broadening its functions and taking up allied agricultural activities such as provision of seeds and fertilisers etc. (Pant, 1986; 2000).

An important element in the acquisition of legitimacy was found to be the extent to which the ID officials met the genuine demands of the farmers. If the repeated complaints of a WUA about an inadequate and irregular supply of quota of water do not rectify the position, the water users lose interest and the WUAs tend to become defunct. On the contrary, if the genuine demands of the WUA are met, it grows, stabilises/institutionalises and becomes a role model like; Ozar based WUAs and Datta WUA.

3. ELIMINATION OF IMPEDIMENTS

The two broad strategies adopted in the implementation of PIM in India are, the legislative strategy and the motivational strategy. The Andhra Pradesh, Madhya Pradesh and Chattisgarh experience broadly exemplifies the legislative strategy. It concentrates on a rapid and extensive introduction of PIM through legislative measures. In contrast, the Maharashtra and Gujarat experience mainly exemplifies the motivational strategy. The emphasis is on first building up awareness, creating motivation and then introducing PIM. These strategies could also be contrasted as top-down and bottom-up strategies respectively. The former is also called the ‘big bang’. Irrespective of the strategy, care needs to be taken to eliminate all such obstacles that jeopardize the successful implementation of the PIM concept.

3.1 Absence of a Clear-cut Policy and Vision Statement

Even states that have enacted legislation have not come out with a clear-cut policy statement that governments have decided to hand over the management of irrigation systems at the minor/distributary level to the WUAs in a phased manner and within a fixed time frame. Consequently, the government officials do not attach required importance to the work concerning forming and sustaining WUAs. The state of U.P. is an excellent case to point the difference between the provision and the intent. Therefore the over emphasis that is laid in various national and international for an on enabling legal requirements are necessary for facilitating PIM but not an adequate condition. On the contrary legitimacy that the author has been emphasising is more critical. The irrigation bureaucracy, meanwhile, works with a rigid mindset. The officials think that it is not their work and that an extra and unnecessary task has been imposed on them. They take up the work under the compulsion of targets. Further, the commitment and priority of higher ups for this kind of work goes on changing and consequently, adhocism is the reigning principle.

Building of WUAs is a long drawn social process and cannot be done by issuing orders. Experience shows that after the system is turned over, the officials of ID feel that their role is over. Ideally, with the completion of the turnover, the role of the ID changes from administrative authorities to friends/guide providing assistance and support to WUAs. The associations can sustain only if they receive continued technical assistance and co-operation from ID officials until they are self-sufficient. It is therefore necessary that each state government should come out with a clear-cut vision statement along with a clear mandate and milestones for making WUAs autonomous. This would require changes both at the project and WUA levels (DSC, 2006 : 20).

3.2 Delays in Completing IMT Requirements

The stage of IMT comes after a number of preliminary requirements are fulfilled. These include registration of WUA, joint inspection of the system to identify the operational deficiencies in the system, signing of MOU, and hydraulic testing of the system. Once registration has been completed, the joint inspection is not carried in time and it gets delayed unnecessarily. Even when it takes place, the presence of the representatives of WUAs in this joint inspection is notional. They are not allowed to make their views incorporated in the joint inspection report. Their views are disregarded on grounds that the same are non-technical. Even when the estimates of rehabilitation works are prepared, the same are not shown to the WUA representatives. Again estimates are not prepared in time. The general tendency in preparing the estimates is to put lot of lining work, which is unnecessary and is incorporated mainly to get the work cost inflated. Once the execution of rehabilitation work starts, it is not done properly, particularly in the work relating to embankments and masonry structures. Finally, the hydraulic testing of the system is not done before handing over the system to the WUA. As per agreement, this is required to be done before the hand over. In the absence of testing, WUA does not know the water conveyance losses and water conveyance efficiencies. It is therefore necessary that that time bound work plans are prepared, discussed and sanctioned and the concerned officers should be held responsible and punished if time schedule is not observed.

3.3 Delay in Rehabilitation Works

The main obstacle in effecting IMT is the rehabilitation of the minor system, which is lagging far behind due to non-availability of funds. This is the main delay between the registration and IMT and the delay was found to be varying between 15 and 27 months. This delay was because of delay in carrying out rehabilitation of minors and the other deficiencies concerning the structures found at the time of the joint inspection. In Maharashtra, up to March 2004, there were 533 functioning WUAs encompassing 158 thousand ha of CCA. As against this, there were 1939 societies containing a CCA of about 639 thousand ha waiting for IMT (SOPPECOM, 2004). The most damaging impact of this delay is that farmers start losing all their enthusiasm and things are again back to square one.

It is estimated that repairs of such work on an average costs between Rs. 8 to 12 lac. These delays were mainly due to non-availability of funds. This is in spite of the fact that in 1995 GoM had issued instructions that 10% of the operation and management grants should be reserved and utilised only for the rehabilitation work relating to registered WUAs where rehabilitation estimates had been worked out. In reality, Operation and Management Divisions were not following this guideline. It is therefore suggested that GoM should open a new 'budget head' in the annual budget and allot grants specifically for the rehabilitation works proposed under each irrigation project and the same should be clearly shown, as such, in the annual budget separately for each project officer. The project officer will then be responsible for demanding and spending of these sanctioned grants specifically for the purpose.

There are cases of non-completion of rehabilitation work in the absence of available funds. In some cases where the ID took up such works after the joint inspection, preparation of estimates and provision of funds, the works remained incomplete. Moreover, in many cases the measuring devices constructed by the ID are faulty and therefore no precise measurement is possible. Above all, there are also other cases where IMT has taken place but measuring devices have not been installed. In the absence of measuring devices, water bills are prepared on the basis of approximate quantities of water worked out by the lower staff on an ad-hoc basis. This means charging the WUAs for quantities of water that they have actually not received. The existence of these WUAs goes against the very premise on which the concept of IMT based – "you pay for the volume of water you take". All this means that the prevailing scenario is highly detrimental for the success of the IMT programmes.

It is generally found that the farmers of tail areas are keen to form WUAs. However, water supply in such areas is most inadequate and erratic. In respect of minors off-taking from distributaries, the availability of water is worse. This is one aspect of the problem related to tail portions. The other and more disturbing is that even after IMT water is not delivered as per the schedule. In fact, every season a schedule is prepared dealing with the duration of water delivery.

3.4 Lack of Transparency

One of the biggest impediments in the successful execution of IMT programme is the lack of openness in preparation of estimates and the execution of work. In fact, in joint inspections, farmers' points of view are not incorporated. Even the estimates prepared for the rehabilitation works are not shown to WUAs not to talk of seeking their consultation. Finally, when repairs are done, no participation of the WUA takes place. These works are undertaken without any involvement of the representatives of WUAs. Generally WUAs are not satisfied with the quality and quantity of work. This procedure is against the principles of joint management and accountability. During our detailed discussions with WUAs, the representatives of these associations were of the view that the involvement of the WUAs in both the stages is necessary. They were of the view that a copy of the rehabilitation estimates prepared by the ID must be given to the WUAs for their comments. Similarly, the repair work done by the contractors appointed by the ID must be supervised and certified as satisfactory by the representatives of the WUAs.

3.5 Target versus Sustainability

Mere targets are not enough; field staff's passion, commitment, devotion and faith in the IMT programme are necessary. Creating collective organisations for common good is a formidable task. It requires a great deal of patience to persuade, encourage and guide the farmers in the process of formation of WUAs. A few meetings with farmers are not enough. Initially 2-3 days duration day and night camps in strategic locations with the presence of senior level ID staff are a must for breaking the grounds. Such camps must be followed by a series of meetings in the same and other strategic locations. (Pant, 2006).

In situations where a host country or a state of that country where a donor assisted project is being implemented is not committed to the concept of PIM then donor assistance becomes more a curse than an opportunity. A case in point is World Bank funded "Piloting Reform Options for Irrigation and Drainage" Project in U.P. In this Project the implementing agency did not do anything for over three years for the establishment of WUAs and then within a span of couple of months undue haste was exercised in the registration and handing over/agreements (MOU) for maintenance to WUAs. Since the Project envisaged establishment of 416 WUAs in the same number of Minors within no time 416 WUA had been registered and agreements had been signed with them for the limited maintenance purposes. Side by side, against all norms of democratic procedures and autonomy of the WHA, the Junior Engineer of ID was made the Secretary of the WUA and a signatory of its bank account. Further, the Chairman of the Project Activity Core Team had claimed after one day's field visit, "that the state is undergoing a silent revolution paving the way to farmers for equitable distribution of irrigation water through minors managed by Water Users Associations (WUAs)". This was done as the apparent focus of program was to attain targets of rapid establishment of WUAs in the project commands without adequate preparation and was bound to turn out to be counter-productive. The model of WUA, which is created with such haste in a ritualistic manner, is bound to be in line with the "filling the records" and as such the institution is bound to be manipulated. As a result, it would remain a creature of the state government and thus quickly fail as a sustainable institution. Although there is an overt state policy on PIM, it seems that this policy has not been covertly accepted and internalised and therefore does not coincide with agreed objectives and obligations under the World Bank funded UPWSRP. Another major problem is found to be rampant corruption in execution of the PIM programme. The nexus between the NGOs, Consultants and the implementing agency has become so institutionalised that it can not be broken unless the donor funding agency is genuinely interested in the implementation of PIM/IMT in letter and spirit. On the contrary, donor and the state government do everything to stifle the concerns of the Specialist, first by pressurising him to withdraw such "undesirable" portions from his report and when he does not relent, they succeed in pressurising the Consultancy firm to terminate his contract mid way so that they manipulate things to suit their ends (Pant, 2006).

3.6 Lack of Appropriate Training

The training needs of WUAs programme far exceed the accomplishments in this respect in any of the states in India. The scale of training needs to be hiked up at two levels. One, at the level of the irrigation bureaucracy. The other, at the level of WUAs where farmers and WUA functionaries need to be provided training. Thus, formal and informal training for capacity building to the concerned officers and field staff of the ID and farmers and office bearers of WUA to form and run the WUAs smoothly and profitably is a must. In order to increase the pace of implementation of PIM and attain sustainability of WUAs it is very necessary to change the mindsets of government officials and to enthuse among them a sense of devotion and commitment to IMT program

In case of farmers it would require orienting them to irrigation in a collective way through group action and joint management with ID ultimately developing management capability both in terms of sub-system management and organizational management of WUAs.In respect of WUAs; it was found that they are not fully aware about their rights and responsibilities. Further, they are not guided about their powers to fix water rates, recovery of management costs, running rates and for enforcing discipline in taking water. Above all, in matters relating to maintenance of records and accounts. For the successful institutional development, training programmes for WUA members and functionaries are essential. The important components of the training programme should include: water measurement, losses, depth of water in the field, how much water is needed for a crop-land unit, financial operations, accounting, auditing, maintenance, upkeep and repairs, office procedures, correspondence, etc.

In U.P. very few courses are organized for the cultivators and WUA committee members and that majority of the training to them is provided by the NGOs who are themselves not well versed on the subject. Therefore, there is a need to make a critical change in this direction. It would therefore be best in all such cases where PIM component is weak that 2-3 days duration day and night camps should be organised in strategic locations in the project area. These 2-3 days camps must be attended by highest level ID officials to give legitimacy to WUAs in the eyes of not only the present day members of WUAs but also in the eyes of potential WUAs which may spring up in future in adjacent and other areas of the state. The camps are not the end in it self and must be, followed by a series of meetings between PIM task team and cultivators in sub strategic locations.

3.7 Lack of Monitoring and Evaluation

In the sphere of major and medium irrigation projects, which are tightly controlled and regulated in all respects like, water allotment, distribution, fee collection and cropping pattern by departmental procedures, any steps towards IMT are fraught by all kinds of hurdles. It is, therefore, mandatory in such a situation that the progress is closely monitored and impacts duly evaluated. IMT involves two stages. The first is the creation of WUA and the second and more important is its sustenance. While the first role could be performed by the government, NGOs or local leadership, the second cannot be attained without the full involvement of the ID, including closely monitoring its progress and evaluating its results.

Everywhere where the PIM is being implemented, the manuals provide detailed aspects and core components of M&E and suggest regular evaluation of WUAs. In case of U.P.detailed checklist for monitoring the program performance in various stages have been formulated together with scorecard for monitoring the performance. Although issues for evaluation are often spelled out, no specific parameters for evaluation are identified. Where parameters are mentioned, no precise measurements are formulated and thus no scoreboards are prepared for monitoring the performance of WUAs. Where detailed manuals are prepared for this purpose, the check list is so detailed that it is not feasible to use such check lists for a quick and quantifiable assessment by teams of officials, consultants, researchers etc. who make short field visits to assess the functioning of WUAs. Keeping all these points in and based on a number of field visits, the author has prepared a simple and easily workable format for assessing the performance of WUAs in a comparative and quantifiable manner (Annexure 1). The format may be further improved after field visit experiences.[11]

4. CONCLUSION

Large canal systems in India contain nearly 40 percent of country's total irrigation potential of 94 million ha, a substantial part of which, remains unutilised. The main reason behind the lack of utilisation is the ill maintenance of irrigation systems, particularly micro systems at lower levels and those at the farm level. Faced on the one hand, by the near collapse of such irrigation systems and on the other, utter financial crunch, administrators are susceptible to donors like World Bank and Asian Development Bank, who are currently coming forward with funds with the conditionality of PIM.

Although the conditions of success and the impediments discussed in this paper are in the context of India, the same are applicable to all countries that are aspiring to achieve success in this respect. Therefore, the aspiring countries, including India must be cautious of the financial allurements of donor agencies because PIM seems to suffer from a number of infirmities that cannot be overridden. This is borne out of the fact that although the concept of PIM is being tried in India for over last thirty years, it has yet to achieve even a semblance of acceptability and replicability, not to talk of scaling up. Considering the fact that by the end Ninth Five Year Plan (2002) an irrigation potential of about 37 million ha had been created through major and medium canal project, not even 1% of this potential had been covered by PIM/IMT, speaks volumes about failure of the concept, which is so dear to the international donor agencies. It is understandable that fund starved state governments are rushing to donors like the World Bank and the Asian Development but what is beyond comprehension, why the donors are keen to sell the PIM/ IMT concept, when it has met with all round failures all over the developing world. They do not even want to learn lesions from the past. A case in point is the Orissa Water Resources Consolidation Project that was initiated by the World Bank in 1995 and was closed in 2004. The project when formulated had proclaimed attaining PIM/IMT but it failed miserably and now a new entrant in the field (ADB) is hoping to succeed where the World Bank failed. The time has come when more pragmatic models leading to greater privatization in respect of large canal sector replace PIM/IMT.

The new examples of relative success in international seminars, forums etc. are said to be from Latin America and China. Large-scale irrigation schemes are said to have been transferred in Mexico since 1989 and till date about 3.3 mha is said to be handed over to 474,000 WUAs (Ochoa and Garces-Restrepo, 2007). Irrigation District No 11 in the Lerma-Chapala basin, three hours north of Mexico City is said to be the largest one with an area of 116,000 ha. Under the 1992 National Water Law the same had been handed over to the responsibility of the users, with the assets remaining in State ownership. The district has about 25,000 users in 11 water user associations (ICID, 2006 : 1)

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[11] The format was sent to a number of persons for use and improvement but none wrote back. This includes the CEO of Aga Khan Rural Support programme in India who verbally mentioned (during the 2007 IWMI-Tata Meet) that they tested it in more than 500 cases but never replied to author's numerous e-mails following the Meet.

It is reported that the available data from China indicates that since the early 1990s and especially after 1995 China has successively established WUA and contracting in the place of traditional collective management. According to the findings of a study done in north China, the share of collective management declined from 91% in 1990 to the 64% in 2001. It was further found that, contracting had developed more rapidly than WUAs as 22% of villages managed their water under contracting and 14% through WUAs (Xu et al., 2003). Guanzhong region of Shaanxi Province is said to provide the most illustrative models irrigation reforms in China. The Guanzhong Irrigation Improvement Project (GIIP) was initiated in 1999, with the overall objective of improving the performance of the irrigation systems in the Guanzhong plain of Shaanxi Province. Initiated with an investment 16 billion yuan (USD 0.2 billion), of which the Chinese government contributed half and the other half was a World Bank loan, it aims at improving irrigation infrastructure above secondary canal level. The project also includes improvement of canals below secondary level covering an irrigation area of 3.4 million mu (225,000 ha). The investment for this is 360 million yuan (USD 45 million), of which 30% is beneficiaries' (farmers') contribution, 30% comes from the World Bank, and 40% from the Chinese government (Mollinga and Bhatia, 2003)[12]

The author apprehends that the whole exercise relating to PIM/IMT smacks a planned propaganda on the part of lending organizations like the World Bank and ADB. In this senseless exercise these organisations are presenting wild goose chase under the wrap of PIM. They themselves know that PIM is an infeasible proposition, hence they are either behaving like an ostrich or are active collaborators of a "willing suspension of disbelief" drama since it serves their interest. The author had the opportunity of seeing this whole drama during the 10th international seminar at Tehran during May this year. Here all big wigs of INPIM (of World Bank) and ICID-CIID were busy with patting each others back for the success of PIM without any regard to the ground level factual position.[13] The farcical drama ended with a field visit to interact with WUAs in Ghazvin Irrigation System of Iran where WUAs had ceased to exist even before the show pieces could have been shown to visiting international participants.

Keeping the view in mind that the conditions success and removal of impediment are insurmountable, it would be apt for the author to repeat what he had said twenty six years ago in the context of Kosi Project in Bihar. "The problem of distribution and delivery of water at the chak level is not just a problem of under utilization of available water but is also linked to the question of equitable distribution of water among the various socio-economic groupings of the farmers. This brings us the problem of the unholy alliance among officials, politicians, and local elites, which is the biggest stumbling block in way of equitable distribution of scarce resources including water, and it is not easy to break this alliance in the existing socio-political framework" (Pant, 1981). The problem remains the same even today and in fact the politics of votes has further accentuated it.

[12] In the INPIM, April 2005 issue six Guangzhong- Management Models were described, consisting of Contract, Lease, WUAs, Auction, Joint stockholders and Water supply companies.

[13] The two main protagonists of Tehran drama were the chairman and the Executive Director of INPIM. While the former was behaving like a dictator in disapproving dissent even in selecting panelists, the latter was busy in resorting to rhetoric, lies and self seeking dirty tricks.

Annexure 1

Particulars
Weightage points

Format for Assessing WUA Performance

	Level of Performance				
	Excellent (5)	Good (4)	Average (3)	Poor (2)	V.Poor (1)
Activities					
A. Level of participation					
Leadership capability					
Members awareness about WUA status					
Productive meetings					
Voluntary physical/labour contribution					
Voluntary financial contribution					
Social Audit/ Transparency					
B. O. & M.					
Removal of silt and weeds					
Repairs/maintenance of structure					
Protection of structure					
Dispute management					
C. Water Management					
Adequate and timely water supply					
Information about water distribution					
Efforts to save water					
D. Financial management					
Fund generation					
Utilisation of maintenance and operation fund					
Recovery of irrigation fees (when applicable)					
Financial audit					
E. Organizational Linkage					
Horizontal linkages with other WUAs					
Vertical linkages					
Information and communication					
Discussion with competent authority					

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WATER ALLOCATION POLICIES IN COASTAL KARNATAKA: AN ANALYSIS OF NETHRAVATHY RIVER BASIN

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Abstract

The paper to looks at the water allocation policy follow in coastal Karnataka. The state water policy accords top priority to drinking water followed by irrigation, power generation through hydroelectric projects, agro industries, industries and transport. However, there is a mismatch in the policy and its implementation. The analysis of the information and data shows that there are negative social and ecological impacts on the livelihood of the farmers and fisher folk because of poor implementation of these policies. Karnataka Agricultural Policy - 2006 is focused on doubling the agricultural production in the next decade with the aim of achieving a 4.5% growth rate for the agriculture sector and a subsequent increase in the net income of the farmer. Simultaneously, the Karnataka government is planning to set up a PCPIL (petroleum, chemicals and petrochemical investment region) in Dakshin Kanadda (DK) and set up MSEZ near Mangalore as a precursor to the PCPIL project. The area selected for setting up the petrochemical zone comprise villages which are currently involved in agriculture, horticulture and fisheries. The establishment of PCPIL and MSEZ are likely to increase the pressure on the Nethrawathy and Gurupur river basins and cause serious degradation of the marine ecology of the region adversely affecting fist yields. The proposed project is similar to the Reliance petrochemicals project in Jamnagar, Gujarat, which has had serious implications for the welfare of the villages displaced and the ecology.

The paper tries to analyses and point out ways in which DK and Mangalore region are likely to be affected because of the proposed petrochemical development. The state has pursued and implemented the water policy contrary to the suggestions from expert recommendations. This is likely to lead to negative impacts on the livelihood of the local communities.

1. INTRODUCTION

The state of Karnataka has a geographical area of 1,50,162 km^2 and is divided into three distinct natural divisions based on climatic conditions and soil type. The coastal plain spreads to 16887km^2, comprises the three districts of Dakshina Kannada, Udupi and Uttara Kannada and receives an average rainfall of 4,000 mm/yr. The second zone is Malnad zone, a densely forested land covering an area of 28,000kms^2, comprises the districts of Dharwad, Shimoga, Chikamagalur, Hasan and Kodagu and receives an average rainfall of 2,500–3,000mm/yr. The third zone, Maidan zone has a land area of 105,113 km^2 (70% of the Karnatakas total land area), with an average rainfall of 500 mm. Karnataka has a monsoon tropical climate and a bulk of the rainfall occurs during southwest monsoon period of June-September.

The coastal ecosystem of Karnataka is a mosaic of monsoon wetlands, beaches and mountains stretched along its 300 km long shoreline. The Western Ghats separate the coastal eco-region of the state. A number of rivers flow from the Western Ghats. These rivers before joining the sea form vast estuaries y and support fish production in both coastal waters and estuarine waters. Coastal wetlands are an important source of economic livelihood for local communities generating income in millions of rupees. The coastline has more than 26,600 fishing units. The region harvests prawns and commercial fish species including sardines, mackerels, oil sardines and some crustaceans. In 2004, Karnataka exported 1500 tonnes of marine products worth Rs. 2000 million. The higher fish production of the Karnataka coast could be assessed by the fact that with only one-third of the coastline of Andhra Pradesh, Karnataka produces as much fisht as Andhra Pradesh.

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Mangalore is one of the fastest growing cities in South India. It is located in the southern region of the west coast of India and lies on the confluence of the Nethravathy and Gurupur rivers and spreads over an area of 141.77 km^2. The population of Mangalore city was 4.60 lac as per 2001 census and is projected to reach 6.82 lakh by 2020.

The city hosts major industries such as oil, fertilizers, chemicals and thermal electricity. These developments have increased the stress on the river to provide water for a variety of services such as drinking, commercial and industrial needs. Large scale expansion of industries during 1990s and later such as fertilizers, chemicals, petrochemicals etc have increased the conflicts in water utilization.

The study provides insights into the nature of the conflict that can emerge as a result of pursuing water allocation policies that do not reflect the concerns of the society at large. This is done through an assessment of the social costs of increasing reallocation of water from Netravathy river basin meant for drinking and irrigation for industrial uses. The specific objectives of the paper are as follows:

To study the current status of water utilization of Nethravathy river, to assess the impact of water allocation policies for industrial growth to study the extent of economic losses to crop and fisheries sectors with diversification of water.

2. WATER UTILIZATION IN THE NETHRAVATHY BASIN

The Nethravathy Rriver length is only 120 km and 50% of it is the Ghat section. The estimated flow of the river is approximately 12,000 million cubic meters (MCM) at 50% dependability and 9400 MCM at 95% cent dependability. Further 78% of the flow is during monsoon and another 20% flows during immediate post-monsoon period. This leaves only 2% of the flow available in the 6 summer months. But, the drinking water supply and irrigation needs, which actually increase substantially during summer, are heavily dependent on lean season flows. Nethravathy River river is the main source of drinking water supply to Mangalore city, one of the fastest growing cities of South India. It lies on the confluence of two rivers namely, Nethravathy and Gurupur, and is spread over an area of 141.77 km^2. One of the important impacts of impoundment of water is that , the down stream flow will consequently be reduced, especially during Jan-May.

Table 1: River flow Pattern of Nethravathy (Million cubic meters)

Month	MCM
June	936
July	4104
August	3606
September	1719
October	940
November	505
December	117
January	66
February	40
March	26
April	15
May	66
Total	12080

The large petrochemical complex plans to utilize the Nethravathy river water to meet part of its water requirement. This is based on the premise that 98% of the river flow is still unutilized. However, due to topographical factors and seasonality of the river-flow, it is not possible and feasible to utilize the river water even to the extent of 2-3%. If we have to make use of this 240 MCM (2%) the entire water needs to be stored with the help of small reservoirs. Even if we construct check dams on Nethravathy River river at a distance of 10-12 km over a stretch of 50 km it is possible to store only 150 MCM of water. This is just enough to meet the requirements of cities, towns and rural areas of the catchment. Hence, there will be no surplus water in the storage that could be made to make available for the new industries.

The additional utilization of water from the river will be possible only through diversion systems. Part of the diversion to meet the concurrent water demands for industrial water use will occur during the lean season. This will reduce the lean season discharge of the river. Such reductions in river discharge will change the conditions of mixing and exchange process in the estuary. As the results of a research by George Abe et al (1997) show, the salinity intrusion magnitude and length will increase appreciably if the river discharge reduces to about $25m^3$.

The proposal to provide water supply, through four barrages, to meet a requirement of 15 MGD of water[1] for a petrochemical refinery in the newly established MSEZ Ltd (Mangalore Special Economic Zone Ltd.) would further reduce the lean season river discharge. This would significantly affect the estuarine and marine fisheries.

The reason is that lean season flows are required for the enhancement of dissolved oxygen and nutrient content such as nitrate, phosphate and silicate in coastal waters. For instance, Humborg et. al. (1997) reported that river discharge plays a major role in bringing large quantities of silicate into coastal waters. Kumar (2004) showed the effects of river discharge in reducing BOD, ammonia and concentrations of toxic trace metals in Nethravathy waters. A study on Nethravathy river by Kumar (2004) very clearly established the adverse effects of reduction in river discharge and increase in salinity and water temperature due to diversions on nutrients (NO_3 and SiO_3) and dissolved oxygen supply to coastal waters.

The time series data of lean season flows in Nethravathy River for 1989-2002 clearly shows an already declining trend in the river discharge to the estuary. With the existing anthropogenic activities, the water temperature, salinity, Ph, nitrate, phosphate, ammonia, TDS and TSS is significantly higher in Nethravathy River when compared to Sharavathy River. The studies have shown that with the proposed new impoundments and diversions, out of 80 days of lean period, the river will have no flows for 64 days (Krishna Kumar, 2004). This would affect the downstream fisheries and population of estuarine fishes and shrimps due to decline in primary productivity of the river.

3. IMPACT OF NEW INDUSTRIES ON RIVER POLLUTION

There is a proposal to establish PCPIR (Petroleum, Chemicals, and Petrochemical Investment Region) by notifying 300 km^2 in Dakshina Kannada district[2]. But, such decisions were not based on proper environmental impact assessments. The justification for the establishment of such a region is that there is large area of non-agricultural land available in the district. Contrary to this, the fact is that the agricultural land available around Mangalore and DK is known for the production of paddy, fruits and vegetables, horticultural crops such as cashew, areca-nut and floriculture. Recently, Dakshina Kannada was selected for the development of horticulture under the Horticulture Mission Project of the Government of India. Whereas, Jasmine, widely grown in the district, is known internationally, and many small, marginal and land-less families are able to earn a good

[1] This is out of the total requirement of 48 MGD of water.

[2] The project proposal was prepared by Karnataka Industrial Investment and Development Corporation (KSIIDC) for the approval of the Government of Karnataka which received the state government approval in August 2007 and sent for the approval of the Government of India. The setting up of strategic storages of crude oil in phases to construct 15 million ton of strategic storage of oil at an estimated cost of Rs.11267 crore over a 9-year period will take six years to build the storage and 3 years to actually fill the same. While all this is for securing just 15 days of reserves, presently the oil companies have product-holding capacity for 83 days

livelihood. Still, the cropland is getting converted because of forcible acquisition by the state for industrial development in the private sector.

KSIIDC had been asserting that PCPIR is environment-friendly. But, as per the recent research by Nayar (2003 and 2005), high concentrations of dissolved or dispersed petroleum hydrocarbon (DDPH) and absorbed or adsorbed petroleum hydrocarbon (AAPH) in the estuary may exert adverse effects on biotic components, particularly those sessile organisms that may not leave site in event of a severe oil spill. The final pre-feasibility report on Mangalore PCPIR does not mention about any survey to determine impact of petrochemical waste on the fisheries environment[3].

Many factors such as toxicants, salinity and eutraphication (excess nutrients) are likely to influence aquatic plants, mangroves, phytoplankton and fisheries. It is important to quantify the existing level of effluents released into the sea and the existing biological carrying capacity of the system here. The increase in effluents and nutrient releases into the river with the setting up of the proposed complex would adversely affect marine life and aquatic plants. This impact on marine life through algae-bloom has been substantially researched in similar ecosystems elsewhere (Nayar et al. 2004 & 2005). The direct impacts of hydrocarbons would be increase in toxicity causing mortality of aquatic plants and animals. The indirect impact would be through food webs of basic physiological aspects or due to environmental change. Most of these direct and indirect impacts could be chronic and acute. Any EIA would be incomplete without proper quantification of acute and chronic toxicity with direct and indirect impacts.

The total water demand of PCPIR (Petroleum, Chemicals, Petrochemicals Investment Region) covering an area of 70,000 acres of land in the coastal hilly region of the district was placed at 641 MLD (144 MGD) and it proposes to source water from Gurupur and Mulki rivers. The pre feasibility report also suggests that existing water impounding structure at Thumbe across Netravathy river can be upgraded. Experts in fisheries ecology say that this would lead to an increase in salinity of estuaries of Gurupur and Mulki rivers due to over usage of river water. The estimated water requirements for petrochemical industrial development in different phases are presented in Table 2. The water is to be sources from three rivers, viz., Nethravathy, Gurupur and Shambhavi. Nearly 76 MLD of effluent and 13 MLD of sewage would be generated in first phase of PCPIR.

Table 2: Estimated water requirement for petrochemical industrial development (PCPIR)

Sr. No	Phase	Total Water Requirement(MGD)
1.	Phase I	45
2.	Phase II	44
3.	Phase III	55
	Total	144

The total water demand of Mangalore city including the utilization by the existing industries such as Mangalore Chemicals and Fertilizers, Kudremukh Iron Ore Company Ltd and many other small scale industries alone is 18 MGD. The total water requirement of one single largest industrial unit will be 8 times higher than the present requirement of the city.

With many industries and municipalities releasing sewage without any tertiary treatment, additional sewage and effluents from PCPIR would cause eutraphication of marine water causing an increase in phytoplankton and reduction in dissolved oxygen levels in estuaries and sea. Experts warn that undesirable increase of phytoplankton would be toxic to fishes. Oxygen level in sea water had decreased due to many reasons and further decrease in dissolved oxygen levels may result in mass mortality of aquatic organisms including commercially important fishes.

[3] Report says that potential environmental impacts had been identified and measures required to mitigate impacts had been identified.

The water flow of Gurupur River is 4127 MLD per year which is one of the main sources of water for the proposed PCPIR (which has 3 times less flow compared to Nethravathy River) out of which 90% flow is during June-Sept (monsoon and post monsoon period). In order to create storage dam to meet the water demand of 46 cubic meters, we will have to construct a dam, which would be almost 10 times the existing dam at Thumbe, which has the capacity to store 4.8 cubic meters to supply drinking water to the city. Thus, water storage capacity has to be created for 8 times the existing dam with less than 3 times water flow. Meanwhile, Petroleum, Oil and Lubricant (POL) traffic had also increased considerably in Mangalore. POL traffic through NMPT was 6, 12,000 ton in 1991 and increased to 1, 63, 18,000 in 2005. This has already contributed to increased oil pollution in the project area.

Table 3: Sources of water supply for Phase I of the PCPIR (Million Gallons per Day)

Source	Water supply MGD	Storage requirements	Assumptions
Nethravathy	10	2 barrages	There will be no reduction in the flow of water to the Thumbe
Gurupur	5	2 barrages	
Treated Sewage	18	3 STPs through a SPV	STPs will supply 18 MGDs
MSEZ Reservoir	12	5 MCM	Reservoir will supply 12 MGD
Total	45		

4. GAPS IN WATER ALLOCATION ASSUMPTIONS

Sewage treatment plants (STPs) will be unable to supply 18 MGD until 2026. Reservoirs will be unable to supply 12 MGD due to seepages and evaporation. For drinking water supply, provision of 90 days of storage has been considered while a minimum need is that of 110 days storage. No reservoirs and STPs would be available. River water would be the only source of additional water. 4 barrages are expected to supply 15 MGD water for Phase I. By the same analogy, theoretically, for 99 MGD 27 barrages would be required. That adds up to 9 additional barrages across each of the three rivers. However, the water yield declines as we go up and getting enough supply is impossible. River flows to Thumbe dam, which is the main storage of drinking water to Mangalore City will be affected and hence Mangalore City Corporation will have to constantly haggle with district administration and PCPIR during summer months. Other smaller but growing towns along the Nethravathy will also face water scarcity. Farmers will have to sacrifice cropland (with large area being impounded) and pay higher price for access to water. It may be the beginning of the legal battle for water as a commodity, which was hitherto a free social good.

5. SOCIOECONOMIC IMPACT

The Dakshina Kannada is one of the most developed districts of Karnataka according Karnataka Human Development Index (Karnataka Development Report, 2006). The percapita income of the district is one of the highest in the country (Rs. 22,000/year) with least number of people below the poverty line (only 9%). In order to study the socioeconomic status of the farmers a socioeconomic survey was made in the region.

Table 4 presents a description of the sample villages, which are being acquired by the Karnataka Industrial Areas Development Board for the MSEZ ltd. Most part of the Tenka Yekkar and nearly 40% of the area in Permude villages are acquired for industries and hence the local households, institutions, culture and also local self governments are likely to be wiped out completely with the establishment of the industries.

Table 4: Description of the sampled villages

Particulars	Permude	Kuthetheoor	Yekkar (Tenka and Badaga)		Delantha Bettu	Total
Total number of families	652	650	660	549	295	2806
Total Population	3233	2675	3294	2419	1451	13072
Male	1554	1354	1600	1163	721	6393
Female	1679	1351	1694	1256	730	6711
Total area (acres)	1742	686	1582	2498	770	7278
Area acquired	874	344	447	-	440	2105
Sample size	38	—	92	—	17	147

Table 5: Housing Ownership and Pattern

Type of housing	Tenka Ekkar		Delantabettu		Permude		Total	
	no. of respondents	%	no. of respondents	%	no. of respondents	%	no. of respondents	%
Tiled housing	77.00	83.70	15.00	88.24	32.00	84.21	124.00	84.35
Cement sheets with RCC	6.00	6.52	0.00	0.00	1.00	2.63	7.00	4.76
Others	9.00	9.78	0.00	0.00	3.00	7.89	12.00	10.20
Total	92.00	100.00	17.00	100.00	38.00	100.00	147.00	100.00

Table 6: Education and Employment

Age	SSLC or Below		Degree/Diploma				Total	
	Female	Percentage	Male	Percentage	Percentage	Female	Male	Female
15 to 20	12.00	57.14	6.00	33.33	9.00	42.86	18.00	21.00
20 to 40	108.00	86.40	11.00	9.65	17.00	13.60	114.00	125.00
40 to 60	32.00	100.00	4.00	16.67	0.00	0.00	24.00	32.00
60 and above	18.00	100.00	0.00	0.00	0.00	0.00	8.00	18.00

The age and educational qualifications of the people likely to be displaced very clearly indicate that the proposed resettlement and rehabilitation package under which the company is promising one job for one family does not help majority of the project affected families. Table 6 shows that only 9.65% of the male and 17% of the female have education up to degree or diploma and hence only they could be employed in the company. All other families will have to be satisfied with very low unskilled jobs with low wages under contractual arrangements.

Table 7 presents the average income from different horticulture crops normally grown by most of the families in the area identified for industrial development. The table shows that the average percapita income in the region is 3-4 times higher than the income estimated by the company sponsored socioeconomic report (Lokesh et al.,). The Table 8 presents the economics of crop enterprises integrated with various horticulture crops (Nagaraj et al., 2005).

Table 7: Total revenue from plantation crops (average/family)

Items	Unit	Average Number of plants/family	Yield/tree	Price/unit	Total Revenue
Average family	number	5			
Coconut	number	15	150	6	13500
areca nut	kg	5	6	90	2705
Mango	number	3	150	4	1800
Jackfruit	number	4	20	10	800
cashew nut	kg	2	3	40	240
Teak	Cubic feet	1	1feet^3	1000	1000
Jasmine	-	2	2000	4000	8000
Banana	kg	15	10	22	2250
Pepper	kg	2	4	150	1200
Beatle nut	number	10	-	200/week	8000
Overall income/ family					39500
Per capita annual income					7900

Table 8: Economics of key horticultural crops and farming systems in Dakshina Kannada

Areca nut based horticulture farming system	Initial investment/ acre	Yield/acre	Gross income	Total cost	Net income	Ratio of net return to variable cost of cultivation
Arecanut pepper	20300	1200 kg+ 250 Kg	87000	27160	59840	2.20
Arecanut+ Pepper+ Banana	25300	1200 kg+ 250 Kg+5 tonnes	127000	37160	89840	2.41
Areca nut+ pepper + Cocoa	29050	1200 kg+ 250 Kg + 250 Kg	119500	32160	87340	2.71
Coconut	5000	3000 nuts	15000	6000	9000	1.5
Cashew	5500	210 Kg	6930	3700	3230	0.87
Mango	4347	1.5 tonnes	15000	11250	3750	0.33
Sapota	5000	1.8 tonnes	18000	12000	6000	0.5
Rambutan	3000	2000 kg	100000	12300	87700	7.13
Garcinia	3000	10 tonnes	50000	2500	47500	19.2
Jasmine (0.15 acre)	5500	2500 bundles	50000	29450	20550	0.69

Note: The economics of different crops are on per acre basis except jasmine

6. IMPACT ON LIVELIHOOD OF RIVER AND ESTUARINE FISHERS

Table 9 presents the cost and returns of multi-species harvests by the river fishers. The table shows that each fishing unit receives a gross income of Rs. 67096 per year out of which around 90% is shared by the crewmen since the capital investment is very less. The returns to labour are as high as 85% indicating the attraction of fishers in this sector.

Table 9: Cost, returns and profitability of river fishing

		Lady fish	Mullets	Mullets (Mugil sp)	Cat fish	Others	Total/unit
A1	Average harvest quantity/trip	4	9	3	5	3	24
2	Average no of fishing trips/year	70	200	200	200	270	200
3	Total Harvested Quantity (kg/year)	2449.55	4725.15	1919	1998.435	1562.2	12653
4	Price/kg	150	30	100	20	25	70
5	Total revenue (Average harvested quantity*fish price)	31687.42	12175	16464.26	3432	3338	67096
6	Net revenue(after 5% deduction of auction cost)	1584	609	823	172	167	3355
B1	Labour cost @90% of the harvested value	27093	10409	14076.94	2935	2854	57367
2	Boat rentals @10% of total revenue	3010	1157	1564	326	317	6374
3	Depreciation @10% of capital investment for crafts and gears	660	660	660	660	660	3300
	Returns to labour ((B1/Total revenue)*100)	85.50	85.50	85.50	85.52	85.50	85.50

The study by (Bhatta 2007) shows that the Nethravathy estuary alone generates a direct income of Rs. 7 crores/year for 350 fishers from fishing within a radius of 5-10 kms and a direct employment of 148200 days per year in the fishing activity it self. If we add the backward and forward linked processes in fishing and post-harvest the employment generation would be double. Further with the capital investment requirement of only Rs. 35000-40,000/unit the fisherfolk are harvesting 14000-15000 kgs of valuable estuarine fishes per year.

Table10 provides the gross income generated by the estuarine fishery and also labour employment generated per year. The study shows that the river fishing generates around 7 crores of income apart from generating a labour employment of 148200 days per year.

Any harm caused to the river discharge and water quality could lead to loss of livelihood and income to poor farmers, who do not have alternative income generating activities. The loss of fish catch over an 8 km stretch of the river with the establishment of river diversion dams could be enormous. Bhatta et. al. (2003) has clearly established the declining trend in marine fish production since 2000. It was estimated that the pelagic fish production would decline from 69412 tons in 2000 to 39937 tons in 2008 and demersal fish production could decline from 37120 tons in 2000 to 25780 tons in 2008. The overall marine fish production could decline from 140,000 tons in 2000 to 125,000 tons in 2008. It was observed that there is positive correlation between the increasing water pollution and fish productivity.

Table 10: Gross Income of the Estuarine Fishery

1	Average no of fishing trips/year	200
2	Number of crew/trip	2
3	Number of fishing boats	350
4	Average annual catch/year/unit(in kgs)	321
5	Number of labour days/year(No of boats*no of crewmen*no of fishing trips)	148200
6	Total income generated a. Rainy season (weighted average price*no of fishing days in rainy season*no of fishing boats)	2820000
	b. Summer season (weighted average price*no of fishing days in summer*no of fishing boats)	4000000
7	Total income (a+b)	6820000
8	Gross income from primary fishing activity (5+7)	6968200

7. EXPERIENCE FROM RELIANCE PETROCHEMICAL INDUSTRIES IN JAMNAGAR

Janpath, a state level network of voluntary organizations in Gujarat has conducted a tour along the coastline visiting 450 villages of 34 blocks of 13 districts of the state. The tour was organized under the banner of Dariya Kinara Samvad Yatra and was actively participated by large number voluntary organizations and community based groups. The experience of small-scale fisher-folk of the villages close to Reliance Refinery at Jamnagar in which the fishers experienced decline in fish catch was documented. The pipelines of the refinery is allowed to pass through the protected areas (marine national park) and because of this lot of marine life is being disturbed and destroyed. On the other hand, small fishermen are not allowed to fish in marine national park area. Four years back, one of the fishermen had accidentally reached into the areas near to the refinery and was fired by the by security.

It was promised by the company at the time of establishing the oil refinery that 33% of the total employees shall be from these villages, but not even 3% of their labour-force is from local area. The traditional fisher-folk of the villages near the refinery (sikka, sarmat, jodia), have experienced 50-60% reduction in fish catch during the past 10-12 years. They have observed oil spillage quite often in the inshore areas from where pipelines pass. Whenever there is oil spillage fish die in large numbers. Because of low fish catch, fishing community is forced to migrate towards Jakhau and Miyana. Farmers who had sold their land to Reliance Company have become daily wage earners. The monetary compensation they earned was spent within 5-10 years.

Past experience in places with high concentration of chemical industries in India is alarming. Vapi, which has a high concentration of similar chemical industries, was featured in the Blacksmith Institute's list of the ten most polluted environmental hotspots in the world. According to a report by the Indian Medical Association, pollution in Vapi has led to high incidence of respiratory diseases, chemical dermatitis, carcinoma and cancer of the skin, lung and throat. A high incidence of spontaneous abortion, bleeding during pregnancy, abnormal foetuses and infertility is reported among women. In children, there is a high incidence of respiratory and skin diseases and retarded growth. A 1999 study by Greenpeace in four industrial areas of Gujarat - Nandesari, Ankleshwar, Vapi and Sarigam - which use Common Effluent Treatment Plants (CETPs) to varying degrees showed that the CETPs fails to deal with all chemical pollutants. They found that not all heavy metals and persistent organic pollutants (POPs) were removed by the CETPs. At best, the effluent was converted into a highly concentrated sludge to be disposed of in a solid waste disposal facility. A Gujarat pollution control board

(GPCB) report in 1995 said that in Amlakhadi, a rivulet that flows through Vapi industrial area, the chemical oxygen demand (COD) was 11,007 mg/l against its own acceptable limit of 250 mg/l and the biological oxygen demand (BOD) was 442 mg/l against the GPCB acceptable limit of 30 mg/l. Mercury in groundwater near Vapi is 96 times the WHO limit according to the Blacksmiths Institute report. Even in developed countries, most solid waste disposal facilities are known to have polluted groundwater in the neighborhood.

The PCPIR will bring in a similar concentration of chemical industries resulting in similar consequences for the local environment. The proposed project poses very high risks to the surrounding population due to toxic emissions as well as due to the possibility of major accidents. The main anchor for the PCPIR, namely MRPL-ONGC, has a questionable environmental management record. Paddy fields and wells in the surrounding area were found to be contaminated with effluents and fishermen complain of a drop in fish catch since the commissioning of the refinery at MRPL. The MSEZ, which is the precursor for the PCPIR is located very close to Mangalore city. It will handle numerous hazardous chemicals. The Rapid risk analysis report for the expansion of MRPL, the first phase of the MSEZ, does not provide a worst case scenario analysis of the risks faced by the workers and general public. For example, it does not consider the possibility of catastrophic failure of an 8000 tonne storage tank for benzene which is a class A carcinogen. As Mangalore city has a high population density of 1500 persons per $km^{2,}$ there could be heavy loss of human life in the case of failure. Even during normal operation, leakage of small amounts of hazardous chemicals can lead to increased morbidity and mortality in the population. The site selection also violates the sitting guidelines of the KSPCB (Karnataka Pollution Control Board) itself in relation to proximity to major human settlements.

8. CONCLUSIONS

The state water policy accords top priority to drinking water followed by irrigation, power generation through hydroelectric projects, agro industries, industries and transport. Karnataka Agricultural Policy 2006 focuses on doubling the agricultural production during the next decade, achieving a rate of growth of 4.5% per annum for the agriculture sector and increasing the net income of the farmer. A comprehensive district agricultural plan in line with the state agricultural policy has been prepared and is awaiting approval. Improving soil health and conservation of natural resources are crucial to achieving the targeted growth rate. Large scale industrialisation will work against this. The National Horticulture Mission envisages a doubling of horticultural production by 2011-2012. DK has been identified as one of 17 districts in the state for providing thrust in this sector. Opening up of cultivable land to non-agricultural use and the environmental damage caused by polluting industries reduce the chances of achieving these targets. In fact, the PCPIR policy document from the Ministry of Chemicals and Fertilizers itself states that acquisition of agricultural land for setting up industries should be avoided. Where land acquisition is required, the natural choice should be wasteland and or abandoned land.

On the request of the Government of India, the Department of Forest Environment and Ecology, GOK commissioned a Danish Joint Venture consisting of COWI consult, RH&H Consult, Carl Bro International, Water Quality Institute and Management Services Group to carry out an Environmental Master Plan Study (EMPS) and Environmental Management Plan and Action Plans for DK district. The Plan (popularly known as the DANIDA Report), approved in 1995, spells out specific actions to be taken by local and state institutions through 21 interventions to ensure that district (undivided DK & Udupi) development proceeds in a sustainable manner. Consideration of a huge industrial complex with refinery, aromatics and olefins complex, together with general multi-purpose industries, power plant, etc needs to be preceded by the implementation of the recommendations from the EMPS.

According to climate change experts (The UN's Intergovernmental Panel on Climate Change, Fourth Assessment Report, "Climate Change 2007" (AR4)), wet tropics will receive higher rainfall and dry tropics even lower rainfall. This will adversely affect agricultural production in tropical countries such as India. Climate change is likely to undermine food production in the developing countries while industrial countries could gain in production potential according to Jacques Diouf, Director General of the UN Food and Agriculture Organization. It was stated that India could lose 125 million tons of rain-fed cereal production equivalent to 18% of its total product (Finance and Development, Sept 2007). In addition to such crop losses due to natural and human induced factors the state is pursuing a policy of converting the crop land for industrial purposes which will undermine the food security of the region and the country. In order to ensure long term food security, agricultural activity should be given priority in areas like DK district where land is productive and which receives good rainfall. Diversion of agricultural and horticultural land for industrial purposes in such areas is unwise.

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WATER POLICIES AND LEGAL FRAMEWORK IN INDIA

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Abstract

The paper tries to look at the legal frameworks in the water sector in India, from the first laws drafted during British India to the revisions and additions post independence. It talks about the provisions in the law as well as the flaws and omissions and suggests an examination of and strengthening of the existing water laws and policies to address the problems of environment, ecology, equity and development. There is a need to devise an alternative socio-legal discourse and practice where the concerned authorities use organic knowledge of water resource management as seriously as the scientific knowledge, and work a consideration of people's struggles for water resource management as pursuit of human rights.

1. INTRODUCTION

Natural resources (NR) are essential for the survival of all forms of life on planet earth. The unsustainable use of these resources in all forms (due to increase in human population and consequential increase in demand) has intensified the competition for multiple uses of NR leading to limitless depletion[2]. The ever expanding rift between availability and use has resulted in a wide spread threat to the ecosystem. Water policies in the past two decades have focused more on the expansion and physical availability of water without regard to sustainability. This approach has lead to poor management of institutional structures and water resources. Current practices in water management may not be enough to meet the water challenges of the next century. There is a need to reexamine these institutional structures.

Water rights in India are closely linked to property rights in land. At an aggregate level, the implication of this is ground water over exploitation. Agriculturally important states in India are witnessing phenomenal fall in water table.[3] Traditional water harvesting has taken a back seat. Rural drinking water is an issue. Panchayats have deprived local people of control of traditionally managed tanks and other common pool resources (CPR's).[4] The paper attempts to highlight the key features in the existing legal framework where gaps and weaknesses in the existing legal system have contributed to the present situations, which are inconsistent with sustainability.

2. WATER POLICIES IN INDIA

This section first focuses on the steps taken prior to 1987 until the first National Water Policy was introduced. Then it examines the existing policies that govern different types of water source in India.

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[2] Changes brought about by the technological advancement are adversely affecting Renewable and Non Renewable resources. Renewable- replenished periodically or to some degree by human action e.g. (water and forest) and Non Renewable-are stocks accumulated in geological time and get depleted with use e.g. (land in minerals);

[3] In Punjab, the level of exploitation is already at around 98%. Haryana follows with 80%. The situation is also precarious in states such as Rajasthan and Tamil Nadu where the level of exploitation is about 62% and 54% respectively. Several parts of these states have seen a rapid decline in water tables, often implying that water is being 'mined' or extracted at unsustainable rates; TERI Information Monitor on Environmental Science, Vol.2, no.1: relied on Ministry of Water Resources 1994, Govt. of India.

[4] Under the Panchayat Acts, financial gains from the village resources have not gone to the Gram Panchayat but to government departments up to the administrative hierarchy thus facilitating the control of external agencies over the village resources; India's water crises: Avenues for Policy and Institutional Reform, TERI Vol2.

2.1 Government Policies: A Historical Background

A historical background of the water laws, policies and decisions is provided below:

2.1.1 1866

The British government decided that future irrigation projects would be constructed by the states through their own agencies and financed through public loans. This decision was far ahead of times in the context of existing water crisis and the sates claiming their monopolies over it. It was established by the government that the sates would not be allowed to come in the way of implementing the best possible solutions[5]. The policies of the British era focused more on the commercial aspect rather than social. The British government classified agricultural works as commercial and non-commercial. The work was deemed commercial if the specified rate of return was available from that particular work by the tenth year of the completion of the project.

2.1.2 The Government of India Act 1935

The act transferred the subject of irrigation from the control of the center to the states. This had a major implication as the center intervened only in cases where there was a dispute between the neighboring provinces.

2.1.3 After 1947

Bengal famine had made food security a major concern. Water development was given priority in view of food security. The era of planned development marked the era of development in the irrigation facility. The need of the people were realized and necessary steps were taken. This contributed to the building of huge infrastructure projects for water storage and development[6].

In the span of 40 years after attaining independence, no serious attempt was made to formulate comprehensive policy guidelines. There was no well-documented water Policy until 1987. Only certain policy guidelines on flood control existed.

2.1.4 1980

In 1980s, the umbrella body for the management of water in the country was constituted. It was chaired by the prime minister of India and called the National Water Resource Council (NWRC). The council was supported by National Water Board. In 1987, the council finalized the National Water Policy. This document was a comprehensive statement of various policy issues considering the opinion of the states. As state governments also represented NWRC, it was agreed that the state would also support the national water policy. Accordingly, policy documents like the irrigation management policy, policies regarding asset management, policies on operational and procedural change etc were finalized through the NWRC.

A chronology of events in the evolution of the Government Water Policies in India is given below:

1866 The government is given the main role in the irrigation and development

1935 Central government transferred irrigation to the states governments.

1950 Beginning of the planned development

1972 Second irrigation commission report

1980 The Rashtriya Barh Ayog (National Commission on Floods) submitted its report.

1986 Formulation of NWRC

1987 National Water Policy (1987) finalized in the first meeting of NWRC

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[5] Mohile Anil.D. Government Policies and Programs. Oxford Handbook of Water Resources in India.2007

[6] At present a considerable storage development with a live storage of about 200 billion cubic meters, a gross irrigation of about 90 million hectares, and an installed hydropower capacity of about 30,000 megawatts has been created through water development.

1994 Modified draft of National Water Policy Allocation among states, circulated to the states.
1998 Water sector review by the GOI and World Bank
1999 Second meeting of NWRC considered water allocation and river basin authorizes
1999 Report of the National Commission on integrated water development
2000 Water vision by India Water Partnership
2002 National water Policy (2002)
2004 CPSP India studies by ICID-IAH

2.2 The National Water Policy 2002: Salient Features

National Water Policy 2002 has graduated from the National Policy on Water 1987 (See Table 2: The Matrix depicting the structural changes that have been made in NWP 2002). The main change was the incorporation of the integrated water resource management (IWRM). River basin management was emphasized. The Policy has been reviewed and updated in response to the number of new issues that have emerged over a period of time since its formulation in 1987. NPW 2002 envisages that water is the part of larger ecosystem, realizing the importance and the scarcity attached to fresh water it has to be treated as an essential component for the sustenance of life. The policy recognizes that water is a scarce and precious natural resource and needs to be planned. Thus, it emphasizes developing management strategies for the conservation of water keeping in view the socio-economic aspects and the needs of the states. Ecology is given a rather low priority (4th) but has been indirectly given recognition for its importance for the management of fresh water. The policy states that the management of the quality of the environment and management of the ecological balance should be the primary consideration[7].The policy envisages the integrated and multi disciplinary approach to planning, formulation, clearance and implementation of projects including the rehabilitation of people and the and command area development. The policy says that the detrimental environmental impacts of the access use of ground water extraction must be taken care of by the centre and the state government [8]. The policy talks about the coordination process for the implementation of the national water policy. Considering the large scale use of water in agriculture and the fact that water rights in India are loosely linked with land rights, policy also talks abut the integration of the water use and land use policies.[9] The central and the state governments are equally responsible for preventing the detrimental overexploitation of water. The Policy takes into account the industries discharging the waste in to the water streams, rivers and other water bodies and says that effluents should be treated to acceptable levels of pollutants before discharging in to the main streams and that the minimum flow should be ensured to maintain the ecology keeping in view the social considerations[10]. The policy envisages that all the possible efforts should be made for developing projects to ensure water availability for tribal people and socially disadvantaged sections of the society. The policy is also vocal on the issue of seeking scientific and technical assistance for the water sector development and planning through public private partnership on need basis. However, some of the salient features of the NWP 2002 needs close analysis.

The important provisions of the National Water Policy 2002 are produced below.

2.2.1 The preamble

The preamble to the policy gives the understanding of the important principles on which the policy is based. The principles identified in the Preamble to the Policy are-

- (i) Commitment for an Integrated Water Resource Management and Development.
- (ii) Importance of environment related concerns
- (iii) The importance of innovative techniques and better strategies resting on a strong science and technology base

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[7] National waterPolicy2002,para 6.5
[8] National Water Policy 2002 ,Para 7.3
[9] National Water Policy 2002 ,Para 9.2
[10] National Water Policy 2002 ,Para 14

Section 2

The section lays importance on the need of a well – developed information system. The section is silent about the need for an open access to the information.

Section 3

The section explains the principle that the available water resources should be converted into utilizable resources. Resting its foundation on the notion that the unused water resource represents the waste of resources managing to address ecology based concerns. The section negates the need to maintain the balancing use of water to maintain environmental balance of the reverine, estuarine, and the coastal ecosystems.

Section 4

The section deals with the institutional mechanism for the Act. Concepts like operation and management (O&M) of better institutional mechanism has been brought into focus. The need for appropriate river basin organization for the planned development and management of rivers has been mentioned.

Section 6

This section is on project planning. It says that the planning of individual water projects would continue to be conducted by the government. The much talked about public private partnership concept for future development projects has been ignored here as the section does not mention anything about the role of private sector in planning and implanting such projects.

Section 11

This is an important provision as it deals with the financial sustainability. It says that the use for water should also take care for the O &M charges and recover the capital costs.

Section 13

It is here that lately the policy deals with private sector participation. It acknowledges that private sector participation may help in introducing innovative ideas, generating financial resources, and introducing corporate management along with accountability to users.

Table 1: Comparison of Water Policies—1987 vs. 2002 (with Reference to the 1989 Review)

The 1987 policy and its limitations as brought out in World Bank (1999) review		Current position
Provision	Main Limitations	
General remarks	Does not reflect new economic policies Pre-determined Priorities inconsistent with social and economic values	The position continues. Private sector participation mentioned briefly. The position continues. This study mentions the need to properly define priorities for domestic water.
Legislative and regulatory framework	Jurisdictional problems about river basins	The position continues. For international basins, India prefers bilateral action rather than basin-wise planning. For interstate river basins, the need for RBOs is mentioned without bringing out the need for providing legislative support and executive responsibilities to RBOs. This study recommends legislative changes. Similarly, it recommends the finalization of a policy for allocation of waters of an interstate river to the states, and the possibility of constraining the allocations by uses. It also recommends a legislative back-up for these policies.

The 1987 policy and its limitations as brought out in World Bank (1999) review		Current position
Provision	Main Limitations	
	Absence of the creation of water rights and uncertainties regarding water rights	The position continues in the 2002 policies. A clear statement in this regard needs to be included in the policy. The author of this paper recommends the recognition of water as a 'negative community' in which only usufruct rights can exist. The 'negative community' status of water indicates that it is a 'common good', which is not owned by any one including the community. Thus, there would be no absolute property rights concerning water. Any potential user, including the state, cannot use the water by causing harm to others or without an agreement or award conferring the rights to use the water. Further, the right can be exercised on the waters, which are in the rightful possession of the user. It also recommends that the 'state' grants water rights to the users by creating water right regime. These water rights of users need to be subject to reviews.
Institutional mechanism concerning the Union institutions of the central government, civil societies, NGOs, communities, and industries	Incomplete monitoring and enforcement of legal provision of water pollution control; inadequate application of water qualities, classifications, regulations; limited effectiveness of River Board Act; lengthy procedures of conflict	The position continues except for the formulation of the central groundwater authorities, and the larger intervention of judiciary in regard to water quality regulations. RBOs with large stakeholder participation are recommended for better regulations. The 2002 policy (paragraph 4.1) mentioned the need for reorienting/reorganizing or creating institutions for multi-sectoral, multidisciplinary; and participatory work based on hydrologic units. However, there are no reforms
	resolutions through tribunals; non-involvement of all disciplines in the decision making of tribunals; fragmentation of water-related responsibilities and inadequate co-ordination has also been mentioned Limited sharing of information; neglecting their potential in water management consultancy and training; policies, regulations, etc., creating barriers in their functioning	Programmes are underway; the present report recommends large institutional reforms for the Ministry of Water Resources (MOWR)/Central Water Commission (CWC) somewhat on the lines of the recommendations of the National Commission. Reforms for giving a legal back-up to the NWRC and for larger autonomy to the national committees have also been recommended in the present report. This position continues. The 2002 policy does not deal with information sharing though information systems. Privatization is mentioned without emphasis. The participatory approach is discussed and is being promoted through programmes.

The 1987 policy and its limitations as brought out in World Bank (1999) review		Current position
Provision	Main Limitations	
Inter-Sectoral allocations and pricing	Water rates are too low and inadequate; charges are area based and not volumetric; no charges for use of groundwater; no disincentive for wasteful groundwater use; overwhelming tendency to subsidize rural water supply. Infrequent rate adjustment in urban water supply; lack of volumetric metering of domestic supplies; inadequate penalties for water pollution	The 2002 policy mentions (section 11) that water charges should cover O&M cost and a part of capital cost and that they should be linked to quality of service. Subsidies need to be targeted and transparent. However, no programs to facilitate or force the states to take actions on these recommendations exist. If the water charges are linked to the quality of service, the user can challenge the recovery of the charge on the basis of deficient service. Since the line departments do not find this convenient, the states, in law, prefer to consider the water charge as a tax. The use of market mechanism, at least in guiding administrative decision about water pricing, is also not being implemented. The author of the present study recommends that water charge needs to be linked to the quality of service, and need to cover at least the full O&M costs, cross-subsidies need to be targeted and be made transparent, and market mechanism needs to guide the administered decisions on water prices.
Intra-sectoral allocations	Allocation decided administratively, on ad-hoc basis, and based largely on historical context and policy priorities; allocations as per relative value of water use are not made; no compensation to users in case of re-allocations	This position continues. The Dublin principles of allocating water to the most productive use have not been accepted. The author of the present study agrees with the non-acceptance, and recommends the establishment of a regime of water rights, which could be subject to review, and re-allocations on the basis of improper use and changing ground situations.
Intra-sectoral allocations	Existing water markets are localized and fragmentedTrading in water rights, either amongst states or by individual users not provided for	The 2002 policy does not change the situation. Although the water markets have authority in deciding the value of water, they continue to be unauthorized.The 2002 policy does not change the situation. No recommendations are made in the present study since, as per the author, water is a negative community, and the usufruct in water can therefore not be traded.

2.3 Conclusion to the policy

The policy concludes on the remark that the depending on the specific situation, private participation in building, owning and operating, leasing and transforming water facilities may be considered.

2.4 National Water Policy 2002 & Issues in drinking water

"India has over the last 50 years spent $50 billion on developing water resources and another $7.5 billion on drinking water" [L.C. Jain, a former member of India's Planning Commission]

The 73rd and the 74th Amendments to the Constitution of India were brought keeping in view the empowerment of the village population by the system of Panchayats. It was also aimed that all the problems of the rural population would be addressed through the Local Bodies constituted by them. However, experience has shown contrary results. It has also been realized that the real issue is not so much about decentralization, but of its optimal level that ensures both accountability and performance at the local level. The data brought out by the Rajiv Gandhi National Drinking Water Mission in 1991 suggested [11]that 27% of the country's rural population that constitutes roughly about 176 million has no access to drinking water. It is claimed that Rs 150 000 million have already been spent in the drinking water services through various government schemes and plans since the inception of NDWM. Although government statistics claim that very high proportion of the villages have been provided with safe drinking water, they merely imply that hand pumps and stand posts have been installed in most of the places.

A study commissioned by UNICEF(United Nations International Children's Emergency Fund) on the type of water source used in India revealed some important facts. It said that the traditional open dug well continue to be the primary source of drinking water in most areas for all purposes. The study said that the hand pump installed by the Government of India were either non-functional or were located too far away for their convenience[12]. The study further highlighted that one out of the three people who did not use hand pumps felt that the hand pump water tastes salty, looks rusty or smells medicinal[13]. Findings of this committee goes on to suggest that merely introducing hand pumps in villages would not be sufficient to overcome the drinking water facility challenges in the rural sector of Indian population. In towns and cities, the scarcity of safe drinking water has its own implications. The unavailability of safe drinking water causes problems at many levels and has many serious implications. A study has shown that the time spent in collecting potable water on an average constitutes 4 to 5 hours a day or seven hrs a week at places like Baroda region of Gujarat[14]. The time and effort involved in collecting water, if calculated in terms of the work hours and lost wages, would suggest that it has serious implications on economy of the country as a whole. Another study suggested that unavailability of drinking water impedes the growth and development of school children as they are forced to carry water from long distances that induces suffering and causes health problems on the other end. It is surprising that the concern for the dinking water has become a priority issue only after the inception of the National Water Policy 1987.

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[11] The Accelerated Rural Water Supply Program (ARWSP 1972-73) by the GOI was also called The National Drinking Water Mission (NDWM, 1980). The NDWM was renamed Rajiv Gandhi National Drinking Water Mission (RGNDWM) in the year 1991.

[12] This is a glaring example of the failure to implement what has been provided in the Policy. The National Water Policy, 1987, recognizes that the existing set up has failed to meet the demands of the growing population. Having realized the need as early as in 1987, efforts in the supply of drinking water in rural areas have been made primarily through the National Drinking Water Mission(NDWM) which was set in 1986. The mission had the objective of providing potable water sources to every village with in a radius of 1.6 km.

[13] (Venkateshwaran, 1995)

[14] (Dasgupta *et al.*, 1993)

2.5 State Water Policies

Many states in India have their own water Policies. These policies are a replica of the National Water Policy, in many cases converting National Water Policy into a strategy relevant to the state. States like Tamil Nadu and Himachal Pradesh have Water Policies that are more inclined towards principle of equity and do take into account the participatory role of the peoples organizations or community based control over water resources.

3. CUSTOMARY RIGHTS OVER WATER RESOURCES

Water is an ancient resource not in terms of chronology but its use and related customary rights. Customary Rights over water were enjoyed by user communities for centuries and have evolved over a long period of time[15]. These informal rules and regulations, which evolved over a long period of time, reflected the socio-economic and political structure of society at any given point of time. They were also influenced by factors such as geo-physical and climatic conditions, socio-economic and political conditions and level of technological development at a given time. In India the emergence of colonialism and formation of welfare state have altered the power relations and have contributed to disintegration of these rights over natural resources, in particular water. Urbanization triggered by post independence industrialization, gave the state rights to extend cities and towns, and extend irrigation systems to bring more area under their command. The state has virtually taken away the existing rights of the people. Water law in India has been closely associated with land. The policies of the colonial period speak volumes about such nexus. Since 80% of the farmers do not own land, the same percentage is denied right to water. Further, more development projects such as dam construction and rehabilitation and resettlement plans of the governments from time to time have taken away the customary/user rights to water, which the inhabitants of the particular area were enjoying since ages. Consequently, marginalized people, whose rights have been appropriated, are defenseless and cannot seek justice in a court of law as there is no legal framework which talks about customary rights of water and community control of water resources in India. The issue of development and the duty of the state to distribute equitable water control over resources speak of how the customary rights were pushed away by state institutions. These developments can be studied in response to the following queries:

A. What were the customary rights that user communities enjoyed since ages?
B. How these rights have been appropriated by the state?
C. While having control over water resources, did state achieve equitable distribution of rights?

3.1 Customary Rights of the User Communities

Human settlements at the dawn of the civilization were close to the river because irrigation technology was not developed in those times. However, water use for agriculture has run parallel with the formation of village societies[16]. These rights, which were not given to its users but acquired over a long period of use[17]. Customary

[15] This is not to glorify the irrigation institutions that existed in the past. Indeed, the kind of irrigation institutions that were controlled by kings or local chieftains was nothing but hydraulic despotism and reflected very much the local power structure and production relations at any given point of time. Nevertheless, there existed some organized and codified rules and regulations, customs, roles and mores, legislations, notifications etc., which not only defined access over water for a community, but also subsumed all critical functions of water management. And, given the local power structure unequal access to means of production, these institutions performed well in protecting the water rights of 'user communities: *Water rights and participatory irrigation management in India*: the case of surface water sector in Tamilnadu state. A.Rajagopal, S.Janakarajan, Madras Institute of Development Studies

[16] Steward, J.H. 1955

[17] Water rights can be understood in the context of riparian rights i.e. rights gained or acquired/gathered over time and rights gained due to access to resources. "Urban industrialists controlling water resources in the rural areas by sinking deep tube wells (much deeper than the existing ones in a village) is a classic case in support of rights gained due to control over resources. (Water rights and participatory irrigation management in India: the case of surface water sector in Tamilnadu state. A.Rajagopal ,S.Janakarajan, Madras Institute of Development Studies)

rights are well recognized in the International law, Hindu law, and later by the English laws in India. As stated, due to geo- climatic diversity, customary laws varied from state to state. These laws had common element of community recognition of rights and informal arrangement for the settlement of disputes relating to rights. The prevalent practice of informal dispute settlement at the local level in some of the rural areas of the north eastern states is the result of the customary practices. These customary laws also had other advantages. They were compatible with the needs of the people. The rule of sovereignty over the water resources was not so rigid as far as its utility to the user community was concerned. If compared with the statutory rights conferred by the various state governments in respect to water allocation and distribution, customary laws were dynamic and broader in approach than the statutory rights[18].

Customary, traditional, and indigenous rights over water in India provided for groundwater management and water harvesting systems. The customary rights also defined self created institutions and rules which helped the traditional system of groundwater harvesting and management work successfully over centuries. The evolved customary set up also provided a mechanism for conflict resolution for groundwater disputes at the local level.

Since the country is rich in natural diversity (and cultural as well), the customary rights were geographical zone specific, and depended on the traditional inhabitants of the area[19]. The important areas where customary water rights were set up, had been adversely affected due to government control over water resources including hilly areas, gangetic plains and other river basin, semi arid zone of the Deccan plateau, coastal areas, arid areas like Rajasthan and Gujarat, wetlands, flood prone areas. It is interesting to learn that the British government made efforts to codify customary laws relating to water. The Easement Act 1832 is a classic example of recognition of customary rights of people in the statutory form. The other state specific example is that of a Tamil Nadu where customary rights were codified and printed as early as in 1813. These were known as mamulnamas.

3.2 How were customary rights acquired?

Broadly speaking water related customary rights were acquired by the community on the basis their role in the construction and management of water resources at the community level. The organizational structure for carrying out the responsibilities of traditional water institutions operated at two levels: The first was that of a supervisory nature which enforced rules and regulations concerning water management. The second one was more of a menial nature, which involved hard labor. In many parts of the country, these positions were held on a hereditary basis[20].

Caste was the core factor in determining the responsibilities of maintenance and construction. In accordance with the caste hierarchy, there existed a hierarchy of functionaries to undertake all these activities. In this system farmer performed the duties of canal manager, and scheduled caste people looked after the general maintenance of the canal (labor). If looked from the socio-liberal view that this set up undoubtedly contained its own weaknesses based on caste system that jeopardized the distribution of work but the village societies enjoyed complete control and access over water resources with in their jurisdiction. The unique feature of this system was that there were un codified but well laid down rules and regulations to manage all critical functions such as dispute resolution, penalty for non participation in management of water resources, water sharing in times of scarcity and so on.

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[18] "*Customary law has been dynamic more in tune with the needs of the people than dogmatic about certain fixed notions of territorially or ownership right.... Limitless to space and quality, they are broader in approach than the legal systems*"; Singh 1991: pp.67

[19] These rights were common in most states in terms of the sanction that they provided to the local inhabitants of the area to access, control and manage community resources.

[20] A.Rajagopal,Madras Institute of Development studies,p.3

3.3 State Control over Water Rights

Pre independence methods to gain state control over water resources could not materialize due the absence of uniform law in this regard. The existence of various state specific regulations, Policies and Government Orders passed by the British Government further complicated the situation. Post independence efforts to gain state control over water include Irrigation Bill 1953 prepared on the pattern of 1924 irrigation Bill. The Bill sought to declare that water is the property of the State, and that the State has the right to control irrigation works under both Zamindari and Ryotwari systems. It also declared that no civil court has power to hold back the government from undertaking any irrigation work. The Bill was not passed for several reasons.

3.4 Comprehensive irrigation Law in India:

Irrigation law in India has much to do with the water rights related to the land. Different Acts focus on different aspects of irrigation. The Irrigation Commission in the year1972 made an attempt to consolidate and simplify the Irrigation Laws in India in order to bring them together and consolidate for the purpose of bringing uniformity. The purpose was also to control exercise over the water resources. On the recommendations of the Commission a Model Irrigation Bill was prepared in the year 1977. The effort was wasted as the Model Bill did not receive attention from the state governments.

3.5 Submissions

The fact that the state had taken number of initiatives to develop irrigation in the rural areas. (a long list of government policies refer to this aspect), one cannot ignore the groundwater irrigation policies funded by the World Bank. The land transfer from the feudal class to the cultivating class has also taken place; the use of technology has further changed the permutations for the management of water resources. The caste system being out of place according to the provisions of law[21]does not allow the maintenance of water resources and allocation of tasks on the age-old caste system. The state has absolute and sovereign power to control and manage the country's resources. A fine equilibrium has to be created before sowing any policy measure for the participatory management of water resources in the country[22]. Communities shall be allowed to maintain traditional water resources with an external support and monitoring from the State. Tamil Nadu Farmers' Management of Irrigation Systems Act, 2000 is the ideal example to follow the equity principle. The Act provides the ideal mechanism in order to strike the fine balance between the community control of water resources and the state control over the water resources of the country.

4. LEGAL FRAMEWORK FOR WATER IN INDIA

4.1 Historical background:

Statutory water law in India includes a number of pre and post colonial enactments in various areas, irrigation being the prominent one. Water law in India has had a long journey from the legislations of the colonial period to the recent regulation of water quality to the judicial recognition of human rights to water. In India water law is closely linked with the irrigation laws and the right to water in the property laws. Historically, irrigation laws constitute the most developed part of the water law because the British saw irrigation as the most important economic activity and made the classification of water accordingly[23].

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[21] The Untouchability Act is a central legislation for the time being in force that discourages caste based institutions and allocation of work.

[22] National water policy 2002 : Clause 12 talks about the participatory approach to water resource management" where it has been laid down that Municipalities and Gram Panchayats should be involved in the operation, maintenance and management of infrastructure /facilities at appropriate level with a view to eventually transfer the management of such facilities to the user groups or local bodies. This is a participatory approach based on equity principle in the sense that it has not clearly said about the customary rights but the approach is somewhere close to it.

[23] Supra note 5

4.2 The Existing Legal Framework:

The existing legal, institutional and decision making frame work for water law in India, both at the National and state level is embodied in the nine major Acts at the National and state level. The National Legislations as applicable to water are:

Water prevention and Control of Pollution Act 1974;
Air prevention and Control of Pollution Act 1977;
Environment Protection Act 1986;
Forest Conservation Act 1980 and amended in 1988;
Public Liability Insurance Act 1991;
Environment Assessment Development of Projects, 1994;

The Ministry of Environment and Forest is the nodal agency in the administrative structure of the central government for planning promotion and coordination and overseeing the implementation of environment legislation and programs and regulatory functions like environment clearance.

4.3 Constitutional Provisions

The constitution defines the allocation of functions relating to water resource development between the centre and state governments. Water is designated as a state subject to the central intervention to regulate the development of interstate rivers and for settlement of interstate disputes on water. The River Boards Act and the Interstate Water Disputes Act are made under these provisions. The central government can also intervene in the interest of protecting environment and forest , and under provisions regarding national planning for development.

Under the Constitution of India which came into force in 1950 water is primarily a state subject. Entry 17 List II i.e. State List 7th Schedule of the Constitution States "water that is to say water supplies, irrigation and canal, drainage and embankments, water storage and water power subject to the provisions of entry 56 to the List I". States are thus free to enact the water law and frame policies in accordance with this provision. Entry 56 of List I (Union List) refers to above states "regulation and development of interstate rivers and river valleys to the extent to which such regulation and development under the control of the union, is declared by parliament by law to be expedient in the public interest."

4.3.1 Under Article 262[24] of the Constitution, Parliament may by law

(1) Provide for the adjudication on any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any interstate river or river valley." and

(2) Neither the Supreme Court or any other Court shall exercise jurisdiction in respect of any dispute or complaint referred to in (1)

5. ACCOUNTABLE INSTITUTIONS

At present, the roles of various institutions in the matter of the evolution of water policies by the Union government are as follows:

The National Water Resources Council

The council performs the function of approving water-related policies through the evolution of a consensus.

The National Water Board

The Board assists the National Water Resources Council.

[24] Article 262,Constitution of India 1950

The Ministry of Water Resources

It has the crucial role of drafting the agenda of the National Water Resources Council. The other important function is of giving effect to the decisions.

The Central Water Commission

The Commission acts as the secretariat to the National Water Board. Prepares the basic documents and drafts about water policies. Advising and assisting the ministry.

The Central Ground Water Board

Its main function is to assess groundwater through geo-hydrological surveys and studies, and through the drilling of exploratory tube wells to facilitate such studies. Banks variously use the groundwater assessment information created by the Central Ground Water Board in deciding the credibility of proposals for obtaining loans in regard to the construction of wells and tube wells.

The Central Ground Water Authority

It has legal powers to regulate the exploitation of groundwater in order to ensure that environmental damage due to overexploitation of groundwater is avoided. As stated already, the Union uses its residual powers in regard to the environment. The central groundwater agency thus has no general powers of regulating groundwater use.

The National Committees

These Committees participated in the deliberations on various specialized subjects such as hydrol-ogy, irrigation and drainage, hydraulic research, etc. for deciding research areas as also in evolving a consensus at the professional level, about the problems and possible solutions.

The Specialized National Institutes

Within the ministry of water resources these institutes carry out research on problem areas including issues like the role of forests in hydrology, the quantum of return flows from irrigation, etc. which have a bearing on policies.

Various River Basin Institutes

The Ministry such as the Brahmaputra Board, the Betwa Board, the Upper Yamuna River Board, the Narmada Control Authority, etc. over sees the implementation of the various agreements, tribunal awards, etc.

Various Water Dispute Tribunals

To adjudicate on the water disputes in accordance with the terms of reference fixed by the government to formulate the awards. The case law so evolved, and the spirit of the award itself, has important implications on future evolution of water policies.

Non -Governmental Organizations

The NGOs act as watchdogs to pressurize the state governments and the central government in regard to various executive decisions and policy evolution. Although, at times, the involvement of the NGOs seems to delay or negate the process of water development, their involvement sometimes leads to better actions. Better policies in regard to rehabilitation and resettlement of reservoir affected persons; better standards for drinking water quality, improved decisions about design of structures (for example, the Ottu weir on the Ghaggar River), etc. are some achievements of actions by the NGOs.

The Judiciary

The decisions of the water dispute tribunal cannot be revised through appeals to the courts. However, before a tribunal is set up, the aggrieved states can and do approach the judiciary for a remedy. For example, the states of Andhra Pradesh and Maharashtra approached the Supreme Court for restraining the state of Karnataka in regard to the construction of the Alamatti reservoir. NGOs or individuals can also approach the courts for giving suitable directions to the government. For example, individuals approached the Supreme Court for intervention regarding water quantity and water quality problems of the Yamuna river in Delhi. Similarly, NGOs approached the Supreme Court for directions to discontinue the raising of the Narmada dam. The case law evolved through the process affects water policies. Interventions as highlighted by the studies were documented.

6. DEFICIENCIES IN THE EXISTING LEGAL FRAMEWORK

6.1 Absence of the Uniform Water Law

Constitutionally water is a state subject[25]. In the absence of uniform law and policy, water management in India remains by and large uncoordinated. Various states have varied legal positions on water ownership. It is felt that water being a common natural heritage has to be governed by different set of laws which are essentially not jus civile[26]. Water is a natural heritage to be protected and not a commercial property for absolute private use and exploitation it has to be governed by different set of laws which meet the requirement of the contemporary society. The Supreme Court of India in various judgments on water related issues has laid emphasis on the principle of jus gentium[27] or doctrine of public trust inherent in the Article 21 of the Constitution of India[28]. This important doctrine of Public Trust can be appropriately utilized for attaining good ecological status for water resources. India is a federation of states, therefore to lay down uniform law and policy it is essential to identify and incorporate those tenets, which are common and applicable to all the states. If analyzed, surface water, soil water and underground water are manifestations of a single resource that can be managed. If there is a deliberated policy based on scientific study of these resources, the water law in India can be given a coordinated shape.

6.2 Other deficiencies

Laws concerning water have grown in a piecemeal and ad hoc manner without a clearly articulated conceptual basis in respect to fundamental, as the nature and content of water.

There are serious questions in relation to the state's authority in regulating the use of water and the manner in which this authority is to be exercised. Governments, both central and state, claim the right of eminent domain over water and absolute right. Where and how it is to be developed and how it is to be managed and to make and change entitlements and allocation is at their discretion.

Vesting eminent domain in the sate without setting any limits to the exercise of its discretionary power leaves too much room for arbitrariness. The danger is increased many fold where all the relevant functions- development and management, implementing regulatory functions, redressal of grievances and conflict resolution are taken by the executive arm of the government. Since the state is supposed to serve the interest of its citizenry, one would think that the regulatory functions regarding development and management of the resource should be vested with the bodies independent of the executive agencies. Making and changing rules of allocation and entitlement should be decided through a transparent process.

Another lacuna is the lack of clearly defined criteria for determining the entitlements of different claimants to the common pool resources in a river basin. Thus, central legislation does not specify the basis for deciding the entitlement of riparian states. In the international context, two different criteria have been advocated as the basis for sharing water in a basin flowing through different states: the Harmon Principle and the Helinsky/ Dublin Rules. The former recognizes the right of a region to use the water, which flows through it while the latter is based on the optimum utilization of the basin's resources for the common benefit of all its inhabitants. In India there is no formal recognition of either principle even in respect of interstate rivers. Tribunals have tended to use a combination of these two principles.

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[25] Entry 17 List II i.e. State List 7th Schedule of the Constitution of India 1950

[26] Laws that are governed by private property

[27] *Jus gentium*, variously translated as law of all peoples or law of all nations. Application of *jus gentium* gave birth to the doctrine of public trust. During the 13th century, public trust entered English common law through the Magna Carta

[28] The Supreme Court has been influenced and rightly so by the exercise of the EU. in the Water Framework Directive of the European Union issued in 2000, the 27 member-nations, with diverse traditions and culture, are working towards changing their water laws to achieve a common vision based on a uniform set of principles inherent in *jus gentium*

None of the state governments have laws or executive notifications specifying the basis for water allocation between different segments of basins falling with in their territories. States are largely free to change the allocation of water between and within a particular system and between uses (for example between irrigation and water supply) at their discretion without observing any consistent application of clearly defined principles and procedures laid down by law.

7. THE REFORMS AND PROGRAM INITIATIVES UNDERTAKEN IN INDIA

7.1 Innovative Policy and Program Initiatives

In the last few years there have been many innovative policy interventions and programs in the water sector. Some of the important ones are mentioned as follows:

7.1.1 In the Irrigation Sector

The accelerated irrigation benefit programme (AIBP) was taken up for early completion of ongoing projects, which were in an advanced stage of completion, by pumping in additional funds. Over the years, this programme has been modified and in the process, the main objectives have become diluted. Delays have also been ex-perienced in the process of transferring the funds from the finance department of the state to the project, depending on the 'ways and means' position of the state. This innovative programme has therefore been only a partial success. The programme perhaps needs to be revamped by specifying stricter criteria for the selection of the projects and by making it easier to operate in regard to direct availability of the funds to the project. There is enough scope for using banking institutions for regulating the flow of funds.

7.1.2 In the Hydropower Sector

The new policy for hydropower has been an important policy intervention. Again, this has been partial success, and only a couple of hydropower projects in the private sector have materialized as a result of the policy. Most hydropower devel-opments continue to be in the public sector, and the public sector corporations are implementing such projects on the basis of loans from Indian or international financing institutions. At present, most hydropower projects under implementation are of the 'run-of-the-river' type. For effectively meeting the peak demands, in the largely thermal-based grid, storage projects are essential. It appears that at present the policy does not adequately address the problems of political risks, delays in land acquisition and in the resettlement of people, and delays caused by consequent litigations in an adequate way. A further revision of the hydropower policy appears necessary.

7.1.3 In Regard to Domestic Water Supply

An important policy intervention consisted specifying that in each irrigation project, a provision for water supply to the adjoining areas, to utilize about 10% of the additional supplies, be made. This seems to have worked well and this provision is being generally adhered to. A post-evaluation, however, may be useful.

7.1.4 In Regard to Conjunctive Use of Surface and Groundwater

The policy intervention requires that all irrigation projects provide for such a use. For facilitating this process, detailed guidelines on conjunctive use have been finalized (INCID and CWC) (INCID: 1994). The feasibility reports of all major and medium projects are supposed to provide for detailed conjunctive use plans. In the experience of the author, these plans are never adequately detailed, and often the costs and benefits of the conjunctive use are not included in the project. The institutional modalities for implementing the plan and the necessary changes in the state policies also are left uncertain. This intervention can therefore be considered only a partial success.

7.1. 5 In regard to Urban Water Supply and Sanitation

Reforms have been undertaken for encouraging decentralization by shifting responsibilities to the municipal governments, changing the role of the government from service providers to regulator, commercialization of existing units, financial reforms for providing market access to service providers etc. The beginning has already been made in respect of private sector participation in urban water supply utilities, for example, in Chennai, Bangalore, Delhi, etc. However, the interfacing of the private sector participation proposals with the protection of water rights of the upstream and downstream users requires careful consideration. The experience regarding the use of the waters of the Sheonath river through private participation indicates that if these details are not considered, serious criticism about the sellout of natural waters can result.

7.1. 6 In Regard to Rural Water Supply and Sanitation

Sectoral reforms have started for empowerment of the community in decision-making. This would include decisions about the planning and implementation of schemes and, eventually, about the control and management. Partial capital cost sharing and full sharing of the O&M requirements is also provided.

7.1.7 In Regard to Rural Water Supply for Problem Communities

The Rajiv Gandhi National Drinking Water Mission (RGNDWM) is an important programme intervention. This has been fairly successful, although supply to communities in areas with endemic groundwater quality problems has not been successful. Sub-missions have been con-stituted to deal with preventive and remedial measures to address problems like arsenic, brackishness, and iron.

8. EXISTING LEGAL FRAMEWORK FOR WATER: PRIORITY[29] AREAS AND WATER RIGHTS

8.1 Ground Water law

The existing ground water law in India is close to inappropriate. This is of major significance as the use of ground water determines the availability of water for tanks, wells and many other minor irrigation systems. Traditionally ground water has been treated as a chattel to land property, where the access is to private land owners alone. Such property laws do not relate to hydrological, ecological or equity concerns at all. Few attempts of less significance have been made in the past at the state level. In the state of Gujarat groundwater rules have been reframed by amending the Bombay irrigation Act. Tamil Nadu water Board had framed certain model water Bills. But these arbitrary experimentations have proved grossly inadequate for the larger private and common property legal regimes, nor do they take into account the ecological and social diversities in which the laws needs to operate. The need for conjunctive use and integration of groundwater and surface water laws have also been conveniently ignored by the state governments.

In the view of the author, there is an urgent need to systematically explore the legal alternatives for integrated set of laws that will incorporate both ecological and social diversity as well as problems related to the inter-relationship between ground water and surface water use. Moreover, saccess to ground water is highly inequitable, since it depends upon land ownership and economic capacity to draw.

8.2 Legal Framework for Ground Water Rights

Existing legal frame work for ground water is as follows:

Ground water rights are under totally private legal regime. These rights belong to the land owner, since it forms part of the dominant heritage and land ownership is governed by the tenancy laws of the state. The transfer of property act necessitates the transfer of ground water based on heritage. Conversely, the land acquisition act, asserts that if someone were interested in getting rights over easement (groundwater for our

[29] Priority areas as identified by author ,which need immediate attention

purposes) he would have to possess land. There is no limit to the volume of ground water a landowner may draw. The consequence of such a legal framework is that only landowners can own ground water in India. It leaves all landless and tribal's, who may have group (community Rights) over land but not private ownership. It also implies that rich land lords can be water lords and indulge in openly selling as much water as they wish.

8.3 Recommendations

To ensure proper and equitable distribution of water it is recommended that water rights should be separated from land rights. No national effort has been taken so far. The only state to move in this direction is the state of Gujarat.

Areas where legal sanction is needed.

1. Where there is over exploitation of ground water.
2. Where there is dispute between two parties regarding the exploitation of water.
3. Where there is environmental degradation due to overexploitation.
4. Where there is ground water pollution.

8.4 Tank Water Bodies

In many parts of India, irrigation has traditionally been tank based. Even now in terms of food production, what is officially called "major irrigation system", namely the irrigation canals, covers only 36% of the agricultural land. 64% is rain fed, ground water irrigated and natural or artificial tank irrigated crop lands. Despite this crucial dependence on tanks and wells, India has witnessed the destruction, negligence and reclamation of thousands of tanks and gross misuse of groundwater. The realization that ground water is unsustainable in an ecological system where forests are fully exploited, soil conservation grossly neglected and rivers have been rapidly supplemented, is reaching the main stream concern rather slowly. That tank irrigation offers a vast potential for alternative approach to water management, needs to be emphasized and need to complement canal irrigation.

There is need to reform the appropriate legal structure that will support local controls and provide incentives for sustainable and equitable use of water tanks. Since traditionally tanks in India have been regulated through the community resource management systems and customary laws, there is need to carry out extensive field studies to examine customary methods of water management and institutional structures.

Legal frame work:

There is juristic aspect associated with the existence of the tanks, which relates to the political economy of the country. Tanks are local water resources; people have immediate access to them and are not dependant on far off authorities for their water supply. The existence of the tanks implies decentralization of power over water resources. The rise of modern state, which seeks centralized control over resources and the dependency on the state or capitalistic authorities would naturally not be in favor of the technologies, or resource distribution which would oppose it. If we are to follow constitutional mandate of economy and social justice, it is extremely important to utilize resource in a manner, which leads to equity and freedom from dependency on others.

8.4.1 Recommendations

It is proposed to make detailed study of the customary and statutory laws of the concerning use of tank and wetland waters in rural areas. It is known that these laws provided various strategies through which common resources could be utilized for common good. The aim of the study would be to devise appropriate legal strategies' for the preservation of tanks, its management and for equitable use of its resources.

8.5 Dam Construction

The neglect of tank and ground water law is directly related to the emphasis on construction of dams, since these have been conceived as the main scientific alternative for irrigation and food production. Unless the appropriate legal framework is conceived for planning and establishment of Dams, it is unlikely that the attention will turn to the development of tank and ground water laws.

Construction of large dams, regarded as boons of development in the first two decades after independence have now become the reason for unfavorable questions, both in official and popular discourse. It is clear from these trends that juristic and legal knowledge is yet to be related to it.

8.6 The legal framework

The executive, more than the legislative or judicial, power is prominent in this area. Indeed, staggeringly large, major decisions are in the realm for discretion.

For example, decisions relating to construction of dams, planning of national and international assistance, location of sites, approval of the size of the dams, rejection of medium and small project alternatives and planning of design and safety. The legislation intrudes in this area but not so substantially as to ensure just and fair, and accountable uses of imperious executive discretion. In all of this the constitutional context is altogether absent.

8.7 Recommendations

1. Review of the emerging constitutional standards of fairness and public accountability in their bearing upon irrigation works should be conducted.
2. Critical examination of international economic law in terms of its bearing on international human rights in the context of large and medium irrigation works in India
3. Impact of forest law and emerging environment law on dam construction
4. There is need for analyzing the constitutionality of cost benefits analysis in the determination of environment impact;
5. Innovative exercising in safe guarding human rights in public projects is strongly recommended.

9. CONCLUSIONS

Reform for water law is crucial for India’s economic, ecological and social development. The existing legal framework inherited mostly from the colonial period, is in need of major reforms and democratization and the appropriate alternatives are the need of the hour. Strategies concerning socio-legal aspects for the management of water system in India however have so far remained grossly neglected. An analysis of the policy and legal framework enables the author to conclude that the regime of water law in terms of rights and duties, originated in civil society and it is not something generated by the state. Second, the emergence of the state in pre colonial and post colonial period in India has been an era of appropriation and misappropriation of water law by various governments. In addition, the mutation of regimes of people’s right over water involves various misconceived theories of development by the state.

Hence there is a need for future work in water law to devise an alternative socio-legal discourse and practice where the concerned authorities use organic knowledge of water resource management as seriously as the as the scientific knowledge, and work a consideration of people’s struggles for water resource management as pursuit of human rights.

SCARCITY IN THE MIDST OF PLENTY: IRRIGATION DEVELOPMENT FOR WATER ABUNDANT ASSAM

Phanindra Goyari*

Abstract

The paper attempts to examine the extent of irrigation development in the water abundant state of Assam, which is disturbed by frequent floods almost every year. Although Assam has many sources of water, only a small fraction of total water resources has are utilized in gainful economic activities. While existing irrigation facilities are not enough for agriculture sector, large portion of irrigation potential already created remains unutilized. Added to it, excess rainwater in the form of frequent floods every year in the kharif season destroys standing crops and damages irrigation facilities, creating water-logging, soil erosion and affecting large crop areas. The rabi season receives low or almost zero rainfall. Therefore, the future plans on the development of irrigation potentials should give more emphasis on (i) developing groundwater based on installation of shallow tube wells, bore wells etc. and (ii) developing surface flow or lift irrigation through construction of small dams on the naturally flowing water ways and distributor channels, and (iii) harvesting rainwater during rainy season.

1. INTRODUCTION

Economic development of a region depends, among many factors, on the quantity and quality of the endowment of resources. More important than the availability, economic development is influenced by the proper management and systematic utilization of the existing resources for gainful economic activities. In the present day world, most of the resources can be either exported or imported. So, abundance or lack of a resource may not be the cause for development or underdevelopment of a state or economy. However, physical export or import of natural resources like river waters or land has some limitations. There are ample instances where people in regions and countries with abundant natural resources suffering from low levels of living such as Israel and Sub-Saharan Africa, and similarly examples of poorly endowed countries enjoying high levels of prosperity like the high performing Asian economies. Lagging regions with low levels of income and growth rates and high concentration of poverty even with when their resource endowment is rich is not uncommon even in a country like India (Rao and Mandal, 2007).

Abundance of water either at the surface or ground level is necessary for creating available irrigation facilities. Many studies (some examples, Rao and Despande, 1986; George and Chaukidar 1972; Coupal and Wilson, 1990; Arabiyat et al., 2001) observe the water scarcity as one important reason behind slow/low adoption of modern seed varieties and hence slow/low growth of agricultural production and productivity. Accordingly suitable water-conserving technologies were suggested. However, situations in Assam are quite peculiar. In general, the farmers in this state face two peculiar situations: (a) excess water from natural sources like rain and streams specially during wet kharif season and (b) less water or almost zero rainwater during dry rabi season in a cycle of one agricultural year. Assured irrigation during non-rainy dry season is undoubtedly very much essential for cultivation. However, excluding two hilly districts, almost all rice growing districts in Assam, which are prone to frequent flooding and waterlogging in the wet season, require drainage measures more than irrigation facilities. In such areas, excess of water, rather than lack of it, is the problem for cultivation in the wet kharif season. A study on irrigation situations in Assam thus assumes special importance.

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2. OBJECTIVES AND DATA

Situated in the north-eastern part of India, as an agricultural state, Assam exhibits quite different agro climatic conditions, particularly in terms of water resources, compared to other parts of the country. It is a state endowed with fertile land, abundant water resources and heavy rainfall, besides a variety of natural resources awaiting proper utilization. According to Swaminathan (2001), Assam is one of the 'sleeping agricultural giants' in eastern India. With a geographical area of 78438 square km, Assam occupies about 2.4% of the country's total area and supports 2.59% (9166.4 lac) of the country's total population (2001 census).

With the above background, the paper attempts to examine the paradox of low level of irrigation facilities in the water abundant state of Assam. Specific objectives are, (i) to characterize existing water sources in Assam, (ii) to examine the extent of growth of irrigation facilities for cultivation and possible impact on agricultural growth and (iii) to analyze the issues concerning the strategies for future irrigation development in Assam. Analysis is based on the available secondary data.

While discussing the irrigation development in Assam, it is worth mentioning some issues on the irrigation data in Assam. Lack of consistent and regular irrigation data set for Assam limits the scope of any analysis on irrigation development. Available data reported by 'Directorate of Economic & Statistics', ministry of agriculture, government of India show that the crop area under gross irrigated area and net irrigated area in Assam are constant since 1957-58, i.e., not updated as if there is no progress in irrigation facilities upto 2000-01. This non-updated data is reproduced in various issues of other publications like CMIE and fertilizer statistics.

However, irrigation data reported in Statistical Handbook and Economic Survey of Assam show that some progress in irrigation is taking place in the state. Systematic data on irrigation in Assam is available only from the year 1980-81 onwards. This data is collected and compiled by the office of the chief engineer, irrigation department, government of Assam. However, this available data only pertains to 'government irrigation schemes' and does not include irrigation from private sources. This is one important reason for which irrigation data of Assam cannot be compared with that of other states of India since in many states irrigation data include both government and private sources. Data on net irrigated area (NIA) and gross irrigated area (GIA), is not reported by the irrigation department of Assam as we find for other states. Instead, data on irrigation potential created and potential utilized is reported. Irrigation data for Assam shown in following sections pertains to government irrigation schemes only; private irrigation data is not available and hence not included.

3. EXISTING WATER SOURCES

There are many sources of water in Assam. These sources can be classified into three: (i) surface water flow or stock - the two mighty river systems (Brahmaputra and Barak along with their tributaries and streams); various ponds and lakes (ii) underground water and (iii) heavy rainfall, which further adds to the vastness of water resource.

Table 1: Number of Districts, area and population in three regions of Assam

Regions	No. of Districts	Geographical Area (Sq. Km)	% to Assam1s total	
			Geographical area	Population (2001)
Brahmaputra Vally	18	56194	71.64	85.03
Hills and Plateus	2	15322	19.53	3.75
Barak Vally	3	6922	8.82	11.22
Assam State	23	78438	100.00	100.00

Notes: Number of districts is as existing in 2003. Four new districts were created in 2005 after the formation of Bodoland Teritorial Area Districts (BTAD) within Assam.

Table 2: No. of Brahmaputra tributaries across districts of Assam

District	No. of Tributaries	District	No. of Tributaries
Dibrugarh	9	Lakhimpur	3
Darrag	9	Dhemaji	3
Dhubri	8	Morigaon	3
Barpeta	8	Bongaigaon	3
Jorhat	7	Tinsukia	3
Kokrajhar	6	Barak Valley	18
Kamrup	6	Hailakandi	9
Nagaon	6	Karimganj	3
Golaghat	6	Cachar	3
Nalbari	5	Hills region	
Sonitpur	5	Karbi-Anglong	12
Goalpara	4	N. C. Hills	7

Source: Compiled by author from "Assam State Gazetteer", Vol.1, 199; NER Data Bank in www.nedfi.com and its district wise links and www.assamgovt.nic.in

Topographically, the land areas of Assam can be broadly divided into two natural divisions – (a) plains and (b) hills. The plains consist of the Brahmaputra valley and the Barak valley. Both valleys derive their names from and are watered by the respective rivers and their tributaries. The Brahmaputra valley comprises the largest area (i.e., 72%) of the total geographical area of the state, and about 85% of the total population of the state resides in this valley (Table 1). The hill areas consist of the two hill districts of Karbi Anglong and North Cachar Hills, reaching an average height of about 1500 m. This hill region acts as the divider of the Brahmaputra and the Barak river valleys in the state. We discuss the two river systems briefly in the following section.

3.1 The Brahmaputra River

The Brahmaputra river is one of the most powerful waterways on earth. It influences the lives and livelihoods of people of five countries (Tibet, Nepal, Bhutan, India and Bangladesh) through which it flows. This river rises in the Chema yung dung and Kubi glaciers of western Tibet, near Mount Kailash and Mansarovar lake, and flows through Tibet, North-East India and Bangladesh before falling into the Bay of Bengal. Known as the Tsangpo in Tibet, the river changes its name as it flows into India. In Arunachal Pradesh, it is known as the Siang. Later it becomes the Brahmaputra as it enters Assam and is joined by the Dibang and Lohit. Further downstream in Bangladesh, it is called the Jamuna and then the Padma, after it merges with the Ganges, until it flows into the Bay of Bengal.

The Brahmaputra river has a total length of about 2900 km of which 720 km run through the Assam valley. This river within Assam is 1.5 - 10 km wide. The approximate average width of the Brahmaputra in the state is about 5.46 km but the actual width varies from place to place. Towards the eastern Assam, it has a width of upto 10 km. In the vicinity of Guwahati as well as near Pancharatna, the width of the river is about 1500 m. Near these two places, this river is flowing between more or less permanent banks with the maximum depths of 18 - 20 m during dry season and 40 - 50 m during rainy season. Before 1954, the work of gauge discharge observations was not started in the river. Prior to that only water level was observed in this river at Dibrugarh, Guwahati, Tezpur and Dhubri. Available records show that the maximum discharge of the Brahmaputra at Dhubri is to the order of 26 lac cusecs. The maximum discharges at various sites for the years 1956-62 show that the peak discharge varies from 50,000 - 72460 cu. metres per second; the maximum recorded discharge being at Pandu.

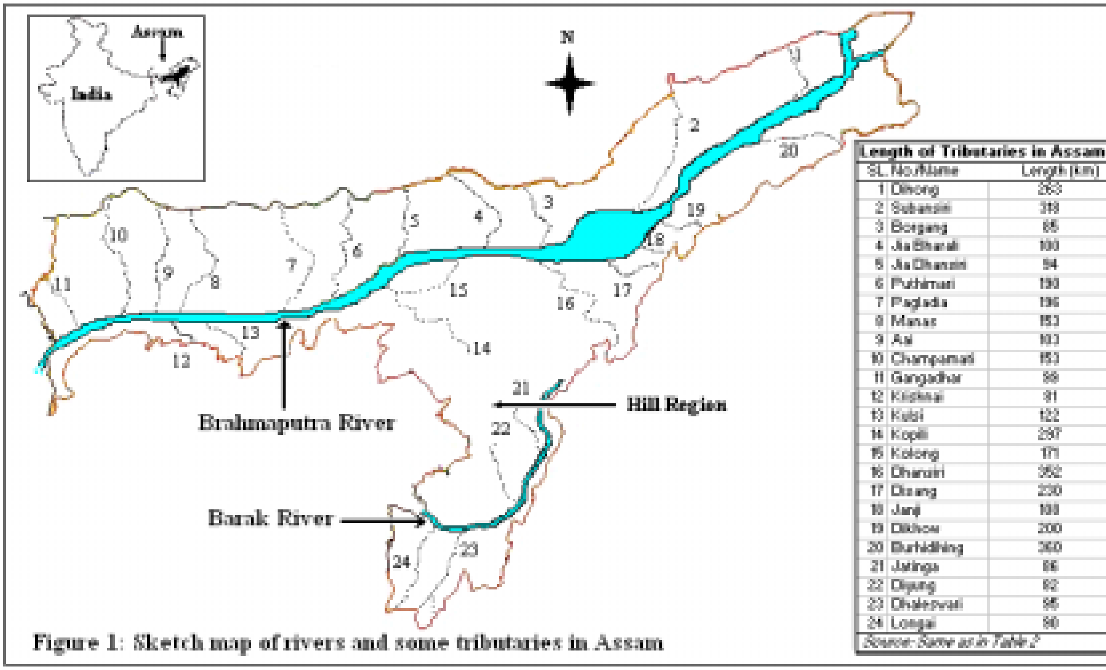

Figure 1: Sketch map of rivers and some tributaries in Assam

As many as 45 tributaries fall into the Brahmaputra river from the northern bank in Assam and another 43 tributaries from the southern bank (Table 2). These tributaries coming from the north as well as from the south feed the master river. Locations of some tributaries are shown in Figure 1.

3.2 The Barak River

Situated on the southern side of the state, the Barak is the second largest river in Assam. Originating at Manipur, the Barak river travels a distance of 403 km, out of which about 85 km is in Assam. The total catchment's area of Barak river system in the state is about 6922 sq. km (i.e., about 9% of state's area) and estimated annual runoff at Badarpur ghat is 41188 million cubic meter. This plain is about 85 km long from east to the west and about 70 km wide on an average from north to the south. The gradient of the plain from the east to the west is very low (from 75 m - 51 m) and the river Barak flows over it sluggishly through an extremely meandering course. Like the mighty Brahmaputra, the Barak is joined by 12 major tributaries from the north bank and 6 tributaries from the south bank in Assam.

The flow of water in these two rivers and their tributaries is perennial in nature. However, while the water level of all tributaries becomes high during rainy season (April till September), some tributaries become low during non-rainy season (November to February). District wise information shows that at least three tributaries are flowing through each district in the state (Table 3). Some tributaries are flowing through two or three districts before falling into the Brahmaputra or the Barak.

4. IRRIGATION DEVELOPMENT

Despite abundant water resources as mentioned above, the irrigation potentials, hydro-electrical power potentials and water transport potentials of both rivers and their tributaries are not yet harnessed fully. Only a small fraction of the vast inland water resources has been utilized for gainful economic activity in the state (Saikia 1999; Basu 1979; Goswami, 1993). For example, the ratio of gross irrigated area (GIA) to gross cropped area (GCA) was only 11% per year on average during the period from 1980-81 to 1999-00, compared to 34% at the all India level, 92% in Punjab, 39% in Andhra Pradesh during the same period (Table 6). Thus, Assam exhibits a paradox of irrigation scarcity in the midst of plenty of water sources. On the basis of the available data, we discuss various aspects of the irrigation development in the state.

4.1 Irrigation Utilization Rate

The information on the irrigation potential created and utilized in Assam has some interesting trends. Data in Table 3 show that the irrigation potential created in Assam has been increasing steadily since 1980-81. The irrigation potential created in the state was about 255 thousand hectares per year on average during the period 1980-81 to 1984-85. This increased to more than 484 thousand hectares per year on average during the quinquennium 1995-96 to 1999-00. However, the irrigation potential utilized has not been able to keep a pace with that of the potential created. The utilization rate of the irrigation facilities in the state has been declining. Out of the total irrigation potential created, only 60% was being utilized during the period between 1980-81 to 1984-85 and declined to 19% in 2000 – 01 to 2002-03.

Table 3: Irrigation potential created and utilized in Assam

Period (Averages)	Irrigation potential Created (thousand ha)	Irrigation potential Utilized (thousand ha)	Utilization rate (%)
A	B	C	D=(C/B)*100
1980-81 to 1984-85	254.5	151.8	60
1985-86 to 1989-90	461.5	222.1	48
1990-91 to 1994-95	454.0	191.7	42
1995-96 to 1999-00	484.3	115.3	24
2000-01 to 2002-03	545.8	102.5	19

Note: Data are from the Office of the Chief Engineer, Irrigation Department, Govt. of Assam
Source: Compilations and calculations are by the author

Looking across the region, available data (Table 4) show the most efficient utilization of the irrigation potential is in the hill region of the state during 1992-93 to 1996-97. The utilization rate in the hill region has been the highest followed by the Brahmaputra valley among three regions. The utilization rate for the hill region was higher than even the state average level during 1992-93 to 1999-00. But, during the same period, two other regions had a lower utilization rate than the state average in each year. Barak valley witnessed the lowest absolute areas of irrigation potential created and utilized as well as the rate of irrigation potential utilization during the period mentioned above. The irrigation utilization rate in the hilly region was 72% in the year 1992-93 against the state average of 47% in the same year. The Brahmaputra and the Barak valleys could utilize only 44% and 32% respectively, of the total potential created in that year. The high irrigation utilization rate in two hill districts indicates the efficient use of scarce resource created in the region. At the state level, all three regions witnessed a fall in the rate of irrigation utilization over the years.

Table 4: Region wise utilization rate of irrigation potential in Assam (1992-93 TO 1996-97)

	Irrigation potential created (000 ha)					Irrigation potential utilized (000 ha)					Utilization rate (%)				
Valley/Region	92-93	93-94	94-95	95-96	96-97	92-93	93-94	94-95	95-96	96-97	92-93	93-94	94-95	95-96	96-97
Brahmaputra Valley	420	430	439	441	442	187	110	131	93	97	44	26	30	21	22
Barak Valley	11	11	12	12	12	4	1	1	1	0	32	6	11	7	2
Hill Region	25	25	26	27	27	18	19	15	19	16	72	76	59	73	61
Assam	456	466	477	480	481	215	130	147	113	114	47	28	31	24	24

Notes and Source: Same as in Table 3

Several factors may be responsible for the low rate of utilization of the irrigation potential created in the state namely, defective irrigation management, lack of co-ordination among various implementing agencies and several technical defects. As per the economic survey, (Assam, 2003-04), "apart from non-practicing of cropping pattern as per approved/designed cropping pattern of the irrigation schemes and lack of eagerness on the part of the farmers to utilize irrigation water due to lack of awareness about the role played by irrigation in increasing yield rates of crops, non-repair of schemes due to paucity of fund, non-energization of pump sets and erratic supply of electricity in case of electrical lift irrigation schemes are some of the reasons of under-utilization of available irrigation potential from government schemes".

As per the available data, more than 93% of the total irrigation potential utilization in the state is that from government canals. Irrigation from these canals requires proper distribution channels, sluice gates and subsequent maintenance of the same. But occurrence of frequent floods, specially during kharif season every year, destroys all irrigation infrastructure namely canals, distribution channels, sluice gates and dams. Once destroyed or broken, it takes time to reconstruct those facilities. In this way, the utilization of created irrigation potential becomes a great problem. Ultimately, the available irrigation facilities created remain unutilized.

4.2 Season wise irrigation facilities

In Assam, kharif season is still the main season for rice cultivation. The irrigation potential created and utilized during the kharif season is higher than during the rabi & pre-kharif seasons (Table 5). Thus, the irrigation utilization rates during the kharif season are also been higher than rabi and pre-kharif seasons. While only about 9% of the irrigation potential created was utilized in the state during rabi and pre-kharif seasons, more than 30% was utilized during kharif season in the year 1996-97. However, the utilization rates in both seasons have been declining over the years.

This season wise irrigation information makes us aware of one important thing. There is a need for irrigation development during rabi season. Heavy rainfall and consequent flood during the kharif season disturb cultivations. During the rabi season many farmers get neither assured water nor rainwater. The cropping pattern analysis for Assam shows that the summer rice and other rabi crops (such as vegetables, fruits and spices) are emerging as important crops in recent years (Goyari, 2007). Hence, if farmers have assured irrigation water, the summer or rabi season can be made one of the important seasons for cultivation. This requires development of more irrigation facilities during summer season as well as better utilization of already created irrigation facilities.

Table 5: Season wise irrigation potential created and utilized in Assam (thousand ha)

	Irrigation potential Created upto the year		Irrigation potential Created upto the year		Utilization rate (%)	
Year	Kharif	Rabi & Pre-Kharif	Kharif	Rabi & Pre-Kharif	Kharif	Rabi & Pre-Kharif
A	B	C	D	E	F=(D/B)*100	G=(EC)*100
1996-97	332.0	148.8	100.1	14.0	30.2	9.4
1997-98	332.2	148.9	101.6	12.9	30.6	8.6
1998-99	334.0	150.0	101.2	15.8	30.3	10.5
1999-00	341.4	154.1	97.8	21.2	28.7	13.8
2000-01	344.6	159.4	99.9	14.8	29.0	9.3
2001-02	348.8	164.5	99.3	13.7	28.5	8.4
2002-03	353.7	166.4	71.9	7.5	20.3	4.5
1996-97 TO 2002-03	341.0	156.0	96.0	14.3	28.1	9.1

Notes and Source : Same as in Table 3

4.3 Source wise irrigation facilities

Source wise, major portion (more than 94%) of the irrigation facilities comes from the government canals. Second important source of irrigation is tube wells. Irrigation from tanks is almost non-existent in the state. Both the canal and tube well irrigation facilities in absolute terms have shown a declining trend particularly after mid-1980s. The canal irrigation facilities were about 208 thousand ha during the period 1985-86 to 1989-

90; it fell to about 100 thousand ha during the period 2000-01 to 2002-03. Irrigation facilities from tube wells also declined by 12 thousand ha during the same period. However, in terms of percentage shares, the contribution of canal irrigation towards the total irrigation facilities increased over the period and that of tube wells declined. The share of canal irrigation in the total irrigation potential utilized in the state was 96.5% during 1980-81 to 1984-85; this increased to 97.7% during 2000-01 to 2002-03.

4.4 Ratio of GIA to GCA

The ratio of gross irrigated area to gross cropped area is a good indicator of the extent of irrigation development in a state or region. However, only 13% of the gross cropped area of Assam was irrigated during the quinquennium period 1995-96 to 1999-00 compared to 94% in Punjab, 43% in Andhra Pradesh and 39% in all India average during the same period (See Table 6)[1]. While this percentage has been slowly increasing over the years at the all India level, it has been almost stagnant at around 13% in Assam since 1985-86.

Within the state, the hill region had the highest percentage of gross cropped area, i.e., 14.5%, under irrigation among three regions in 1998-99. This percentage for the Brahmaputra valley and the Barak valley were respectively 13.4% and 4.1% in the same year. Coming to the ratio of irrigation potential utilization to gross cropped area, the situation is still worse. Only 7% of the gross cropped area of the hill region was under the irrigation potential utilized; 3.1% in the Brahmaputra valley and less than 1% in the Barak valley in the year 1998-99.

The low percentage of gross cropped area under (government) irrigation facilities in Assam indicates that still the vast cropped areas depend on either community managed private irrigation facilities or rainfall. It is a known fact that majority of farmers in the state still depend on rain water for cultivation. Community managed private irrigation, like by constructing dams on streams or on the naturally flowing waterways, also depend on rainfall. Because streams and naturally flowing water ways get more water only when there is rainfall, farmers in Assam are still at the mercy of erratic and uncertain rainfall for cultivation.

Table 6: Percentage of gross irrigated area (GIA) to gross cropped are (GCA)

Period	Assam	Punjab	Andhra	India
1980-91 to 1984-85	7.5	88.2	36.2	29.8
1985-86 to 1989-90	13.0	92.2	38.2	32.5
1990-91 to 1994-95	12.2	94.7	40.3	35.9
1995-96 to 1999-00	12.7	93.6	43.0	38.9
1980-81 to 1999-00	11.3	92.2	39.4	34.3

Note: For Assam, GIA is total irrigation potential created & GCA is sum total of crop acreages

Source: a. Assam irrigation data are from the Chief Engineer, Irrigation Department, Assam
b. For Punjab, Andhra and India, data are from 'Fertilizer Statistics' & CMIE (Various issues)
c. Calculations are by the author

4.5 Rice area under irrigation

Rice being the dominant crop in the state, the study of irrigation facility under rice has special importance. Rice occupies about 70% of the GCA in the state out of which only 21% is under irrigation. Unlike Punjab where almost 100% of rice is under irrigation, the state of Assam as whole is far below the national average. In southern states of Andhra Pradesh and Tamil Nadu, the rice area under irrigation is more than 92%. The percentage of rice area under irrigation in Assam remained constant at about 21% between the period 1991-92 to 1997-98. However, for the country as a whole, this percentage increased from about 47% in 1991-92 to more than 52% in 1998-99 (Table 7). Available data from the irrigation department, government of Assam,

[1] As noted earlier, the low percentage of GCA under irrigation may be due to the fact that irrigation data here includes only government irrigation facilities and are not including private irrigation facilities.

show that in absolute areas, the irrigation potential utilized for the total paddy has been declining over the years. Within the various seasonal paddy crops, winter or sali paddy occupies the largest irrigated areas followed by the early ashu paddy.

Table 7: Percentage of rice area under irrigation

Year	Assam	Andhra	Tamil Nadu	Punjab	India
1991-92	21.0	94.9	92.4	99.0	46.7
1992-93	21.1	94.5	92.3	99.3	48.1
1993-94	21.1	95.5	92.3	99.2	48.8
1994-95	21.7	94.7	92.6	97.9	50.0
1995-96	21.3	94.8	92.1	99.4	50.1
1996-97	21.4	95.6	92.7	99.0	51.3
1997-98	21.1	96.4	93.2	99.2	50.2
1998-99	22.0	96.0	93.6	99.2	52.3
1999-00	20.1	95.7	93.2	86.9	51.9

Source: CMIE and 'Area and Production of Principal Crops in India' (Various issue)

Due to low irrigation facilities combined with flood disturbances in the state, the growth of production and yield of rice and foodgrains remained very low during the last 25 years, except for summer rice and rabi foodgrains (Table 8). Although the output of summer rice and rabi foodgrains increased at an annual rate of 12.5% and 6.4%, respectively, these output growths were mainly contributed by acreage growth. Output of total rice recorded an annual growth of only 2.4% against the national rate of 3%. Food grain output of Assam increased at a lower rate compared to the corresponding national rate of 2.6%.

Table 8: Compound annual growth rates of area, yield and output of crops in Assam during 1975-76 to 1999-2000 (%)

	Area	Yield	Production
Autumn rice	0.1	1.4	1.5
Winter rice	0.4	1.5	1.9
Summer rice	9.2	3.3	12.5
Total rice	0.6	1.8	2.4 (3.0)
Khariff food grains	0.3	1.6	1.8
Rabi food grains	3.2	3.1	6.4
Total Food grains	0.6	1.7	2.3 (2.6)
Non-food grains	..	..	1.0
All crops	..	..	1.6

Note & Source: Taken from Goyari (2005), Figures in brackets are for all India

5. RAINFALL AND FLOOD DAMAGES[2]

The heavy rainfall every year further adds to the vastness of water resource in Assam. On average, Assam and its neighbouring states receive the highest annual rainfall in India. Cherrapunji of Meghalaya (a bordering state of Assam) is known for the highest amount of rainfall in the world. Assam receives an average annual rainfall of about 2000 mm. However, it varies from season to season. The seasonal rainfall is the

[2] This section draws from Goyari (2005).

heaviest during June-September (south-west monsoon) period of the year [Figure 2]. While the period from early May to October is wet due to heavy rainfall, rest of the agricultural year in Assam is relatively dry. Thus, farmers experience two cultivation conditions – excess rainwater and relatively no rainwater - in a single agricultural year itself. The state receives more than 80% of the average annual rainfall during the south-west monsoon period. The rainfall varies not only across seasons; it varies from place to place even in a year within the state.

Rain water is useful for crop cultivation. Since irrigation facilities are not well developed, many farmers in the state still completely depend on rainfall mainly for rice cultivation[3] While the rainfall is the heaviest during May-September, other months are relatively dry with low rainfall or sometimes no rainfall at all. Due to lack of rainwater harvesting provisions in the state, the excess rainwater during rainy season goes waste. Earlier many farmers cultivated paddy only in two seasons – winter (Sali rice) and autumn (ashu rice) in one agricultural year. But with the arrival of short-duration High Yielding Variety (HYV) paddy seeds, summer season has also emerged as one of the crop seasons. It is now possible to cultivate paddy upto three times in one year. However, many farmers can not cultivate paddy during summer season (boro rice) when the rainfall is low or sometimes nil. Goyari (2007)'s study in Udalguri sub-division of Assam found that only two types of sample farmers were cultivating summer rice – (i) farmers whose plots have access to naturally flowing water and (ii) farmers who have (or who can afford) artificial means of irrigation through pumpsets and borewells.

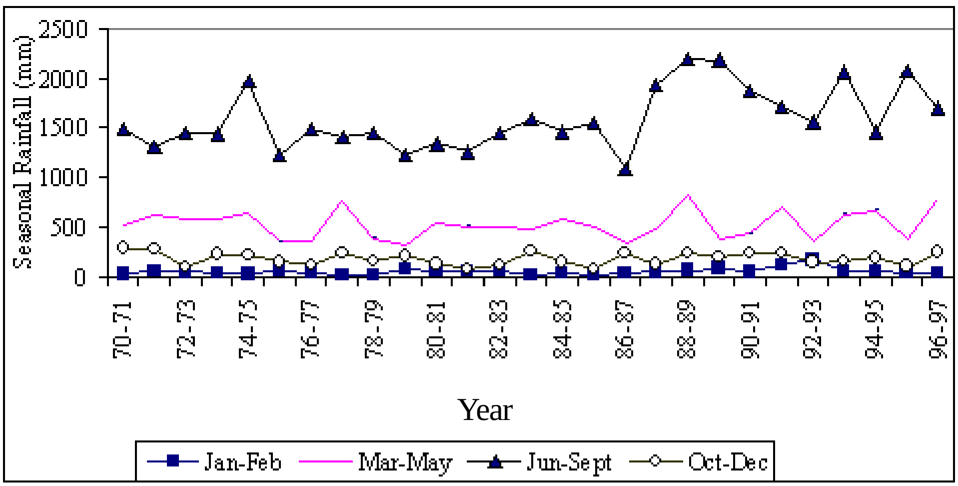

Figure 2: Seasonal rainfall in rainfall zone "Assam & Meghalaya" during 1970-71 to 1996-97
Source: Data are from 'Weekly Weather Reports' of Indian Meteorological Department, New Delhi, reproduced in 'Fertilizer Statistics' (Various issues)

Due to lack of proper water management facilities, heavy rainfall in Assam has one bad effect on the economy, i.e., damages due to flood problem. Every year, starting from early May to late September, Assam receives heavy south-west monsoon rainfall and due to excess water in rivers and tributaries, floods occur. This is also the important period for rice cultivation when ashu rice (autumn) is harvested and Sali (winter) rice is cultivated. Sometimes, floods occur upto five waves with high intensity in a single year. Frequent floods cause enormous damages to various sectors, especially the agricultural sector which is the mainstay of the state

[3] A study by Goyari (2007) in Darrang district observes that the main sources of water for rice cultivation in two sample regions are rainwater, irrigation by means of small dams on naturally flowing waterways and underground water through pump sets and bore wells. Farmers in region 1 get water only from rain and small dams. However, naturally flowing waterways also depend on rainfall as farmers get water from small dams on waterways only during south-west monsoon period. Artificial means of irrigation through pump sets and bore wells are in use only among rice farmers in the region 2. As large as 61% of the total area under paddy in region 2 is completely rainfed.

economy. Within agriculture, rice crop is the worst hit by floods (Goyari, 2005). The main reason is that rice is cultivated more in low-lying areas, which are generally flood-prone. Out of the three varieties of rice grown in Assam (winter, autumn and summer rice)[4], winter rice is the most popular among farmers due to easy availability of rainwater. However, floods disrupt agriculture. Floods in early parts of the rainy season mainly damage the 'ashu' rice crop. But the floods occurring late in the season are the most devastating as they damage the standing 'sali' rice, the main 'kharif' crop of the state.

Occurrence of frequent floods is one of the major factors hindering farmers from adopting improved agricultural production techniques in Assam, mainly during winter (sali rice) season. Due to frequent floods, many farmers have adopted a risk averse strategy of not using purchased inputs such as HYV seeds, chemical fertilizers and pesticides. Cultivation of winter rice starts in June-July. During this period, the rainfall is the highest. Paddy fields, most of which are low-lying areas, are flooded with excess water. Excess water washes away chemical fertilizers from one plot to other plots. So many farmers do not apply fertilizer in the winter rice even if some farmers can afford to apply it. Moreover, HYV paddy varieties, most of which are of short-height, are damaged due to flooding. Although excessive rain water is not so much a problem for cultivation of autumn and summer paddy, farmers do not want to apply chemical fertilizers even in the autumn and summer paddy mainly due to less irrigation facilities. Frequent floods in the state have been able to shift the cropping pattern to some extent especially among three varieties of rice during the last three decades (Goyari 2007). Area wise and production wise, winter rice has traditionally been the most important among three categories followed by autumn rice. However, the acreage shares of winter rice and autumn rice in total rice area have been continuously declining during 1975-76 to 1999-00. On the contrary, the importance of summer rice, which is grown during flood-free season, in the total area under rice, has been increasing continuously. Winter rice used to occupy more than 71% of the total area under rice cultivation during 1975-79. But it came down to 68.3% during 1995-99, a fall of about 3%. Autumn rice also lost its area importance by almost the same percentage points like winter rice. The autumn rice acreage share in total area under rice declined from 27.1% during 1975-79 to 23.7% during 1995-99. All these losses in areas went to summer rice. Summer rice, which used to occupy less than 2% , increased to 8% of the total area under rice in recent years. This increase became sharp especially after 1990-91. The main reason was the fall in the winter + autumn rice and the rise in the summer rice due to floods. To avoid crop losses due to frequent floods, many farmers in the state have stopped cultivating winter and autumn rice altogether.

Thus, any development policy in Assam should also consider measures of flood control. Without controlling floods, none of the productivity enhancement packages will bear desired fruits. While most of the flood control measures undertaken so far are short-term in nature, concerted policy decisions on long term measures, both of the state and central governments are needed to solve flood problems permanently.

6. GROUNDWATER AND SHALLOW TUBE WELLS (STWS)

Different surveys have found that there is tremendous scope for developing groundwater based irrigation system in most parts of Assam. Das (1984) wrote "the entire Brahmaputra valley can be considered as a vast reservoir of groundwater. The water table is generally within 5 meters below the land surface except in a narrow belt of 10 to 15 kilometers of width in the northern side running along the foothills of the Himalayas. In this belt, water table generally lies at a depth of 15 to 35 meters below the surface. Development of irrigation from groundwater through shallow and deep tubewells is feasible in the entire Brahmaputra valley". He further states that "The sediments comprising the water bearing horizons of the Barak valley down to 50 m are predominantly clayey and do not support good tube wells. It is, therefore, considered that tube wells in this region can not be successful". The prospect of groundwater irrigation in the hilly region (comprising two

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[4] Each category derives its name from the season in which the crop is harvested and not by the cultivation period. Winter rice is cultivated in early June-July and harvested in November-December. Autumn season is from February to June-July. Summer rice season is usually from November to April-May.

districts of NC Hills and Karbi Anglong), to him, is generally limited to the small intermountain valleys. He states, "In the limestone terrains such as the Umrang basin of Karbi Anglong, the sinkholes of various sizes, if interconnected, are capable of yielding large quantities of groundwater". Goyari (2007), in his field surveys in Udalguri sub-division on the northern bank of Brahmaputra valley found that 'generally, for dug well, it is easy to get groundwater by digging 2 to 4 meters inside the ground' in 2005. However, 'for borewell and tube well operations, it is necessary to put water pipe about 10 to 13 meters inside the ground. But for effective discharge of water, some farmers (who are using bore wells) put water pipes to even 30 meters inside the ground'. Compared to findings in Assam, in an article on tube well drilling in Punjab, Agnihotri (2004) quotes the statement of one driller, 'To ensure good water discharge, we have to dig 300 to 375 metres in Derabassi block. Earlier, 120 metres of drilling used to be sufficient.'

Table 9: Groundwater resource and numbers of shallow tube wells installed in Brahmaputra Valley of Assam

Sl. No.	District	Gross Dynamic Ground Water Resource (mcm)	Utilizable ground water resource (mcm) for irrigation	Feasible Numbers of Shallow Tube Wells based on 100% utilizable resource and 0.0216 mcm annual draft	Total number of STWs installed till June, 2001	Balance Number of STWs Feasible	Net area sown (000 ha) in 1999-00	Area (000 ha) in 1999-00	As % of net sown area (Col.9 as % of Col.8)
1	Dhubri	1205.1	1024.3	47421	20798	26623	146.6	14.4	9.8
2	Bogaigaon	622.2	528.9	24485	10789	13696	92.7	5.5	6.0
3	Kokrajhar	949.8	807.3	37375	3850	33525	86.8	26.1	30.1
4	Goalpara	565.4	480.6	19935	7442	12493	79.0	11.8	15.0
5	Barpeta	1133.9	963.8	44620	12406	32214	182.6	55.8	30.6
6	Nalbari	866.3	736.4	34091	12508	21583	149.3	18.2	12.2
7	Kamrup	1035.4	880.1	39357	15206	24151	174.5	33.1	18.9
8	Darrang	1121.7	953.5	44142	11500	32642	203.6	55.4	27.2
9	Sonitpur	1530.7	1301.0	60237	5763	54474	160.9	52.3	32.5
10	Lakhimpur	707.8	601.6	27853	1909	25952	97.2	10.4	10.7
11	Dhemaji	1023.7	870.1	40282	1360	38922	54.7	6.0	11.1
12	Dibrugarh	1100.9	935.5	43320	4800	38520	127.5	11.8	9.2
13	Tinsukia	1222.3	1039.0	48099	2580	45519	96.9	5.6	5.8
14	Sibasagar	1140.9	969.8	44895	3700	41195	129.0	15.9	12.3
15	Jorhat	938.9	798.1	36946	3172	33774	116.0	12.2	10.6
16	Golaghat	1111.2	944.5	43725	5091	38634	116.3	16.2	13.9
17	Nagaon	1309.2	1112.9	51520	17476	34044	234.4	16.0	6.8
18	Morigaon	386.4	328.4	15204	6908	8296	101.4	87.3	86.1
	Total	17971.1	15275.8	703507	147250	546257	2349.3	454.1	19.3

Source: Column 3, 4 and 5: Central ground water Board, NE Region, Guwahati (2002), reproduced from ADR (2002)

Column 6: Department of Agriculture, Govt. of Assam

Column 8: Statistical Hndbook, Assam, 2004, Directorate of Eonomics & Statistics, Govt. of Assam

Column 9 : Office of the Chief Engineer, Irrigation Department, Assam (Data only for govt. irrigation schemes).

Column 7 and 10: Calculations by the author

The central groundwater board, north east region (2002) has estimated the gross dynamic groundwater resource to be about 17.97 thousand mcm for the Brahmaputra valley comprising 18 districts (see Table 9). Out of this, 85% (i.e., 15.28 thousand mcm) is estimated to be utilizable groundwater resource for irrigation. The feasible number of STWs, which can be installed based on 100% utilization in the whole valley, is estimated to be about 7.04 lakh. Out of this feasible numbers, only 21 percent (i.e., 1.47 lakh STWs) had been installed for irrigation till June 2001. Thus, a balance of 5.46 lakh STWs (i.e.79%) can be installed to irrigate the cultivated areas in the Brahmaputra valley. About 19% of the net sown area was irrigated in the year 1999-00 from different sources including STWs. Hence, a vast cultivated area, i.e., 81% of net sown area, is yet to be brought under assured irrigation.

7. FUTURE IRRIGATION DEVELOPMENT STRATEGIES: SOME ISSUES

Findings from the above analysis have important bearings on the policies for irrigation and agricultural development of the state. Large potential of untapped irrigation potential, both surface and ground water exists in Assam. Although summer season is emerging as one of the important crop seasons for paddy cultivation, irrigation facilities in this season are not enough and not available in many places. Unlike in the wet sali season, the cultivation of paddy in the summer is largely conditioned by the availability of irrigation. Summer season is dry, with very less or sometimes no rainfall. Only those farmers can cultivate summer rice, who can afford pump set and bore well irrigation or whose plots have access to naturally flowing water. Had there been available irrigation facilities, many farmers would have cultivated paddy in the summer season. Moreover, summer season is flood-free season. There is no fear of costly inputs such chemical fertilizers being washed away or short-height HYV paddy plants being damaged by floods in the summer season.

While lack of irrigation is one important reason for many farmers not cultivating summer rice, there are other reasons also for not cultivating lands during summer or rabi season in the state. Traditional varieties of paddy seeds like haldharam, maisali maima, maibra etc. do not grow well during summer as climate/humidity is not suitable for those varieties. Even if there is irrigation facility, many farmers do not cultivate traditional paddy seeds in summer. However, with the arrival of new paddy seeds (i.e., high yielding varieties), most of which are not season-specific, farmers can cultivate paddy during summer also.

Many farmers have been traditionally cultivating only rice in their lands. For many farmers, rice cultivation plots are different from plots meant for vegetables and other crops. Rice is generally grown only in low-lying areas, which are not suitable for vegetables like cabbage, potato etc. Like traditional rice seeds, some varieties of vegetables and fruit crops also do not grow well during summer season due to unsuitable humidity conditions. Cultivation of rabi crops like vegetables, fruits, spices is still not wide spread during summer season due to lack of proper facilities like marketing centres, storage, price support, transport network and food processing. Thus, along with irrigation development schemes, the government should give emphasis on the development of those related infrastructure facilities.

Since big irrigation projects are costly and, in most cases, beyond the resource capacity of the state's exchequer, Assam can depend more on small and minor irrigations by harnessing groundwater for future irrigation development. It is true that large-scale development of groundwater based irrigation systems may lead to new problems like depletion/lowering of water table. Many studies conducted in others parts of India and abroad have revealed this problem. However, Assam is less likely to face such a problem since it generally receives heavy rainfall during kharif season, which can replenish the groundwater table annually.

Assam, in general, has a vast potential of developing irrigation facilities based on groundwater through installation of shallow tube wells and bore wells. Harnessing of groundwater through shallow tube wells and dug wells are both affordable and easily accessible to average farmers. Moreover, these facilities can be created in a short period at the household level. With a view to explore groundwater for cultivation, the government of Assam enthusiastically initiated the scheme of installation of shallow tube wells (STWs) in 1996-97. This programme was launched under the Samridha Krishak Yojana (SKY) with finance from NABARD and Assam Rural Infrastructure and Agricultural Service Project (ARIASP) financed by the World Bank. Taking into account the technical and geo-physical parameters across districts, only 18 districts of the Brahmaputra Valley of the state were selected for this scheme. Official records claim that shallow tube well program has worked well in the state (ADR, 2002). But the low percentage of gross irrigated area to gross cropped area in all three regions of the state indicate that there is a great need to create large irrigation facilities in the state. There is a balance of 546257 STWs still feasible to be installed in 18 plain districts of the Brahmaputra valley (Table 9, column 7). The government should spend money to install these feasible tubewells. During 1997-98, the total cost of each STW including the installation charge was approximately Rs. 23,000. Under the STW scheme, the government was bearing 67% or two-thirds (about Rs. 15333) of the total cost and the balance amount (Rs. 7666) was borne by the beneficiaries. This amount was too high and beyond capacity for many small and marginal farmers. Share-croppers or tenants still do not have access this irrigation facility. Since electricity subsidy is not possible in Assam, as in states like Andhra Pradesh, the government of Assam can subsidise STWs further. If the state government bears 80% percent (Rs. 18400) of each STW cost, it will have to spend about 100 crores rupees to install the feasible number of STWs in the Brahmaputra valley. Such facilities, if created may irrigate about 81% of the net cropped area in the Brahmaputra valley.

Assam has naturally flowing water ways, small streams, rivers and lakes which can be developed into minor systems in the form of small dams and distribution channels and used for surface flow and lift irrigation. Such private irrigation systems exist in many villages. One component of small and minor irrigation development in Assam can be providing financial support to such community managed small dam and other minor irrigation projects. This type of small irrigation is feasible almost in every district where naturally flowing water ways are present. Unlike STWs installation, this small dam based irrigation system will not cost much to the government exchequer. While installation of STWs may solve irrigation problem in the short term and even medium term, the state government should always try to explore possibilities of harnessing water from rivers and tributaries to solve the irrigation problems of the state for sustainable agriculture development in the long term.

Due to large initial investment and long gestation period, large scale irrigation systems based on big dams and large canals have several limitations in the state. Moreover, due to heavy rainfall and frequent floods every year, possibility of large scale irrigation systems being destroyed and causing great loss is obvious. Any scheme of surface water irrigation system development must be integrated with flood control measures.

Although Assam receives heavy rainfall every year, no effort or scheme has been undertaken to store it. It is wasted. Harnessing water resources in this way will help farmers not only in the summer but also in other seasons of the year. Development of more irrigation facilities based on ground water will really help farmers, especially to cultivate summer paddy on a larger scale. Rainwater harvesting schemes, if adopted and implemented properly, will certainly be useful not only for irrigation but also for other purposes.

Creating irrigation facilities, whatever be the type of irrigation, is important for all seasons. But, for sustainable irrigation development, importance should be given to the development of an institutional set up which can integrate irrigation creators, users and maintainers. Active participation of farmers is necessary for the success of any irrigation scheme and overall agricultural development. Formation of so many new committees may not bring good results. Instead, existing institutional schemes like “Farm Management Committee (FMC)” and “Water Users’ Association (WUA)” should be strengthened and expanded in all corners of the state. Only 450 WUAs have been formed upto 2002-03 by the irrigation department of Assam. Majority of villages still do not have FMCs. Such committees or associations, through mutual discussions, can perform several activities, such as collection of irrigation service charges, maintenance of irrigation channels and small repairs besides selecting cropping pattern, crop rotation and improved farm practices. The existing tenancy and land reform programmes should also be implemented in the state more vigorously.

8. CONCLUSIONS

The paper attempted to examine the extent of irrigation development in the water abundant state of Assam whose economy is damaged by frequent floods almost every year. Irrigation development in Assam exhibits the paradox of scarcity in the midst of plenty of water sources. Although Assam has many sources of water like two great perennial rivers and their enormous tributaries, groundwater and heavy rainfall, the ratio of GIA to GCA was only 11% per year on average during the period 1980-81 to 1999-00, compared to 34% at the all India level and 92% in Punjab. The low percentage of gross cropped area under (government) irrigation facilities in Assam indicates that still the vast cropped areas depend on either community managed private irrigation facilities or rainfall. This finding gives us some useful information. First, in many districts, inspite of presence of perennial water ways, irrigation potentials has not been exploited or harnessed. Second, it is also possible that these waterways may not be suitable for irrigation. Third, another possibility is that there may be several technical, financial and institutional problems in harnessing water in those rivers and tributaries for irrigation purposes. A separate in-depth study is required to understand the irrigation potentials of each and every waterway in the state as well as various problems encountered in harnessing existing water sources for irrigation.

While existing irrigation facilities are not enough for agriculture sector, large portion of irrigation potential already created remains unutilized each year. Added to it, excess rainwater in the form of frequent floods every year in the kharif season destroys standing crops and irrigation facilities, creating water-logging and affecting crop areas. The summer or rabi season suffers from low or zero rainfall. Although summer season is emerging as one of the important crop seasons for paddy cultivation, irrigation facilities in this season are not available.

Keeping in mind the existing agro-climatic conditions, availability of water sources and irrigation needs, the future plans on the development of irrigation potentials in Assam should give more emphasis on the following (i) development of groundwater based on installation of shallow tube wells, bore wells etc., (ii) development of surface flow or lift irrigation through construction of small dams on the naturally flowing water ways and distributor channels, and (iii) storing or harvesting of rainwater during rainy season and utilizing it during dry season.

Active participation of people at the grass root level is necessary for the success in any scheme of irrigation and overall agricultural development. Already existing institutional schemes such as FMC and WUA should be strengthened and expanded in the entire state.

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THE CO-OPERATIVE AS AN INSTITUTION TO MANAGE WATER DISTRIBUTION FOR IRRIGATION: LESSONS FROM THE CHANDA EXPERIMENT IN MAHARASHTRA, INDIA.

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Abstract

The paper looks at the potential of co-operatives as an institution to manage water distribution for irrigation by studying the Chanda village in Maharashtra. The study concludes that the co-operative approach to distribution of canal water can not only be an efficient and equitable system of water distribution as against the earlier centralized government system, but it also has the potential to be applied to more such areas of public goods, especially natural resources which need to be conserved or used judiciously.

1. INTRODUCTION

Government played a major role in the developmental effort in India in 1960s and 1970s. This was especially the case for provision of public goods like roads, water, electricity, ports, communications, banking etc. Along with this governmental initiative, the cooperative model too was used extensively in India to ensure peoples participation in solving their problems, rather than relying only on the state. Cooperative has been used in various different areas like credit, diary, sugar, consumers, marketing and fishing. These endeavors were mostly restricted to areas of private goods provision where the implementation was successful. Co-operatives for the provision or distribution of public goods or common property resources were rare. Most of the public goods provision was in the hands of the state. Even if co-operatives for the provision of public goods existed, they are not very prominent or extensive.

Over the period of the 1980 to 2000, there has been a paradigm shift in the Indian policy making. The past two decades have seen the emergence of the market mechanism as a favored instrument to initiate and maintain the developmental pace. Currently, a massive wave of privatization is sweeping across the economy. Public policies are increasingly based on the acceptance that markets are better suited to initiate development. (Taimni K.,1999). This policy change is reflected in lot of areas of state intervention being privatized, such as roads, ports, airlines, telecom, power etc. (Datta and Sundaram, 2004).

To aid the increasing privatization of public utilities in India, public-private partnerships are now being promoted in various public utilities. There is an emphasis on increasing people's participation in solving economic and social problems of provision, pricing and distribution of goods and services and resources. The co-operative model too is being used wherever possible. This is a hitherto unexplored area for the co-operative in India. Given this, it is interesting to see how the co-operative as an institution can contribute to the complex question of producing and distributing common property resources or how the co-operative can be used in the provision and distribution of public goods. As stated before, co-operatives in the field of public goods provision were rare but of late, some effort in this direction can be seen.

Water supply, one area that has so far been in the realm of the public sector in India, is now being mooted for privatization. (Dharmadhikary S, 2002). Here, the co-operative model, in the form of Water User Association (WUA) too is now being actively promoted specially in the area of canal water distribution, which so far has been in the hands of the state and is in the nature of a public good. Earlier, the co-operative model was being used to manage lift irrigation schemes (well irrigation), but this particular application (in canal water distribution) is an altogether new application of the co-operative. A co-operative meant to distribute canal water

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from dams to farmers would necessarily be much larger spatially and more complex than lift irrigation societies. Hence, a cooperative venture in this area becomes a unique experiment, which calls for analysis and study.

Water being a national property, its harnessing and distribution is in the hands of the government. However, there has been considerable disenchantment with the performance of the public sector with respect to surface irrigation development. The main problems here were that the government could not collect the water dues and maintenance of the irrigation system too was lacking (Narain, 2003). According to official estimates, fiscal recovery from surface water irrigation services (dam water distribution) in Maharashtra state was only about 40% to 50%. Moreover, the irrigation service delivery too was not satisfactory.

This has led to the recent attempts to address this problem through instituting water user associations (WUAs). A pioneering effort in this direction was attempted in the nature of a pilot project at the Chanda village of Ahmednagar district in Maharashtra state way back in 1989. Seeing the success of this experiment, many more WUAs came up at other places in Maharashtra especially in Nashik. In fact, by 2003, 534 WUAs were in operation in Maharashtra. Seeing this, the state government has given the WUAs statutory status through an Act. This is called the "Maharashtra Management of Irrigation Systems by Farmers Act" (MMISFA) 2005. By this act, the government has laid down the condition that surface water irrigation systems in the state will be managed through these WUAs. Hence, the government can sell canal water only to WUAs and not to individual farmers.

2. OBJECTIVES OF THE STUDY

Given the above scenario, the present study aims to examine the co-operative venture in this green-field area of surface water distribution for irrigation. The objectives of the study are to understand the working of the government system, the problems therein, the design and the working of the co-operative and to glean from this important lessons for better working of the co-operative. Mainly, the objective is to see if the co-operative as an institution can contribute to bringing about a more efficient and equitable allocation of a public good.

2.1 Structure of the Paper

The study is divided into the following subsections:

1. What were the problems with the government system in the provision of the canal water for irrigation?
2. What led to the emergence of a co-operative in the area of canal water distribution?
3. What were the distinctive features of this unique co-operative? How was its mechanism designed to ensure that it would carry out its functions as best as possible?
4. What was the experience in the actual working of the system?
5. What are the experiences of other such cooperatives that have come up?
6. What are the lessons to be learnt from the observation of the working of these cooperatives?
7. Are co-operatives in this area viable? What needs to be done to make them viable?

2.2 Emergence of Cooperative Venture in Canal Water Distribution/Surface Water Distribution in Chanda Village

The Water User Association at village Chanda, district Ahmednagar, in Maharashtra state of India is a pioneering effort in Maharashtra. Chanda is a small agricultural village, which relies for its water needed for irrigation, on rainfall, underground water (wells) as well as on the government canal irrigation/surface irrigation. It falls under the command area of the Mula river and is served by the canal named "Minor 7".

3. WORKING OF THE GOVERNMENT SYSTEM

Before the advent of the WUA at Chanda, the government canal irrigation system worked somewhat as follows: The farmers had to fill in a form, specifying the water they would require from the canal in the coming agricultural season. This requirement of water had to be specified in terms of the acreage and the type of crop they would be cultivating, for instance, 5 acre farm cultivating sugarcane crop, or 4 acres of wheat etc. This annual cultivation pattern had to be communicated by all farmers who wanted to use the surface irrigation in the coming season. All these demands of the various farmers would be put together, and on the basis of this, the irrigation department would allocate the amount of water to the village and also prepare a schedule for its release in the canal. The schedule was notified to the farmers in the section office of the irrigation department near the village. Based on this schedule the farmers had to prepare their fields accordingly to receive the water.

The water from the main canal would be released according to this schedule prepared by the irrigation department officials. This release of water at the minor level/village level was handled by one government official who is called "patvari" in the local language.

The rates at which water usage was charged to the farmers were decided at high level government committees at the state government level. The water rates were set on the basis of the acreage of crop with different rates for different crops: food crops attract lower rates than cash crops. For instance, the canal water rates for sugarcane were fixed by the state government at Rs. 1200 for 2.5 acre or approximately at Rs. 400/ acre. Water rates for other crops like wheat, jowar, harbara (staple cereals) were lower at around Rs. 60/acre.

These government prices were set so as to cover the operation and maintenance cost and the salaries of the maintenance personnel of the irrigation departments. Capital costs of the irrigation system or its depreciation were not considered. If capital costs were also to be covered the prices would be too high for the farmers, it was felt. Thus, government prices were subsidized prices.

3.1 Problems in the Existing System

This was broadly the existing system before the advent of the WUA. The water rates in this system were found to be too high (especially for sugarcane cultivation) by the farmers and therefore a parallel market in water had emerged here. The local government officials and the village farmers were reportedly trading in canal water at rates much lower than those prescribed by the government. This led to very low revenue trickling in, in the government coffers, although water from the canal was being lifted. So, the government faced a major problem in terms of recovery of dues. Moreover, since the farmers were getting the water at much lower rates it lead to wasteful and inefficient use of water in the village.

Secondly, all farmers could not participate in this parallel market. Specifically, in the dry periods when water was scarce, the trade was restricted to between the rich farmers and government officials; the poorer/ small farmers could not get water. Thus, there was exclusion in the market. Also, the one man in charge of the distribution of the water to different users, the patvari, could not handle and control so many users and their varied requirements. This used to lead to a lot of theft of the water and resulted in inequitable distribution of water in the village.

Another problem faced by the farmers in using the government managed system was that if they planned to grow crops other than the staple crops or sugarcane in their farms, they had to apply for prior permission. They found this very cumbersome.

4. EMERGENCE OF THE WUA: FORMATION OF A COOPERATIVE SOCIETY FOR WATER DISTRIBUTION IN CHANDA

To address all these problems, the cooperative venture for water distribution was proposed. There was a need to remove the black market and substitute it with something in which all stakeholders (all farmers) could participate and benefit. To this end, a cooperative was started in 1989. The objective of this cooperative, as stated in the MOU between the society and the government was, "to ensure farmer participation in water management so as to optimize the use of the available water and raise agricultural productivity in the command (Lele).

The proposal of the society came from the government's end. It was at the instance of the government and an active NGO,[1] that the WUA took shape. The government's Irrigation Research Development Center and CASAD (the NGO) were directly instrumental in the formation of the society. The process began in 1987, when CASAD and the government representatives held several discussions with the farmers about forming such a society.

Initially there was some opposition to this idea. All the farmers were not very keen on this, especially the big farmers as they were already getting water at relatively cheap rates. Nevertheless, the society, named, "Shri Datt Sahakari Pani Vatap Saunstha Maryadit" (SDSPVSM) was formed with 92 members after a long and protracted process of registration in 1989.

4.1 Deciding the Leader

The first board of directors/governors, was appointed or selected by the NGO, CASAD and the government. CASAD undertook the exercise by listing 5 - 6 potential candidates among the farmer members and considering each one from the point of view of making the venture a success. (Lele, 1994). The President was appointed by the catalyst agencies and he along with advice of the catalyst agency representatives, selected the other eight office bearers.

5. THE DESIGN OF THE NEW SYSTEM

The new system was designed to work as follows: the society bought water from the irrigation department of the government at volumetric rates. It was entitled to receive water on a volumetric basis annually, broken in three phases on the basis of the agricultural seasons as shown in Table 1. If the sanctioned water in the rabi season is not fully utilized, this claim could be carried forward to the next season and more water could be drawn then. The maximum amount of water allotted to the society for each season is shown in the Table 1 and the rates at which the government or the irrigation department would charge the society are shown in Table 2.

This water was then sold by the society to its members and non-members according to predetermined rates, which were crop area based and not volumetric. The water rates for staple crops were continued as the earlier government rates but the water rate for sugarcane was decided by the members of the society collectively. This was now pegged at a much lower rate than the earlier government rate of Rs. 400/acre at Rs. 100/acre. (See Table 3). The water rates for non-members were 30% higher across the board.

Table 1: Water Allocation Season-wise.

Sr. No.	Season	Duration	% allocation	Amount in '000 cum
1.	Kharif (monsoon)	1st July –15th October	24 %	433
2.	Rabi (winter)	16th October- 28th Feb.	60 %	1058
3.	Summer	1st March –June end.	16 %	283
	Total		100	1774

Source: Compiled from Lele, 1994.

As earlier, the members had to apply for water. But now, they had to apply to the society office and not the section office of the irrigation department, which is located approximately 6 km from the village, whereas the society office is located within the village and is therefore much more accessible to the farmers. Once all the applications for the coming season are collected, the office bearers of the society work out the total water requirement and its schedule. This quantity and schedule is then conveyed to the section office of the irrigation department.

[1] Center of Applied System Analysis in Development (CASAD) which is now Society for the Peoples' Participation in Ecosystem Management (SOPPECOM)

Table 2: Water Charges to Society (per 1000 cum)

Season	Rate in Rs. 1000 cum	Max. Allocation ('000 cum)	Total Amount in Rs	Current Rate as on 31.3.06 (Rs.)	Total Amt as per New Rate (Rs.)
Kharif	10	433	4330	47.60	20610.8
Rabi	15	1058	15870	71.40	75541.2
Summer/HW	37.50	283	10612.50	144.80	40978.40
Total		1774	30812.50		137130.40

Source: Compiled from Lele, 1994, and field visits.

Once the schedule is conveyed to the ID, they approve it and this approved, proposed schedule of release of water by the ID into the Minor 7 canal is communicated to the society. The society then decides which field channel gates are to be opened when. This detailed schedule of opening the gates of the various field channels is put up in the society office so that members can come and check on which day their field is due to receive water. Accordingly, they have to keep their fields ready to receive the water.

Table 3: Water Rates Charged by Society to Members (Rate in Rs. per Acre)

Crop	Rate Before Society in Rs./Acre	Rate after Society Formation in Rs./acre.		
		Kharif (Monsoon)	Rabi (Winter)	Summer
Sugarcane	400	100		
Bajri		60		
Sunflower/Soyabean		60		
Wheat		60		
Green Gram harbara		60		

6. WORKING OF THE WUA/ IMPACT OF SOCIETY AND THE NEW SYSTEM

The new system started working as described above, the society started buying water from the government and selling it to its members. In terms of water rates, the society was able to charge water rates from its members at less than the government rates. So members now had to pay only Rs.100/acre for sugarcane as against Rs.400/acre earlier. For other crops water rates were much less at Rs.60/acre. The society was probably able to provide lower water rates to its members because of the initial subsidy given to it by the government as also because they could sell water to non-members at 30% higher rates.

The government also provided the society with maintenance funds for three years. These funds were used for repairing field channels.

The society was able to handle the inter season and inter member water distribution efficiently. For instance, during the rabi (winter) season the society did not use all the water allotted to it because of high water table. (They were using well water, which was getting replenished due to the seepage from the canal). Instead, they used the unused allocation in the summer season when there was general water scarcity.

Another change that the society brought about was the freedom that the farmers got to cultivate any crop they wanted. They did not have to ask for permission from the irrigation department. They had to just give their water requirement to the society.

On the whole the society worked well for the initial three years. In fact, it worked so well that surplus income was generated which was distributed to members. Thus members' income increased due to improved agricultural conditions, namely availability of cheap water, freedom to choose crops and decrease in paper work and transactions costs.

Although working on the basis of no profits, the cooperative was able to create surplus funds. Most of its members were satisfied about the water distribution. Moreover, the society was able to ensure some infrastructure development in terms of improvements of the village roads. The village roads used to get damaged mainly due to the trucks of the sugar factories coming to the farms to collect the sugarcane. The society was able to impress upon the sugar cooperatives that this was their responsibility and were able to get several of the village roads repaired. This was possible because the farmers were under one umbrella and with a competent leader. They were also able to secure some funding for further infrastructure development from an international agency because of their work.

The society also undertook regular cleaning of the canal, which did not happen very often during the period of government management.

The apprehensions of the farmers before the society was formed were allayed after the Managing committee (MC) took charge, because transactions were now more transparent, the MC was more vigilant and did not allow for misquoting of acreage on the demand form as against the actual acreage irrigated. (In a village, all members generally know about each others farm sizes. So there was minimal theft) Moreover, the MC maintained good discipline in supplying water to members by adhering to schedules.

The functioning and the general success of the water distribution society led to many visitors coming and studying this pioneering experiment. This experiment inspired an NGO of Nasik to advocate this model in their region.

6.1 Elections and Change of Leadership 1994

This period of success of the Chanda co-operative came to an end after 3-5 years around 1991-1994. Once the subsidy given by the government stopped, the water rates charged to the members had to be increased. The rates at which the society bought water from the government too were increased every year. This adversely affected the financial position of the society.

Around the same time, internal differences started cropping up in the society. Elections took place in 1994 and the initial body was voted out. There may have been disillusionment with the first governing body but there is also a view that this disillusionment was limited to a few who had their own vested interest in getting a new body elected and they influenced the remaining members into doing so.

Table 4: Water Rates Charged by Society to Members (Rate in Rs./Acre)

Crop	Rate Before Society, 1987 (Rs./acre)	RateAfter Society in 1989 (Rs./acre)	Rate After Election in 1994. (Rs./acre.)		
		Kharif	Kharif	Rabi	Summer
Sugarcane	400	100	250	350	350
Bajri		60	150	——-	——-
Sunflower/Soyabean		60	150	———	——-
Wheat		60	——	300	———
Green Gram harbara		60	——-	250	———

Note: Crops other than sugarcane are seasonal crops.

6.2 Leadership and Working of the New Managing Committee

The result of all these pulls and pressures was that a new governing committee was elected. Initially the new body worked fairly well but later problems started surfacing. It was a popularly elected committee but it reportedly lacked the competence to administer the distribution of a common property resource like water. The committee members were not well equipped to understand concepts related to measurement of water based on the flow of the water, width of the channels etc. It was reported that the office bearers of the society were unable to dispense their duties adequately. The distribution of water was not as efficient and equitable as before. Lack of discipline and vigilance was noticed in the functioning of the society.

Table 5: New Water Charges to Society (per 1000 cum).

Season	Old Rate in Rs. (Per ’000 cum)	Max. Water Allocation in (’000 cum)	Total Amount In Rs.Payable by society	New Rate as on 31.3.06 in (Rs. / ’000 cum)	Total Amt as per New Rate in Rs. Payable by society
Kharif	10	433	4330	47.60	20610.8
Rabi	15	1058	15870	71.40	75541.2
Summer/HW	37.50	283	10612.50	144.80	40978.40
Total		1774	30812.50		137130.40

Source: Compiled from Lele, 1994., field visits.

During this period, the society saw a lot of problems. The government subsidy stopped, the NGO withdrew from the day to day management. Finances and water allocation could not be managed as well as earlier. The farmers farther away from the canal would get little water and this led to internal differences. The water rates applicable to the members had to be increased because of increase in government rates and reduction in water availability. The promised grant by an international agency lapsed, reportedly, because the committee members were unable to comply with the formalities in time.

We gathered that these problems facing the society are mainly due lack of technically qualified people within the society or lack of an advisory capacity to the society. The society members are now realizing the importance of having a technically qualified leadership rather than only a popular one. The other major reason put forth by the people for the poor functioning of the water cooperative is that the water to every member cannot be metered. Water is measured only when the government releases it into the sub canal, in this case, Minor 7. However, the distributaries after that and the field channels do not have metering devices at their heads, because of which it is difficult to keep an account of how much water is let out and how much is to be paid for.

6.3 Recent Developments in the Chanda WUA

The Chanda WUA, which so far has been under the co-operative and the irrigation departments, has recently, in 2007, been delinked from the co-operative department. In accordance with this, the word, “Sahakari” has been dropped and the WUA is now called, “Shri Datt Pani Vatap Saunstha Maryadit” (SDPVSM). According to the secretary of the society, this is a more streamlined approach as now they have to adhere to the rules laid down by the irrigation department only.

Another recent development is that elections were held in 2007 and a new managing committee has taken charge, with a woman as the chairperson. It remains to be seen how this will impact the working of the society.

The society members are also trying to deal with the financial problems that have emerged. In our field discussions with members, we realized that although the society has increased the water charges to the members, they are not complaining. They maintain that even with higher charges to be paid to the society, they would rather use this system to procure water than the low priced government water because here their transactions costs (in terms of several visits to the section office, getting hold of the patvari to get their water etc.) are greatly reduced and they are getting the required water at the required time.

Members are also suggesting that the society should take up some commercial activity, which will augment the resources of the society. They have suggested that the society can undertake milk collection, which is currently being done by private middlemen in the village. Members would sell their milk to society and the society can earn some income from this. Another activity being suggested is the service of water testing and provision of labor. All these services are required by the members and hence can be to the mutual benefit of the society and the members.

7. WORKING OF WUA IN OTHER PLACES: EVIDENCE FROM OTHER PLACES IN INDIA

There has been a worldwide trend of increased farmer's participation in irrigation management. In India too, WUA are being promoted by the state governments like that of Haryana, Maharashtra, Karnataka and Andhra Pradesh.

Generally the evidence on the success of the farmers' participation in irrigation management is mixed. According to Gulati et al., many times, blame for failure is attributed to governmental interference but the real reason is also the lack of management and technical skills in the people (Gulati et al., 2005). At many places in India various strategies to induce participation by farmers are followed, like deploying governmental staff to assist these associations or deploying NGOs to help these farmers. Even in the current case study the association was promoted by the government and an NGO together. Moreover, the NGO was present of and on to help the society.

Among the various factors that could contribute to the success of such societies, size and composition of the association are important ones. Gulati et al argue that smaller groups can be successful because the transactions costs of negotiating within the group can be low, where as larger groups can give the advantage of financial viability and economies of scale in terms of hiring professional staff. Larger groups of farmers would lead to reduction in transactions costs of negotiations between the society and the irrigation agency but increase the transactions costs of negotiating within the group. (Gulati et al., 2005)

For India, Gulati et al., suggest that the smaller groups would be more successful. Gulati et al., discussing the desirable composition of the group, contend that a group exclusively of either poor farmers or rich farmers may not work too well. This is because the poor farmers lack time and money to mobilize themselves and the rich may not be have the need to act together. (Gulati et al., 2005). R. K. Patil, one of the key persons involved in formation of the Chanda co-operative, feels that the social cohesion of the group is important for it to succeed.[2] Hence, it seems that smaller groups, which are socially cohesive but differentiated in terms of income levels, are most likely to succeed. Moreover, the presence of an external agency to guide the society in concepts of water measurement and in conducting meetings seems necessary.

8. LESSONS FROM THE CHANDA WUA EXPERIMENT: THE CO-OPERATIVE VS THE GOVERNMENT SYSTEM

Examining the Chanda co-operative, one can see that it functioned well for the initial period when the NGO and government functionaries were actively involved, but later, the society was unable to function as well. If we examine the co-operative as an institution versus the government as an institution, to manage a common property resource like canal water for irrigation, the following points emerge:

1. The co-operative model in the area of canal water distribution (WUA) can be more efficient that the government system. This is because misquoting of acreage irrigated can be minimized in the system of the WUA. In a village, everyone knows everyone's farm size where as a single government officer the patvari may not know every farmer's farm size. Moreover, he has neither the incentive nor the means, to verify it.
2. In a WUA, all members are jointly responsible for paying water charges to the irrigation authority. Hence, in case of the co-operative model, peer pressure can be leveraged to ensure payment by most members, whereas in the case of one government functionary there is a tendency to cheat on payment of water charges by farmers by underreporting the farm area irrigated. Peer monitoring can be leveraged to decrease the cost of monitoring payment of water charges.
3. The same factor discussed above (peer pressure) is also likely to ensure an equitable distribution of water. If the co-operative does not ensure that the water reaches the farther off fields, farmers who own these fields can refuse to pay the water charges. Thus pressure can be brought about to maintain equity, where

[2]Opinion expressed at a conference on "Integrated River Basin Management" held at BAIF, Pune on 10th and 11th April, 2007 by Gomukh, Pune and Arghyam Bangalore.

as in the case of government system the single person (patvari) in charge has no major incentive to ensure a fair water allocation.

4. Moreover, a well run WUA can assure an efficient way to decentralize the water distribution. A government administered system may become too centralized and fail to take in the local conditions, problems and requirements while distributing water. When the government system was in place, a farmer wanting to cultivate a crop not mentioned in government price list/schedule, had to apply for special permission. This, according to most members, was a cumbersome thing. However, under the WUA, members are free to cultivate any crop. Hence, this kind of a decentralized approach can be advantageous.
5. A WUA can make another vital contribution which is absent under the government water distributing system. This is that people are inevitably brought together to resolve their problems and with this approach they learn to take responsibility for them. As seen in the Chanda experiment, although the WUA ran into problems of funds and conflicting interest, they have also begun to address these issues and will no doubt learn to resolve them in due course of time. Having realized the benefits of the WUA, they may co-operate in other areas such as marketing their produce, using newer techniques of farming, and ultimately also in protecting their common property resources. There are enough examples of the success of such ventures in their vicinity for them to get inspired. For instance, the Ralegaon Sidhhi village where Shri Anna Hazare has helped the people to help themselves and make it a developed village, similarly the Hiware Bazaar village where Shri Popat Rao Pawar has motivated the villagers to develop the village.

Hence, even if the WUA goes through a turbulent phase in the short term, over time one may expect very positive outcomes in terms of overall development. Any successful experiment has a strong demonstration effect, (the Chanda co-operative was visited and the Chanda model was emulated by the NGO of Nasik). Hence, one feels that the Chanda model or the WUA approach to water distribution has the potential to work well and deliver on the expected outcomes as well as have an impact on other larger issues of environmental protection, albeit over time. In the meanwhile some roadblocks could lengthen the process. If these can be removed, the process may be fastened.

1. A major one is to ensure active participation by all members. This is sometimes lacking because some farmers are too poor to be able to attend meetings. Rich members may not participate because they do not realize the benefit of doing so.
2. It is difficult to ensure fairness in water delivery and collecting the appropriate water charges because the canals are not lined and it is difficult to measure the water actually supplied to a particular field. This brings about scope for human error and dishonesty.
3. Some members have bore wells in their farms and draw water from these, a large part of which may have come from seepage losses of the canal. Although in the "Maharashtra Management of Irrigation Systems by Farmers Act" (MMISFA) 2005, farmers have to pay some charge to draw well water if well is located in the command of the dam, it is difficult to enforce this and collect these charges.

   Hence, to realize the complete potential of the co-operative model to ensure an equitable and efficient water usage, some concomitant factors have to be in place. These are:

1. Canals should be properly lined to reduce seepage losses and should be better maintained. Some system of metering the water at the field level would help.
2. Deploying competent persons of the government or any other independent agency to advice the co-operative functionaries in dispensing the water and measuring its usage is necessary.
3. As a fundamental and long-term solution, thought can be given to laying pipe lines to deliver water to farms to minimize evaporation and seepage losses and enable better measurement of water drawn.

9. SUMMARY AND CONCLUSIONS

Co-operatives in the area of canal water distribution for irrigation or WUAs are now a reality and no longer an experiment in the various states of India. The Maharashtra government has chosen this as the vehicle to distribute water for irrigation. So the question now is how to make these WUA realize their full potential to ensure efficient and equitable distribution of water

Having studied the pioneering attempt at Chanda in detail, one can say that the co-operative as applied in this area certainly has the potential to do what the government system could not. Since a co-operative is of the affected stakeholders, there is a greater incentive to use the canal water judiciously. In addition, in a village where everyone knows everyone, it is difficult for WUA members to cheat and under-quote the acreage irrigated by them using the canal water. Hence, the peer pressure of a co-operative can work to bring in efficiency, minimize thefts and ensure more equitable water distribution.

The detailed study of the Chanda WUA shows that the WUA could work well in the initial years due to two main reasons: one being that the governing body was selected by concerned state irrigation department personnel and an NGO. The other reason was the initial government help that it received in terms of the subsidy and the maintenance fund as well as technical guidance in the initial period. Since the initial office bearers were selected, they were mostly competent people who understood the nuances of not only farming but also of canal irrigation and water measurement. This competence in no small terms helped the society to function well. In fact, one can hypothesize that had a similar competent committee taken charge of the society after the elections, it could have continued the good work despite other drawbacks like the withdrawal of the subsidy.

Despite these drawbacks, it is seen that the Chanda co-operative members are attempting to improve the working of the WUA. They are suggesting commercial activities, which can be taken up to augment the resources of the co-operative. Moreover, despite the problems, they are showing a preference for this co-operative decentralized system as against a centralized government system of water distribution. According to them, this system is able to meet their requirements adequately and minimize their transactions costs.

Further, the co-operative members are showing a readiness to co-operate for a common goal, namely to get the system problem free and moving. This readiness can imply that in the long run, such a co-operative may take up problems of conserving common property resources once they realize that by doing so they will all benefit. This realization may not take too long a time as they have inspirational examples in their vicinity, namely the villages of Ralegaon Sidhhi and Hiware Bazaar.

Some problems could delay the process of realizing the above discussed benefits of applying a co-operative model in water distribution. One of these is that the water distributed to each individual farmer cannot be metered. This leads to problems of extracting the fair and proper price for the used water. Another problem which is encountered, though not necessarily only in the cooperative model, is that the sub-canals are not properly lined leading to major seepage and evaporation losses.

Hence one can say that the decentralized cooperative model can be useful in addressing the problem of efficient and equitable distribution of a common property resource like water, as against the centralized government system. Moreover, the adoption of the co-operative model may lead to other positive externalities, encompassing the general development of the village. Providing some enabling conditions, as detailed below, may help to speed up the process. Firstly, proper lining and maintenance of the sub-canal and the field canals can help to minimize the seepage and evaporation losses. Secondly, introducing some system of metering the water to measure how much water is drawn by each farmer may help. If not meters at every canal head, what is needed are competent persons who can calculate the approximate area that gets irrigated by studying the flow of the water and the width of the canals. Deploying competent persons of the government or an independent agency like an NGO, are needed, at least in the short run. Thirdly, as suggested by some of the society members themselves, a fundamental change as a long term solution to the problem of inefficient use of water, is that pipes could be used to take the canal waters to the fields so that measuring the water delivered is possible, is more accurate and evaporation and seepage losses are minimized.

In conclusion, the co-operative approach to distribution of canal water can not only be an efficient and equitable system of water distribution as against the earlier centralized government system, but it also has the potential to be applied to more such areas of public goods, especially natural resources which need to be conserved or used judiciously. Hence, a prudent implementation of the co-operative model in water distribution (the WUA), is necessary to ensure that the potential of the co-operative model to ensure an equitable, efficient and sustainable use of canal water for irrigation is realized.

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RIVER BASIN ORGANISATIONS IN INDIA: AN OVERVIEW

K. V. Raju and Avinandan Taron[1]

Abstract

The paper proposes river basin management as crucial to development and stresses the need of proper management. It looks at the various river basin organizations formed in India, lists their functions and performance. The paper concludes with pointing out the various impediments – political, economic and institutional – in formation of RBOs in the Indian context.

1. INTRODUCTION

Down the ages river basins have been home to civilizations across the world. River water has always catered to the needs of society in different ways. With growth of competitive uses and users at a tandem we have now realized that such a natural resource is priceless and needs to be managed properly. The philosophy of manipulating supply according to the demand for water is shifting towards designing ways and means for economical and efficient use of this resource. In this context, the concept of river basin management becomes important. Further, the institutions responsible for such management need to be evaluated for better allocation and efficient use of water resources.

River basin management may be taken up for various objectives depending on local needs including capturing run-off, minimizing soil erosion or reducing pollutions. This approach requires integrated development of non-arable land, arable land, rain water, vegetation, livestock, local materials, common property resources, human resources and programs for landless in a participatory process. Productive employment generation and conservation of resources are important concerns of watershed management projects. Even emphasis on landless, gender issues and biodiversity utilization are included in the principles of the basin management.

Around the world this idea is gaining importance although implementation may be at the pilot level rather than the whole country. Management models vary from country to country and the direct experiences that have accumulated are relatively small but increasing. Situations across countries vary since they have different cultural, political and administrative traditions. Further, within country basin characteristics, uses and users are also different. For this reason we cannot state any specific set of rules according to which river basins can be managed, but some principles can be identified which will be useful guidelines and can be adopted based on the situation.

This paper tries to address the issues pertaining to river basin management in India from the perspective of River Basin organizations. It probes how River Basin Organizations (RBO) are characterized by law and practice and tries to suggest ways to manage RBOs and overcome constraints of RBO.

1.1 Institutional Aspects of River Basin Management

An institution sets the ground rules for resources use and establishes the incentives, information and compulsions that guide economic outcomes. According to North (1990), institutions are defined as "the rules of the game in the society, or more formally, the humanly devised constraints that shape human action". Institutions can be both formal and informal. While written laws, rules and procedures form the formal institutions,

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informally established procedures, norms, practices and patterns of behavior also form part of the institutional framework. Institutions can take a variety of forms:

- Policy and objectives,
- Laws rules and regulation,
- Organizations, their by laws and core values,
- Operational plans and procedure,
- Incentive mechanisms, and
- Norms, traditions, practices and customs.

Organizations are defined as "networks of behavioral roles arranged into hierarchies to elicit desired individual behavior and coordinated actions obeying a certain system of rules and procedures" (Cernea, 1987). Organizations are groups of individuals with defined roles and bound by some common purpose and some rules and procedures to achieve set objectives.

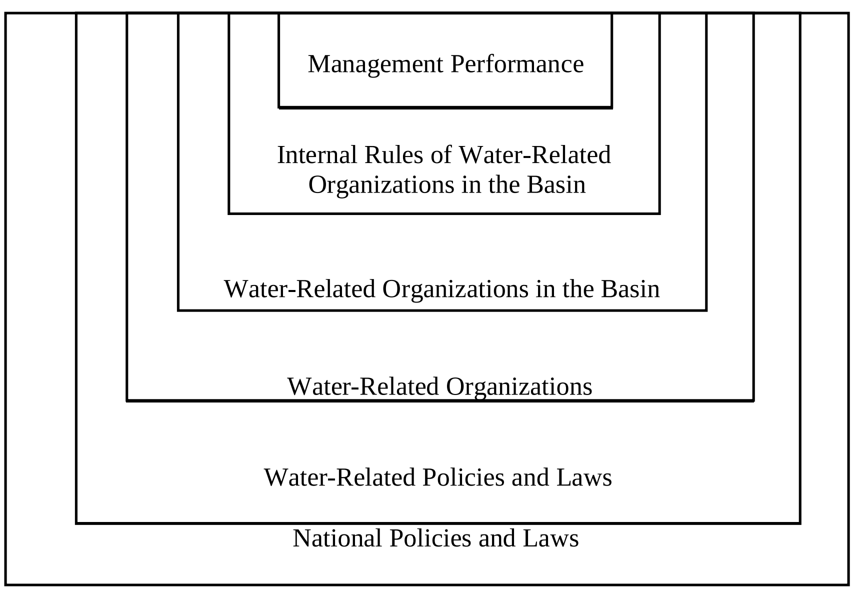
The institutional framework for water resources management in a river basin context consists of established rules, norms, practices and organizations that provide a structure to human actions related to water management. The established organizations are only a subset of all possible existing institutions. We can broadly classify the whole institutional framework into three categories – (i) Policies, (ii) Laws and (iii) Administration, all of which are related in some way to water resources management in a river basin context (Bandaragoda, 2002)

i. Policies:
   - National policies,
   - Local government policies,
   - Organizational policies

ii. Laws:
   - Formal laws, rules and procedures,
   - Informal rules, norms and practices,
   - Internal rules of organizations.

iii. Administration:
   - Organizations at policy level for resources management,
   - Organizations at implementation level for delivery management.

Figure 1: Water institutions that play a role in the management of water resources



Source: Adopted from Small and Svendsen (1990).

The entire framework can be clearly understood from the diagrammatic representation given here. In the diagram we find the representation of the three aspects of the water institutions that play an active role in the management of water resources if we consider the basin as the hydrological unit of study. In this study we restrict ourselves to the administrative unit of institutions and try to find its relationship with policies and laws. Hence, the following sections will concentrate on the administrative units particularly the River Basin Organizations (RBOs) and how are policies and laws related to such organizations.

1.2 Administration Responsible for Water Resources Management in India

At the national level, the Ministry of Water Resources (MoWR) is recognized as the nodal agency for water resources. While under the MoWR, there are a number of technical agencies, such as the Central Water Commission to manage surface water, the Central Groundwater Board (CGWB) on ground water resource and the National Water Development Agency (NWDA) in assessing inter-basin transfer options. There are other agencies linked to the MoWR, the Indian National Committee for Irrigation and Drainage, the Indian Water Resources Society, Water and Land Management Institute, Central Water and Power Research Station (CWPRS), National Institute of Hydrology, Indian Council for Agricultural Research (ICAR) and others. In addition, there are agencies that are involved in various aspects of river basin management, through wasteland development, promoting drinking water and sanitation, agricultural development, pollution control and others. The Planning Commission at the national level provides project clearance and approves financial allocation to various water (irrigation/ hydropower/ multipurpose) projects in different states. However, given that 'water resources' are a state subject under the constitution, the actual legislative and managerial responsibilities are with the public works, irrigation, or water resources departments at the state level. There are also important organizational arrangements to achieve inter-state and center-state coordination. These include various river boards created under the River Boards Act of 1956 and the National Water Resources Council (NWRC) set up in 1983, and the National Water Board (NWB) set up in 1990. The NWRC is an important policy organ in the Indian water sector as it is the apex body chaired by the Prime Minister and includes the Union Minister of Water Resources and the Chief Ministers of each state. The NWB – considered as executive arm of NWRC is chaired by the Secretary of MOWR and includes the Chief Secretaries of all the states, secretaries of the concerned Union ministries as well as the Chairman of CWC. While state irrigation departments have a larger role in the provision and management of public irrigation systems, local governments such as municipalities and *panchayat* (village council) also play an important role in drinking water supply. In larger cities and towns, water for drinking and some other pressing needs is also supplied by small private contractors (though at exorbitant costs) especially during summer months when municipal supplies fall short of the soaring demands. Pollution control boards set up both at the center and in the states have the responsibility for water quality aspects (Saleth, 2004).

2. POLICIES, LAWS AND RIVER BASIN ORGANISATIONS

National Water Policy, 1987

The Indian National Water Resources Council adopted the National Water Policy in September 1987.[1] The National Water Policy of 1987 recognized water as a precious national resource and it talked of development of water resources based on national perspectives. The Policy called for conjunctive use of surface and groundwater, the need for planning water use on a hydrological basis and inter-basin transfers of water from surplus to deficit regions. More importance was placed on drinking water followed by irrigation, hydro-power and industrial uses. The policy mentions proper institutional arrangements for such purposes.

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[1]The Prime Minister is the Chairman, Union Minister of Water Resources is the Vice-Chairman and Minister of State for Water Resources, concerned Union Ministers/Ministers of State, Chief Ministers of all states and Lieutenant Governors/Administrators of Union Territories are the Members. The Secretary, Ministry of Water Resources is the Secretary of the National Water Resources Council.

National Water Policy, 2002

India's National Water Policy of 2002 was adopted by the National Water Resources Commission (NRWC) April 1, 2002. With water demands outstripping supplies, the government felt the need for revision 15 years after first National Water Policy of 1987.

The Policy recognizes that water is a scarce resource and precious national resource and lays down the broad principles that govern the management of the country's water resources. Some of the key additions are shown in Section 4.1:

"4.1 With a view to give effect to the planning, development and management of the water resources on a hydrological unit basis, along with a multi-sectoral, multi-disciplinary and participatory approach as well as integrating quality, quantity and the environmental aspects, the existing institutions at various levels under the water resources sector will have to be appropriately reoriented / reorganised and even created, wherever necessary. As maintenance of water resource schemes is under non-plan budget, it is generally being neglected. The institutional arrangements should be such that this vital aspect is given importance equal or even more than that of new constructions.

4.2 Appropriate river basin organisations should be established for the planned development and management of a river basin as a whole or sub-basins, wherever necessary. Special multi-disciplinary units should be set up to prepare comprehensive plans taking into account not only the needs of irrigation but also harmonising various other water uses, so that the available water resources are determined and put to optimum use having regard to existing agreements or awards of Tribunals under the relevant laws. The scope and powers of the river basin organisations shall be decided by the basin states themselves." (National Water Policy, 2002).

While National Water Policy 1987 mentions about proper institutional arrangements National Water Policy, 2002 clearly spells out the need for RBOs and recommends such institutional establishments for river basin management. However, in implementation it was not the same.

2.1 Legal framework for Creating River Basin Organizations in India[2]

The legal framework for constituting an Inter-State River Basin Organization is contained within the Constitution of India itself. The Constitution of India has vested powers on the Parliament of India for the "Regulation and development of Inter-State rivers and river valleys to the extent to which such regulation and development under the control of Union is declared by the Parliament by law to be expedient in the public interest" by virtue of Entry No. 56 of List I in the Seventh Schedule to Article 246 [as has been described above]. This power vested in the Parliament of India is supreme because the powers vested in the state (Legislatures) over water, by virtue of Entry 17 List II Seventh Schedule to Article 246 is specifically made subject to Entry No. 56 of List I in the Seventh Schedule to Article 246. The parliament of India within six years of adopting the Constitution of independent India, enacted a specific law for the constitution of the River Basin Authority, namely the River Boards Act, 1956 (Act 49 of 1956). However, despite this path breaking law of 1956, not a single River Board has been constituted under this Act (Iyer, 1994; Naqvi, 2006).

This is largely due to the fact in Section 4(1) of the Act the exercise of the power of the government of India to establish a River Board is dependent on a "request received from a state government". No state government has either made any such request nor is any state government likely to make any such request.

Another reason for the failure of this act might be the Inter-State Water Disputes Act, which was also enacted in 1956 (Act 36 of 1956). Under the Inter-State Disputes Act the central government is bound to constitute a Water Tribunal when there is a complaint even by any one of the riparian states, whereas in case of the River Boards Act there should be a collective request for the constitution of an inter-State River Board. If this be the position, the co-existence of a River Board and a Water Tribunal seems questionable. Even if a River Board would have been set up it cannot be said that the riparian states would have waived their rights under the Inter-States Water Disputes Act of seeking the constitution of a Water Tribunal for the settlement of any disputes with respect to the very same inter-state river for which the Board is operating. An element of "dispute" seems to be the primary reason for the government to act and not the "regulation and development of the river".

[2]This section captures the central theme of the draft report of Naqvi (2006).

River Boards under the 1956 Act were also not constituted as in that case the State's constitutional power over water under Entry 17 would become subject to the power of the River Board following its constitution. Yet another reason could be that whereas under the dispute resolution mechanism under the Inter-States Water Disputes Act of 1956 a state would become entitled to a specific share in the inter-state river water, but under the River Boards Act a state can merely raise a dispute pertaining to an advice given by the Board with respect to the inter-state river. Whereas by the Tribunal Award the state would enjoy absolute rights over the use of that share of water, an agreement subjected to the River Board may prevent the state in exercising its rights over the river water which may have been apportioned to it.

2.2 Approaches to River Basin Management in India

In this section we summarize Indian River Basin Boards with reference to their origin, functions, structure and achievements. As a whole it can be understood from this section that, in the Indian context, most RBOs are structured for planning, design and implementation of large projects-and thus follow the top-down approach rather than the bottom-up approach.

2.2.1 Origin of existing basin boards[3]

The origin of River Basin Boards in India can be seen from two perspectives: (i) function vested upon the board by certain policies, (ii) legal considerations for its formation. The legal instruments that have been applied for the establishment of these boards are –

- Specific Acts for the establishment of RBOs as in the case of the Damodar Valley Corporation or Brahmaputra Board
- RBOs formed by Tribunals as a result of existing inter-states river water disputes among riparian countries. Here the Inter-State Water Disputes Act of 1956 was made use of
- Specific State Acts (Bhakra Beas Management Board), Notifications (Tungabhadra Board) or MoU between states as in the case of Upper Yamuna River Board.

The main functions entrusted upon these River Basin Boards or Organizations include flood control, completion of multipurpose projects, allocation of water resources as provided under the Tribunals, and preparation of basin and regional plans for optimum water usage. No use was made of the legal framework at this point.

2.2.2 Organization structure of the RBOs[4]

River Basin Organizations in India are typically either headed by the Ministry of Water Resources or Power or a Chairman appointed by the GoI (who may be a chief engineer of that particular basin or in certain cases may be the Chairman of the Central Water Commission). The structure of the RBOs is generally highly bureaucratic, with no participation of the stakeholders. Thus, all existing basin boards in India follow the top-down approach with decisions taken at the centre or a basin state. Few water users or waterusing sector are generally represented on these boards.

The majority of the Boards are single-tier consisting of the board members headed by a Chairman. The performance of Basin Boards is influenced by the Chairperson in charge. In general, it is perceived that if a board is headed by engineers (whether of that particular basin or the Central Water Commission) it would perform better than a board headed by the state or Central Ministers[5].

Only few River Basin Boards in India have supporting committees with powers delegated to those committees. For instance, the Bhakra Baes Management Board has separate wings for irrigation and power which are headed by members of the board under a common chairman. The DVC (Damodar Valley Corporation), on the other hand has a corporate structure, but the board has no Committees or sub-committees.

[3] Detailed Description of this is present in Annex 2, Table 1 provides summary

[4] Detailed Description of this is present in Annex 3, Table 2 provides summary

[5] This statement is based on the perceptions of some of the personnel of Central Water Commission interviewed.

Table 1: Origin of the Existing RBOs in India

River Basin Organisation	Year of establishment	Purpose of Origin			
		Legal			Policy
		Acts	Tribunals	State and Central Acts	
The Damodar Valley Corporation	1948	Damodar Valley Corporation Act, 1948.			
Tungabhadra Board	1955			Notification No. DW VI(4)(S) dated 10.3.55 by the GOI[6] in exercise of the powers vested under Section 66(4) of Andhra Pradesh State Act	Completion of the Tungabhadra Project, maintenance and operation.
Bhakra-Beas Management Board	1976			Constituted by GOI under Section 79 of Punjab reorganization Act 1966	Administration, maintenance and operation of Bhakra-Nangal Project.
Cauvery River Authority	1998		River Cauvery Water Disputes Tribunal (1998)		Implementation of interim order of the tribunal, final verdict was awarded recently.
Ganga Flood Control	1972				Resolution by the Ministry of Irrigation and Power for tackling floods in Ganga and its tributaries
Bansagar Control Board	1976				Constituted for efficient, economical and early execution of Bansagar Dam and connected networks.
Brahmaputra Board	1980	Brahmaputra Board Act, 1980			

[6]GOI refers to Government of India

Table 1: Origin of the Existing RBOs in India

River Basin Organisation	Year of establishment	Purpose of Origin			
		Legal			Policy
		Acts	Tribunals	State and Central Acts	
Narmada Control Authority	1980		Narmada Water Disputes Tribunal under clause XIV		Proper implementation of the decisions of the Tribunal
Rajasthan Canal Board	1958				To ensure efficient, economical and speedy completion of the project
Upper Yamuna River Board	1994			MoU signed by the Chief Ministers of the riparian states (HP, Haryana, UP, Rajasthan and Delhi)	Allocation of utilizable surface water flow
Betwa River Board			Constituted under the Betwa River Board Act, 1976		Efficient, economical and early execution of Rajghat Dam project
Krishna-Godavari Commission	1961				Review of availability of supplies in the concerned basins and to determine the extents to which further demands can be met from this basins
Sone River Commission	1980				Compiling and analyzing Hydrological and Hydrometerological data, consumptive use data and to carry out investigations and studies for basin level plans

Source: Compiled by the authors from the websites listed below:

http://www.uryb.nic.in/home.htm
http://wrmin.nic.in/cooperation/uyrb.htm
http://www.dvcindia.org/
http://wbpower.nic.in/dvc.htm
http://wrmin.nic.in/cooperation/brahmaputra.htm
http://bbmb.gov.in/english/index.asp
http://wrmin.nic.in/responsibility/bbmb.htm
http://www.rajirrigation.gov.in/2ignb.htm
http://www.wrmin.nic.in/cooperation/ abhadra.htm
http://www.tbboard.org/
http://wrmin.nic.in/cooperation/betwa.htm

Table 2: Organizational Structure of the RBOs

River Basin Organization	Organizational structure					
	Number of Tiers	Controlled By	Board	Executive Committee	ED/Manager/Secretary	Other Committee
The Damodar Valley Corporation	Corporate (presence of delegation of powers through line officers where respective offices are headed by Chief Engineers)		The Board is headed by the Chairman under whom there are 3 personnel. There are two other members appointed by the riparian state governments			
Tungabhadra Board	Single tier		Board consists of 4 members headed by a Chairman (Engineer Godavari-Krishana basin), 1 member from GOI (Financial Advisor to MOWR), 1 Chief Engineer (Irrigation and CAD dept.) from Govt. of AP and 1 Secretary to Govt. of Karnataka (Water Resources)			
Bhakra-Beas Management Board (BBMB)	Two tiers - under the Chairman comes the Power, Irigation and Finance and Accounts wing. These wings are further delegated		BBMB is headed by a Whole Time Chairman and two Whole Time Members i.e. Member (Irrigation) and Member (Power) who head the Irrigation and Power Wings of BBMB respectively. There are 5 other members out of which 3 are secretary to the Govt. of riparian			i) Under the Member (Power) there are 3 Chief Engineers, ii) Under the Member (Irrigation) there are 3 Chief Engineers, iii) Under the Finance and Accounts Advisor

River Basin Organization	Organizational structure					
	Number of Tiers	Controlled By	Board	Executive Committee	ED/Manager/Secretary	Other Committee
			states (power and irrigation) and 2 to the GOI (Power and Water Resources).			comes the Deputy Finance and Accounts Officer and Senior Officers
Cauvery River Authority	Single tier		Board consists of 5 members headed by Prime Minister of India, the other members being the Chief Ministers of the 4 riparian states		The Union Minister of Water Resources would be the Secretary of the Authority	There exists a 11 member Monitoring Committee headed by the Secretary to the Ministry of Water Resources (GOI), 2 members from CWC, 4 Secretaries of the riparian state governments and 4 Engineers of the State Governments.
Ganga Flood Control Board(Ganga Flood Control Commission[7] established in 1972 is the Secretariat and Executive wing of the Board)	Single tier	Subordinate office of the Ministry of Water Resources	19 member Board headed by Union Minister of Water Resources comprising of six Union Ministers, Chief ministers of 11 riparian States (including Delhi) ,1 member of Planning Commission and Chairman of GFCC (Patna)			

[7] Ganga Flood Control Commis sion (GFCC), a subordinate office of Ministry of Water Resources, with its headquarter at Patna, was created in the year 1972 to deal with floods and its management in Ganga basin States vide Govt. of India Resolution No. F.C.47(3)/72 dated 18.04.72, as secretariat and executive wing of Ganga Flood Control Board, headed by Hon'ble Union Minister of Water Resources. Chief Ministers of basin States or their representative and Member, Planning Commission, are the members of the Board. Chairman, GFCC acts as the Member -Secretary of the Board. The Commission is headed by a Chairman, who is assisted by two full time Members, four Directors and 94 nos. of supporting staff. The representatives of the concerned Central Ministries as Well as Chief Engineers of the basin States are either part-time Members or permanent invitees of the Commission.

River Basin Organization	Organizational structure					
	Number of Tiers	Controlled By	Board	Executive Committee	ED/Manager/Secretary	Other Committee
Bansagar Control Board Single tier	Single tier		Board headed by Union Minister of Water resources with all members being politicians including the Chief Minister, Minister of Power and Irrigation of the three states (Madhya Pradesh, Uttar Pradesh and Bihar)	Executive Committee looks into the day to day affairs. It is headed by Chairman of CWC		
Brahmaputra Board	Single tier	Autonomous statutory body	Board consists of 21 members of which, 4 are full time and 17 part-time and 4 other invited member. Members represent seven states of the north-eastern region.		The General Manager, as the Chief Executive Authority of the Board, is responsible for proper administration of the affairs of the Board	
Narmada Control Authority	Single – Comprising of the board members and other Sub-Committees		Board of Fifteen members, out of which 4 are Secretary to GOI, 4Secretary to the riparian State Governments 3 Chief Engineer appointed by GOI for Environmental concerns and R&R, 4 other engineers appointed by GOI for power and irrigation		The Authority shall employ a Secretary, who shall be an Engineer	Sub-Committees – Environmental Sub-group, Resettlement and Rehabilitation sub-group, Resettlement Committee, Hydromet Sub-group, Narmada Main Canal Committee, Power sub-committee, Sardar Sarovar Reservoir Regulation Committee

River Basin Organization	Organizational structure					
	Number of Tiers	Controlled By	Board	Executive Committee	ED/Manager/Secretary	Other Committee
Indira Gandhi Nahar Board (previously Rajasthan Canal Board)	Two – i) Standing Committee and Chief Engineer, Bikaner ii) Financial Advisor and chief Engineer, Jaisalmer	Under purview of Inter State Control Boards during their construction phase and were passed on to the State Irrigation CAD & WU departments for maintenance and operation headed by Minister (Indira Gandhi Nahar Project) followed by Committee of Directors headed by Chief Secretary	Twelve member Board headed by Chairman cum Administrator, comprising of 7 Secretaries to different Departments and rest are engineers			
Upper Yamuna River Board (one-tier)	Single tier		Board constituting of eleven members headed by Chairman of CWC and comprising of engineers (10)and one hydro-geologist			

River Basin Organization	Organizational structure					
	Number of Tiers	Controlled By	Board	Executive Committee	ED/Manager/Secretary	Other Committee
Betwa River Board (three tier)	Three – Board, Executive Committee and High Level Committee		Headed By Union Minister of Water Resources. It is the apex body of the Board and reviews the progress and performance of the project	Exercises all the executive and financial powers. Headed by Chairman of CWC		High Level Committee – comprises of Chief Engineer, Secretary and Financial Advisor of the Board. This body carries out the activities as laid down by the EC

Source: Compiled by the authors from the websites listed below:
http://www.uryb.nic.in/home.htm
http://wrmin.nic.in/cooperation/uyrb.htm
http://www.dvcindia.org/
http://wbpower.nic.in/dvc.htm
http://wrmin.nic.in/cooperation/brahmaputra.htm
http://bbmb.gov.in/english/index.asp
http://wrmin.nic.in/responsibility/bbmb.htm
http://www.rajirrigation.gov.in/2ignb.htm
http://www.wrmin.nic.in/cooperation/tungabhadra.htm
http://www.tbboard.org/
http://wrmin.nic.in/cooperation/betwa.htm

Thus, there is currently no uniform basin structure in India. Simply increasing the number of members in the board would not necessarily increase the efficiency of the organization; instead a delegation of duties according to the situation that may arise could improve water resources management.

The large majority of the various basin boards and RBOs currently in existence in India are functional in scope, that is, the adopted approach is demand-oriented and focuses on the resolution of specific problems in the river basin.

2.2.3 Primary Functions of Indian RBOs

The functions of River Basin Boards vary ranging from

I. preparation of basin level and regional plans,

II. maintenance of the allocation of water supplies for different uses,

III. generation of hydroelectric power

IV. investigations for further allocations if it is to be made

V. maintenance of the multi-purpose projects

VI. monitoring etc.

Thus, different Basin Boards have different motivations behind their formation, which are basically need-specific. Moreover, the funding of these boards differ: While some generate their own funding and budget, others depend on the government. Details are provided in Table 4.

Table 3: Functions of Indian River Basin Boards

River Basin Organisation	Functions						
	Allocation of Water	Distribution of Water	Civil Construction	Power Generation and Transmission	Comprehensive Plan for Basin Management	Data Generation and Dissemination	Other
The Damodar Valley Corporation	For irrigation and water supply	Supply of water for kharif, rabi and boro cultivation in the command areas as well as for non-agricultural use	From inception a network of four dams have been constructed. The board takes car e of maintenance and operation of the dams	Generation of Thermal and hydroelectricity as well as transmission and distribution of power			Flood control, control of soil erosion and socio-economic development of the people living in the valley
Tungabhadra Board	Allocation according to the Tribunal between AP and Karnataka		Maintenance of dam and reservoir of the project	Regulation of power from the two power houses			Granting of lease to the fisheries, development of new schemes for hydropower generation and generation of revenue from the assets of the Board
Bhakra-Beas Management Board		Regulation of supply of water among the riparian states	Operation and maintenance of Bhakra-Nangal project	Generation, regulation of hydroelectricity and distribution of power among the riparian states			Providing and performing engineering & related technical and consultancy services in the various fields of hydroelectric power projects and irrigation projects and to carry on all kinds of business related thereto, either independently or as a Joint Venture with any Central/State/ Public Sector Undertaking(s) or establishment(s) under the administrative control of Ministry of Power. Joint venture with any other agency/organization will be subjected to the approval of the Central Government

River Basin Organisation	Functions						
	Allocation of Water	Distribution of Water	Civil Construction	Power Generation and Transmission	Comprehensive Plan for Basin Management	Data Generation and Dissemination	Other
Cauvery River Authority	Allocation of water among riparian states according to the Tribunal's award						
Ganga Flood Control Commision					Plan for flood control and its implementation	Documentation and dissemination of information	Preparation of budgets for implementing plans, monitoring flood control measures and to monitor the execution of the important flood control schemes particularly those receiving Central Assistance or being executed under the Central Sector
Bansagar Control Board							
Brahmaputra Board					Preparing Master Plan for flood control		Controlling bank erosion and improvement of drainage congestion, construction and maintenance of projects

[8] PAPs refers to Project Affected Persons

River Basin Organisation	Functions						
	Allocation of Water	Distribution of Water	Civil Construction	Power Generation and Transmission	Comprehensive Plan for Basin Management	Data Generation and Dissemination	Other
Narmada Control Authority	Implementation of the Tribunal for sharing of water			Sharing of power between riparians			Acquisition of land for Sardar Sarovar project, rehabilitation and resettlement of the PAPs[8], taking environmental safeguards
Upper Yamuna River Board	Supply of water according to the MoU				Planning for catchment area and watershed management, rehabilitation and conservation of environment	Submission of annual reports to the Central and the riparian states	Maintenance of ecological considerations and monitoring groundwater exploitation
Betwa River Board	Sharing of water as per the MoU between UP and MP						
Krishna-Godavari Commission						Reporting on the requirements of the projects on Krishna and Cauvery and on the feasibility of diversion of surplus supplies of the basins	

River Basin Organisation	Functions						
	Allocation of Water	Distribution of Water	Civil Construction	Power Generation and Transmission	Comprehensive Plan for Basin Management	Data Generation and Dissemination	Other
Sone River Commission						Compile and analyse data on - hydrological and hydrometerological, utilization of Sone waters, socio-economic variables, agronomic and geological, and the completed projects. Preparation of regional plans for optimum use of Sone waters	

Source: Compiled by the authors from the websites listed below:
http://www.uryb.nic.in/home.htm
http://wrmin.nic.in/cooperation/uyrb.htm
http://www.dvcindia.org/
http://wbpower.nic.in/dvc.htm
http://wrmin.nic.in/cooperation/brahmaputra.htm
http://bbmb.gov.in/english/index.asp
http://wrmin.nic.in/responsibility/bbmb.htm
http://www.rajirrigation.gov.in/2ignb.htm
http://www.wrmin.nic.in/cooperation/tungabhadra.htm
http://www.tbboard.org/
http://wrmin.nic.in/cooperation/betwa.htm

3. ACHIEVEMENTS OF INDIAN RIVER BASIN BOARDS

Achievements of Indian River Basin Boards need to be measured in relation to original objectives.

The Damodar Valley Corporation was formed following the model of TVA. The main functions of the DVC are civil works and power generation. The DVC constructed a total of four dams. The board takes care of maintenance and operation of these dams. DVC is responsible for the generation of thermal and hydro electricity as well as transmission and distribution of power. The flood absorption capacity as envisaged in the original plans could not be created due to the reduced scope of work. Despite this, significant flood prevention was achieved. The provision of irrigational facilities has been handed over to the government of West Bengal.

Against the allocation, the utilization of water from the Tungabhadra Project has drastically come down due to heavy siltation in the reservoir.

The constraints facing the BBMB are - (a) Transfer of Control of Head Works at Ropar, Harike and Ferozepur from Govt. of Punjab to BBMB, and (b) Selection of Gauge Discharge sites for installation of Automatic Stage Recorders and drawing of Gauge Discharge Curves at various contact/ control points.

The Cauvery river Authority is a semi-political body for the implementation of the interim order of the Tribunal only. The authority can afford little precedent value or can act as an authority for river basin management. The authority has not yet been formed because the Tribunal has not been accepted by the riparian states of Karnataka and Tamil Nadu. The Narmada Control Authority, Rajasthan Canal Board and the Betwa river Board are yet to complete the projects assigned either by the central or the state governments. The Krishna-Godavari and the Sone river Commission shut down after submission of their final reports as planned.

Table 4. Achievements of the RBOs

RBOs	Envisaged Plan	Achievements
The Damodar Valley Corporation	The Damodar Valley Project was modeled according to the Tennessee Valley Authority and envisaged to generate 200MW of electricity and irrigate 0.308 million hectares in West Bengal through the construction of eight barrages and dams across the river	It was later decided upon to go for four dams – Tilaiya, Konar, Maithon and Panchet and a barrage at Durgapur. Subsequently Tenughat Dam has been constructed by the Government of Bihar. There are hydro-electric power stations at Tilayia, Maithon and Panchet, with total installed capacity of 144 MW. DVC has created irrigation potential of 3640 square kilometres.DVC operates thermal power stations at Bokaro, Chandrapura, Durgapur and Mejia, with total derated capacity of 2745 MW. The power station at Bokaro was biggest in the country when it was built in the fifties. DVC is expanding its thermal power capacity and with the completion of its present plans by 2012 it would be generating more than 5000 MW of power.
TungaBhadra Board	The Krishna Water Disputes Tribunal has made specific provision in the Award for the use of Tungabhadra waters by the States of Karnataka and Andhra Pradesh.	The Board is regulating the water for irrigation, Hydro Power generation and other uses, from the reservoir.

RBOs	Envisaged Plan	Achievements
	The responsibility for carrying out this specific provisions relating to the use of Tungabhadra waters has been entrusted to the Tungabhadra Board by the Tribunal. Two Power Houses are maintained by the Tungabhadra Board with a total installed capacity of 72 MW	The working table for canal-wise distribution of water to the States is prepared every year by the Tungabhadra Board in consultation with the State governments, and is reviewed from time to time during the water year. The working table for canal-wise distribution of water to the States is prepared every year by the Tungabhadra Board in consultation with the State governments, and is reviewed from time to time during the water year. Power generated is 114.8 million units against a target of 200 million units (according to 2000-01 data).
Bhakra-Beas Management Board	Other than operation and maintenance of Bhakra-Nangal Project , Beas Project I and II , regulation of supply of water and power from these projects to the states of Haryana, Punjab and Rajasthan, the other duties envisaged were construction of new Hydro Projects within and outside BBMB System. Construction of Hydel Projects at Thablan, Saunda and Chanarthal on Bhakra Main Line (BML) with an aggregate capacity of 19MW.	It has been remarked that it is one of the best managed Boards in the country. One of the unique characters of the Board is the absence of any Minister either from the State or central in the Board. BBMB plays a vital role in the day to day operation of the northern grid. The powerhouses help in frequency regulation of the grid by flexing generation between 1900 MW and 2800 MW in summers and between 500 MW and 1900 MW during winters. The States of Punjab, Haryana, Rajasthan and Delhi are being supplied, on an average, about 34537.49 MCM (28 MAF) of water per year. All the five units of Bhakra Right Bank powerhouse have been renovated, modernized and uprated from 120 MW to 157 MW each, resulting in an additional installed capacity of 185 MW and additional annual generation of 310 MU. Two units each at Ganguwal and Kotla powerhouses have also been renovated and modernized. All the Six units of Pong Power Plant have been uprated from 60 MW TO 66 MW each. This has resulted into additional peaking capacity of 36MW and additional energy generation of 17.3 MU besides additional reactive power of 90 MVAR.
Cauvery River Authority		
Ganga Flood Control Board	The Commission has been assigned the task of preparing comprehensive plan for flood management of the river system in	The important achievements of GFCC since its establishment in 1972 are summarised below:-(i) An outline plan for flood man

RBOs	Envisaged Plan	Achievements
	flood management of the river system in the Ganga basin, drawing out the phased programme of implementation of various schemes, monitoring of important flood management schemes, assessment of adequacy of waterways under road and rail bridges and providing other technical guidance to the basin States.	agement in Ganga Sub-basin was prepared in 1973.(ii)An approach to the flood problem and remedial measures in Ganga Sub-basin was prepared in 1980. (iii)The comprehensive plans for flood management in all the 23 sub-basins of the Ganga river system were prepared and are being periodically updated. (iv)Formulated guidelines on preparation of flood management schemes including design criteria. (v)Examined the adequacy of water ways in the road and railway bridges in 20 river systems and reports sent to concerned departments/ organizations of Central/ State Governments for follow up action. (vi) Performance evaluation of six completed major flood control schemes has been carried out. (vii)GFCC has been monitoring eight "ongoing flood control schemes in Ganga basin
Bansagar Control Board	It has been decided to set up the Bansagar Control Board with a view to ensuring the efficient, economical and early execution of Bansagar dam including all connected works in Madhya Pradesh, but excluding the canal systems which will be executed by respective States namely, Madhya Pradesh, Uttar Pradesh and Bihar. Expected year of completion of the project was: Dam – 2003 Canals - 2012	The project is being executed by the Madhya Pradesh Government under overall direction of the Board/Executive Committee on broad policies concerning the project. There are two field units e.g. Works and Land Acquisition and Rehabilitation (which is functioning independently since 1987).
Brahmaputra Board	The main functions of the board are spelled out in the Brahmaputra Board Act 1980. This consists mainly of preparation of the master Plan to control floods after carrying out surveys and investigations. The Master plan should have regards to the utilization and development of the water resources for irrigation, hydropower and navigation. This should also contain the budgets and estimates for proposed projects.	Three Master Plans (I, II, III) have been set up for Brahmaputra, Barak and 41 tributaries respectively. Several Multipurpose Projects have been identified by the Board namely, Pagladiya (in Assam), Tipaimukh (at Manipur-Mizoram), Subansiri (at Gerukamukh, Tamen), Menga (in Arunachal Pradesh), Dehang at Pasighat, Along, Pugging (in Arunachal Pradesh), Lohit (in Arunachal Pradesh), Debang (in Arunachal Pradesh), Kameng (in Arunachal Pradesh), Bairabi (in Mizoram), Someshwari (in Meghalaya), Jadukata (in Meghalaya), Kulsi (in Meghalaya). Till now Detailed Project

RBOs	Envisaged Plan	Achievements
		Reports of five multipurpose projects have been completed by the Board. These are Subansiri, Dehang, Pagladiya, Tipaimukh and Bairabi Dam Projects. In addition to this North-eastern Hydraulic and Allied Research institute have also been set up to facilitate the functioning of the Board.
Narmada Control Authority	The role of the Authority will mainly comprise of overall coordination and direction of the implementation of all the projects including the engineering works, the environmental protection measures and the rehabilitation program and to ensure the faithful compliance of the terms and conditions stipulated by the Central Government at the time of clearance of the aforesaid projects	i) The Resettlement and Rehabilitation Policy for the affected persons of Sardar Sarovar Project (SSP) is based on the decisions and final orders of the Narmada Water Disputes Tribunal (NWDT) Award. Considering the socio-economic and cultural background of the population being displaced and with a view to improving the living conditions of these people, all the three participating States have formulated their own policies which contain more liberal provisions than those envisaged in the Narmada Water Disputes Tribunal (NWDT) Award. ii) All studies relating to the clearance of Sardar Sarovar Project and Indira Sagar Project have been completed. Further studies to firm up to mitigative measures are continuing. The studies so far conducted have shown that the positive impacts, if any, can be managed with the help of safeguards being implemented. Relevant environmental action plans are also in place and under advance stage of implementation. Draft guidelines for conservation and development of Fisheries in the reservoir, streams and rivulets are on the anvil. A management information system using computer network with participating States and coordinating Ministry of Government of India is being developed in NCA. iii) The Narmada Control Authority has planned the setting up of Energy Management Centre at Indore at a cost of Rs. 36.9 million for monitoring the sharing of power produced at Sardar Sarovar Project by the Party States. The Narmada Control Authority has planned the setting up of Energy Management Centre at Indore at a cost of Rs. 36.9 million for monitoring the sharing of power produced at Sardar Sarovar Project by the Party States.

RBOs	Envisaged Plan	Achievements
Rajasthan Canal Board/IGNP	Indira Gandhi Nahar Project was designed to utilise 9,367 Mm3/yr of the total 10,608 Mm3/yr allocated to Rajasthan from the surplus waters of the Ravi and Beas rivers. The construction of the project has been divided into two stages: Stage I – consists of 204 km feeder canal, 189 main canal and 3454 km long distribution system. In addition to irrigation and domestic water supply through this project, it has been proposed by the Rajasthan State Electricity Board (RSEB) to install a total of 12.76 MW of mini hydro electric power stations, to utilize the available water fall in the canal. Stage II - IGNP Stage II comprises construction of a 256 km long main canal and 5,606 km of a lined distribution system, and will serve 1,410 kha of CCA	Stage I – feeder canal, main canal as well as the distributary canals are all lined serving an area of 553 kha of command area. One such power station, with an installed capacity of 2.2 MW has already started functioning at the Suratgarh branch of IGNP stage I. Stage II - The main canal in the entire length was completed in the year 1986.
Upper Yamuna River Board	After the MoU was signed between the states (comprising of Himachal Pradesh, Delhi, Uttar Pradesh, Rajasthan and Haryana) a separate agreement on construction of Hathnikund Barrage on the Yamuna was signed on 2nd November, 1994, and agreements on Kishau Dam on the Tons river and Renuka Dam on the Giri river were signed on 6th November, 1994 by all co-basin States, except Rajasthan.	The construction of the Hathnikund Barrage, since completed, was taken up under the World Bank assisted Haryana Water Resources Consolidation Project. While the Renuka Dam Project has been cleared from the techno-economic angle subject to clearance of concerned State Governments/ Ministries for cost sharing, environmental conservation and rehabilitation and resettlement considerations, the clearance of Kishau Dam Project has been deferred pending establishment of its economic viability. A review Committee to the UYRB has been set up to look into the allocation of the available surface water.
Betwa River Board	The Betwa River Board has been established for the creation of a reservoir at Rajghat by Construction on behalf of the Government of Madhya Pradesh and Uttar Pradesh, of a Dam on Betwa River at Rajghat and for the regulation of such reservoir. It is an Inter-State Project and it performs development of Betwa River & River Valley by creating a dam known as Rajghat Dam.	The Rajghat Dam and Rajghat Hydro Electric Projects are inter-State projects of Madhya Pradesh and Uttar Pradesh. The estimated cost of the Rajghat Dam is Rs 300.60 crore (at 2000 price level) and that of the Power House Rs 139.74 crore (at 1997 price level). The total expenditure incurred on the project is Rs 270.38 crore up to December 2004. The Rajghat Dam is almost complete. All the three units of

RBOs	Envisaged Plan	Achievements
		Rajghat Hydro-Electric Project have been synchronised during 1999 and 1431 units of electricity was generated during the year 2004-05 and 972 units up to 5 December 2005.
Krishna-Godavari Commission	Review the availability of supplies in Krishna and Godavari basins and to determine the extent to which further demands on these basins.	The Commission was wound up after submission of its final report in 1962. The recommendations of the Commission include establishment of a network of hydrometrological, sediment and water quality observation sites as well as setting up of inter-state river board for coordinated planning and integrated operation of all projects.
Sone River Commission	The scope of the Commission was limited only to the extent of compiling and analyzing hydrological and hydrometerological data, consumptive use data and to carry out investigations and studies for the preparation of basin and regional plans.	The Commission prepared a comprehensive Sone river basin plan for the optimum use of its water for various uses after carrying out system studies. The Sone River Commission had since been wound up in 1988 after submission of the final report containing the details of master plan for the Sone basin.

Sources: Compiled by the authors after visiting the following websites –
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http://wrmin.nic.in/cooperation/uyrb.htm
http://www.dvcindia.org/
http://wbpower.nic.in/dvc.htm
http://wrmin.nic.in/cooperation/brahmaputra.htm
http://bbmb.gov.in/english/index.asp
http://wrmin.nic.in/responsibility/bbmb.htm
http://www.rajirrigation.gov.in/2ignb.htm
http://www.wrmin.nic.in/cooperation/tungabhadra.htm

4. CONCLUSION

According to Hooper (2006), we can classify the River Basin Organizations into the following heads: Advisory Committee / Board, Association, Commission, Corporation, Council, Federation, Tribunal and Trust. This classification is based on the structure, formation and the functioning of the institutions related to the river basin management. In India, all the boards which are discussed fall under Advisory Committee/Board excepting DVC (which falls under Corporation) and Cauvery River Authority and Narmada Control Authority which are formed under the Tribunals (though both of them are set as Authorities).

Parliament can develop inter-state river basin boards [1956 River Boards Act] when they are in the public interest and requested collectively by states, but states are generally not interested, and perceive this as a loss of power. Till date this remains a 'dead letter' (Iyer, 2003). The legal instruments that have been applied for the establishment of these boards are –

- Specific Acts for the establishment of RBOs as in the case of the Damodar Valley Corporation or Brahmaputra Board
- RBOs formed by Tribunals as a result of existing inter-states river water disputes among riparian countries. Here the Inter-State Water Disputes Act of 1956 was made use of
- Specific State Acts (Bhakra Beas Management Board), Notifications (Tungabhadra Board) or MoU between states as in the case of Upper Yamuna River Board.

Indian river basin management to date thus focuses on solutions of specific problems

Similar to other countries and regions, for example, Sub-Saharan Africa, the great majority of existing organizations for IRBM in India is functional in scope, e.g. the adopted approach is demand-oriented and focuses on the resolution of specific problems in the river basin in question. The two main functions are planning and construction of infrastructure, and conflict resolution. Many of the Indian basin organizations have short-term objectives and some have been disbanded following achievement of these objectives.

Integrated approaches to (transboundary) river basin management that focus on the river basin as a whole and try to resolve the existing hydrologic, ecologic and socio-economic problems through holistic policies is not currently practiced in India. The integrated approach has been widely endorsed and promoted by international organizations, for example, GWP, as well as by NGOs and scientists but suffers from very limited practical applications. Examples include the Damodar Valley Corporation, the Bhakara-Beas Management Board, or the Cauvery River Authority, respectively. The experience gathered in these Basin Boards and River Authorities could serve for future more integrated approaches to river basin management. End users are currently not included in basin management structures.

Study on Indian River Basin Boards, how they can be more integrative in terms of agencies involved and in terms of end users. This is to be done particularly keeping in mind the efficiency of the proposed functions for the RBOs. Several model RBOs have been proposed of which perhaps the model proposed by the National Commission for Integrated Water Resources Development and Plan (recommendations put forward in 2004 report) can be taken up for such purposes after considering its suitability.

However, the following impediments can be identified for the formation of the RBOs in India. There impediments are based on formal rules, laws and procedures. Leaving those aside there are also other impediments originating from the political, economic, and institutional environment.

Political Impediments

Political reasons might have led to the enactment of the River Boards Act in 1956, but might also have stopped the central government in constituting any River Boards for the inter-state rivers. The political compulsions may be due to multi-party political structure of the country where there may not be the same political party ruling at the Centre and the State simultaneously. This prevents the central government from imposing upon a state, a decision, which a state is unwilling to accept.

Economic Impediments

Insufficient funds for the large projects may also be one of the reasons to create River Boards and Organizations.

Institutional Impediments

Over the past 50 years several River Basin Authorities have been constituted. Despite this, the National Commission for Integrated Water Resources Development Plan admits in one of its reports submitted in 1999 that India does not have a successful model of RBO and it is in this report it recommended for a model RBO. Till date such a model RBO has not yet been constituted.

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Tungabhadra Board

http://wrmin.nic.in/writereaddata/linkimages/anu232446218181.pdf

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Upper Yamuna River Board

http://uyrb.nic.in/banner.htm

http://wrmin.nic.in/writereaddata/linkimages/CHAPTER%20-%2081946894100.pdf

Bhakra Beas Management Board

http://bbmb.gov.in/english/index.asp

Betwa River Board

http://wrmin.nic.in/writereaddata/linkimages/BRBAct5732622713.pdf

Ganga Flood Control Commission

wrmin.nic.in/writereaddata/linkimages/anu156988494413.pdf

Bansagar Control Board

http://wrmin.nic.in/writereaddata/linkimages/anu228556756739.pdf

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United Nations Development Programme

http://europeandcis.undp.org/WaterWiki/index.php/River_Basin_Organizations#Lessons_Learned_re:_River_Basin_Organizations

Annex 1: RBOs and their origin

River Basin Organisation	Origin
The Damodar Valley Corporation	The Damodar Valley has been ravaged by floods of varying intensities, but it was the flood of 1943 that left the worst devastation in its wake. As a result the Governor of Bengal appointed a Board of Inquiry to search for a solution. The Board recommended the formation of an Authority similar to that of Tennessee Valley Authority of USA. The Government of India then appointed Mr. W.L.Voorduin, a senior engineer of the Tennessee Valley authority (TVA) to make recommendations for comprehensive development of the valley. He submitted "Preliminary Memorandum of the Unified Development of the Damodar River" suggesting a multi-purpose development plan designed for achieving flood control, irrigation, power generation and navigationin the Damodar Valley. By April 1947, full agreement was reached between the three governments of Central, Bengal and Bihar on implementation of the scheme. In 1948, the Damodar Valley Corporation Act was passed by the Central Legislature requiring the three governments to participate jointly for the purpose of building the Damodar Valley Corporation (DVC).
TungaBhadra Board	Tungabhadra Board was constituted in March, 1955 vide notification No. DW VI (4)(S) dated 10.3.1955 by the Government of India in exercise of the power vested under Section 66(4) of the Andhra Pradesh State Act for completion of Tungabhadra Project and for its operation and maintenance.
Bhakra-Beas Management Board	The Bhakra-Nangal and Beas Projects were originally the joint ventures of the States of erstwhile Punjab and Rajasthan. On reorganisation of Punjab on Nov.1, 1966, Bhakra Management Board was constituted by the Government of India under section 79 of the Punjab Reorganisation Act 1966 for the administration, maintenance and operation of Bhakra-Nangal Project with effect from 1.10.1967. The Beas Project works on completion were transferred to Bhakra Management Board and it was renamed as Bhakra Beas Management Board (BBMB) w.e.f. 15.5.1976.
Cauvery River Authority	The States of Karnataka and Tamil Nadu are the main riparian States to River Cauvery. The disputes between these States dates back to the 18th century. Two agreements were executed between the States, one in 1892 and the other in 1922. In seventies, disputes arose again with Karnataka contending that the agreements have expired. After negotiations failed the Government of India, on the directions of the Supreme Court of India in a Petition filed by the farmers of Tamil Nadu, constituted the River Cauvery Waters Disputes Tribunal. The Tribunal issued an interim order directing Karnataka to release 205TMC of waters to Tamil Nadu in a year. Disputes arose again on the allegations by Tamil Nadu that Karnataka has failed to implement the interim order of the

River Basin Organisation	Origin
	Tribunal. Tamil Nadu moved the Supreme Court for the implementation of the interim order. Before the Supreme Court the Government of India, which was arrayed as party by Tamil Nadu, agreed to constitute an Authority for the implementation of the interim order of the Tribunal. It is in these circumstances that the Cauvery River Authority came to be constituted in 1998.
Ganga Flood Control Board	Ganga Flood Control Commission (GFCC) was constituted through a resolution of the erstwhile Ministry of Irrigation and Power in April, 1972 for tackling the flood problem in the Ganga and its tributaries and the facilitate effective coordination of flood management amongst the Ganga basin states.
Brahmaputra Board	The Brahmaputra Board was set up by the Govt. of India under an Act of Parliament i.e. Brahmaputra Board Act. 1980 (46 of 1980) under the Ministry of Irrigation (now renamed as Ministry of Water Resources). The jurisdiction of the Board includes both the Brahmaputra and Barak Valleys and covers all the States of the North Eastern Region either in full or in part.
Narmada Control Authority	In pursuance of the decision of the Narmada Water Disputes Tribunal under Clause XIV of its final order, the Government of India framed the Narmada Water Scheme, which, inter-alia, constituted the Narmada Control Authority and Review Committee in 1980 for proper implementation of the decisions and directions of the Tribunal.
Rajasthan Canal Board	The Rajasthan Canal Board, later renamed as Indira Gandhi Nahar Board was constituted in December 1958 under resolution No. 19/4/8 1 /IT dated 7th Jan. 1985 by the Ministry of irrigation and Power, Government of India, to ensure efficient, economical and speedy execution of the project. The Board was reconstituted under resolution No. 19/4/81/ IT dated 26th Feb. 1990 and again under resolutions dated 6th Jan. 1992, 21st April 1992 and 4th March 1993. The Headquarters of IGN Board is at Jaipur.
Upper Yamuna River Board	Yamuna water dispute regarding allocation of utilisable surface flow of Yamuna among the co-basin States up to Okhla was resolved by way of a MoU signed by the Chief Ministers of Himachal Pradesh, Haryana, Uttar Pradesh, Rajasthan and National Capital Territory (NCT) of Delhi on 12 May 1994. As per the provision in the MoU, the Upper Yamuna River Board (UYRB) with its headquarters in the National Capital Region was constituted. Upper Yamuna Review Committee (UYRC) was also constituted, for supervising the working of the UYRB to ensure implementation of the MoU regarding allocation of surface flow of Yamuna and to issue directions, as deemed necessary, for proper development and management of the upper reaches of the Yamuna River Basin up to Okhla. Uttaranchal has also been made Member of Upper

River Basin Organisation	Origin
	Yamuna River Board and Upper Yamuna Review Committee. The Upper Yamuna Review Committee held a meeting under the Chairmanship of Hon'ble Union Minister (WR) on 12 April 2006. The meeting was inter alia attended by Hon'ble Chief Ministers of Rajasthan, Haryana and NCT of Delhi and Irrigation Ministers of Himachal Pradesh and Uttar Pradesh.
Betwa River Board	The Betwa River Board was constituted by the Ministry of Water Resources for efficient, economical and early execution of the Rajghat Dam Project, a joint venture of Madhya Pradesh and Uttar Pradesh. Headquarter of the Board is at Jhansi (U.P.).
Krishna-Godavari Commission	The Krishna-Godavari basin was constituted in 1961 in order to review the availability of supplies in Krishna and Godavari basins and to determine the extent to which further demands on these basins could be met on the basis on annual flows at Vijaywada on Krishna and Dowlaiswaram on Godavari and the other points taking into account upstream utilization.
Sone River Commission	The Sone River Commission was constituted in 1980. The scope of the Commission was limited only to the extent of compiling and analyzing hydrological and hydrometerological data, consumptive use data and to carry out investigations and studies for the preparation of basin and regional plans for the optimum use of Sone river waters for irrigation and multi-purpose uses, without any binding on the part of the states to accept its findings.

Annex 2: Structure of Indian RBOs

River Basin Organisation	Origin
The Damodar Valley Corporation	The Board is headed by a Chairman and two other members appointed by the Central government.
TungaBhadra Board	Composition of the Board: i) Chairman- Appointed by the Government of India ii) Members – one representative each from the riparian states of AP and Karnataka and the Central Government, iii) The administrative set-up is divided into (a) Irrigation wing (b) Hydro-electricity wing.
Bhakra-Beas Management Board	The Board consists of: i) a whole time Chairman, ii) two whole time members, appointed by the GOI, iii) one representative each from states of Punjab, Haryana, Rajasthan and Himachal Pradesh, iv) one member from Ministry of Power, v) one member from Ministry of Water Resources
Cauvery River Authority	Two tier authority: i) Authority – this consists of the Prime Minister of India and the Chief Ministers of the four riparian states. ii) Monitoring Body – composed of a)the Secretary-in-charge of the Ministry dealing with the Water Resources, b) Chief Secretary of the riparian states and their nominees, c) Chairman of the CWC, d) one officer each from the riparian states not below the rank of chief-engineer.
Ganga Flood Control Board	The Commission is headed by Chairman, two full time Members, nine part time Members and four permanent invitees
Bansagar Control Board	i) Union Minister of the Water resources is the Chairman, ii) Union Minister of Power as a member iii) Chief Ministers, Finance and Irrigation Ministers of partner riparian states as members iv) Electricity Minister of MP as a member. The day-to-day affairs of the Board are managed by the Executive Committee under the Chairmanship of Chairman, CWC.
Brahmaputra Board	The Board is headed by a Chairman appointed by the Government of India and has members from governments of the basin states.
Narmada Control Authority	The Authority is headed by the Secretary, Ministry of Water Resources, Government of India, as its Chairman, with Secretaries of the Union Ministries of Power, Environment and Forests, Social Justice and Empowerment, Chief Secretaries of the four party States, one Executive Member and three full-time Members appointed by the Central Government, and four part time Engineering Members nominated by the

River Basin Organisation	Origin
	party States, as Members. The Review Committee of the Narmada Control Authority (RCNCA) headed by the Union Ministry of Water Resources may suo-moto or on the application of any party State or Secretary to the Government of India, Ministry of Environment and Forests, review any decision of the Authority. In urgent cases, the Chairman of the Review Committee may, on application of the Government of any party State, or Secretary to the Government of India, Ministry of Environment and Forests, grant stay of any order of the Authority pending final decision or review.
Rajasthan Canal Board	The Board is headed by a Chairman who is also the Administrator of the Project and is ex-officio Commissioner and Secretary to the Government of Rajasthan in the Indira Gandhi Nahar Department. The members of the Board are:- 1. Financial Advisor, Ministry of Water Resources 2. Jt. Secretary Agriculture, Ministry of Agriculture GOI 3. Commissioner, Indus Ministry of Water Resources, GOI Chief Engineer CAD, Ministry of Water Resources, GOI 4. Chief Engineer Monitoring CWPC, GOI 5. Secretary Finance Department, GOR 6. Secretary CAD, GOR 7. Secretary PHED, GOI 8. Area Development Commissioner CADA IGNP 9. Chief Engineer IGNP 10. Chief Engineer II IGNP I 1. Chief Engineer CAD IGNP 12. Colonization Commissioner, GOR
Upper Yamuna River Board	The Board consists of Member, CWC as part-time Chairman and one nominee each , not below the rank of Chief Engineer, from the States of U.P., Rajasthan, H.P., Haryana, Uttranchal and NCT of Delhi and a Chief Engineer of Central Electricity Authority and respresentatives of Central Ground Water Board and Central Pollution Control Board as part time Members. A full time Member Secretary of the Board is required to be appointed by Central Government for a period of 3 years at a time. Further, the expenditure on UYRB is to be shared equally by the aforesaid basin States viz U.P., Uttranchal, Rajasthan, H.P., Haryana and NCT of Delhi
Betwa River Board	The Union Minister for Water Resources is the Chairman of the Board. The activities of the Board are managed by the Executive Committee of the Board under the Chairmanship of Chairman, Central Water Commission.

Annex 3: Functions of Indian RBOs

River Basin Organisation	Origin
The Damodar Valley Corporation	The original functions of the DVC were: promotion of development and operation of irrigation, water supply, drainage, generation of thermal power and hydro-electricity, flood control, afforestation, navigation, control of soil erosion, public health, agricultural, industrial, economic and general well-being of the valley.
TungaBhadra Board	The board is in charge of the common portion of the Tungabhadra Project and it was entrusted by the Krishna Water Disputes to carry out some specific provisions made in its Award for the use of Tungabhadra water by the sates of Karnataka and Andhra Pradesh. The State has been utilising the water for irrigation through the Left Bank main canal, which is exclusively for Koppal and Raichur districts and from the two canals on the right bank — high level and low level — in three taluks of Bellary district along with Andhra Pradesh.
Bhakra-Beas Management Board	i) to regulate the supply of waters Beas, Sutlej and Ravi to the states of Punjab, Haryana, Rajasthan and Union Territories of Delhi and Chandigarh ii) Distribution of power in the above States and Union Territories
Cauvery River Authority	Limited purpose of the authority – for the implementation of the interim order of the Tribunal, until the tribunal issues its final order (Award).
Ganga Flood Control Board	The main functions of the Commission are- i) to prepare a comprehensive plan for flood control for the Ganga basin, ii) draw out a phased program for implementation of the plans, iii) advising the concerned states to take up specific guidelines, iv) preparing the budgets for the measures to be undertaken, v) monitoring the works taken up for flood control measures vi) Documentation and dissemination of information.
Bansagar Control Board	The actual works of the construction will be carried out under the direction of the Control Board by Chief Engineer concerned of the Government of Madhya Pradesh. The Control Board will be overall in charge of the project including its technical and financial aspects.
Brahmaputra Board	The main functions assigned to the Board are to- i) carry out survey & investigation and to prepare Master Plan for the control of floods, bank erosion and improvement of drainage congestion giving the importance to the development and utilization of water resources of the Brahmaputra Board & Barak Valleys for irrigation, hydropower, navigation and other beneficial purposes. ii) Its assignment also includes preparation of detailed project report of the dams and other projects identified in the Master Plan as approved by the Central Government and iii) to take up construction and maintenance of the projects approved by the Central Govt. and works connected therewith as proposed in the Master Plan and also to maintain and operate such dams and works.

River Basin Organisation	Origin
Narmada Control Authority	The Narmada Control Authority has been vested with the powers for the implementation of the orders of the tribunal with respect to the storage, apportionment, regulation and control of the Narmada waters, sharing of power benefits from Sardar Sarovar Project (SSP) regulated release of water by Madhya Pradesh, acquisition of land likely to be submerged under the Sardar Sarovar Project by the concerned States, compensation, resettlement and rehabilitation of the oustees, sharing of costs and implementation of the environmental safeguard measures.
Rajasthan Canal Board	Mainly for irrigational projects.
Upper Yamuna River Board	The main Functions of the Board include: i) Regulation and supply of water from all storages and barrages having regards to the agreements made in the MoU. ii) maintenance of minimum flow for ecological considerations, and monitoring return flow after allowing different consumptive uses, iii) Overview of the plans for the catchment area, water shed management, rehabilitation and the conservation of environment, iv) monitoring the exploitation of groundwater in the Upper Yamuna catchment, v) submission of Annual Reports to the Central government and to the Basin States.
Betwa River Board	
Krishna-Godavari Commission	a) reporting on the requirements of the projects on the Krishna and Godavari – i) in operation in 1951, ii) as approved by the GOI for execution, iii) included in the plans but not yet approved by the GOI, iv) projects proposed by the States; and v) such minor schemes as may have been sanctioned upto March 1961. b) reporting on the feasibility of diverting any surplus supplies in the Godavari to the Krishna indicating the quantity to be diverted and the cost involved.
Sone River Commission	i) to compile data and analyse hydrometerological data of river Sone and its tributaries including assessment of yield according to different dependability at different points, ii) to collect and compile data in respect of projects completed, under construction, proposed or under investigation, iii) to collect and compile data of utilization of Sone waters in the tree states including agronomic, geological and socio-economic aspects, iv) to undertake supplementary investigations and studies as necessary for preparing basins and regional plans for development of water and land resources, v) to prepare a comprehensive and regional plan for optimum use of Sone water for irrigation and other multi-purpose uses.

INSTITUTIONAL CHANGE AND WATER PRODUCTIVITY: A SCENARIO TESTING OF CANAL IRRIGATION COOPERATIVES IN NORTHERN GUJARAT FOR FINANCIAL VIABILITY

G.G.Koppa[1]

Abstract

First, the study attempts to know the capacity and willingness to pay the water charges based on the water productivity of the farmers of newly formed Canal Irrigation Cooperatives in Dharoi Irrigation Project in Gujarat being developed by Development Support Centre and AKRSP, Ahmedabad. The broad objective of this study is to use a new approach to help investigate the sustainability of irrigation cooperatives, especially small holding and ability of the farmers to pay the water fees determined by Irrigation Cooperatives (IC). The study tries to identify and analyze the critical factors for financial success or failure of canal irrigation co-operatives, assess the capacity of the farmers to pay and elicit the conscious steps taken by the government and farmers for ensuring the financial strength of ICs. Research found that IC can help improve livelihoods. However, the sustainability of cooperatives largely depends on the fee collection efficiency and proper maintenance and repair of the canal network. Adequate financial planning to address these costs is key to the success of Irrigation co-operatives.

1. INTRODUCTION

Among the key outcomes of the Earth Summit held in Rio de Janeiro in 1992, were the recommendations that water should be treated as an economic good (with a right attached to it), that water management should be decentralized, and that farmers and other stakeholders should play a more important role in the management of natural resources, including water. Increasingly, local management solutions are sought to address global problems of food and resources (Ostrom 1990). Irrigation management transfer, or turnover, has become a widespread strategy in Asia, Africa, and Latin America. Participatory irrigation management and irrigation management transfer reforms often have the stated objectives of providing sustainable and adequate financing for operation and maintenance of irrigation and drainage services and of facilitating investment in the required rehabilitation or upgrading of irrigation systems. Overall reform of water resources management often encompasses these reforms. It often includes demand management to encourage efficient water allocation and imposes new externalities on irrigation systems in terms of environmental performance.

The sustainability of the water users associations however does not depend on their capacity to provide an adequate water delivery service and control and to allocate water and to provide an improved service to enable gains in agricultural productivity (Svendsen, 1997). This is essential for the capacity of farmers to pay water and for the water users associations to be financially viable. As a result, it is now recommended that strategies of gradual improvement of irrigation systems be adopted to support the transfer.

Most often, governments pursue management transfer programs to reduce their expenditures on irrigation, improve productivity, and stabilize deteriorating irrigation systems. Over the past three decades, the world's irrigation sector has increasingly seen a global trend towards decentralization and privatization. Many countries have embarked on a process to transfer the management of small as well as big irrigation systems from government agencies to local management entities (Vermillion, 1997). This process of Irrigation Management Transfer (IMT) includes state withdrawal, promotion of water users' participation, development of local management institutions, transfer of ownership and management. India has cautiously initiated IMT in government

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managed big and smallholding irrigation schemes and most transfer operators are still unsure about how to design and implement the process. At present, India has an estimated 100 million ha of gross area under irrigation and 58 million hectares of net irrigated area (Planning Commission, 2007)). Owing to history and past policies, India is having irrigation projects of different sizes ranging from few thousand hectares to millions of hectares. Because of ever-increasing population, the average land holding in general and irrigation in particular has gone down. Also, the new National Water Policy of 2002 promotes the creation of Water Users' Associations (WUAs). It is envisaged that such local institutions take over most irrigation management functions, i.e. water allocation and distribution, maintenance, water charging system, financial management, and so on. Absence of peoples involvement and participation is one of the several causes for poor status of irrigation projects (IWMI, 2001). With regard to a rehabilitation and Irrigation Management Transfer process, these issues raise a series of questions at different levels: national and provincial governments (rehabilitation policy and implementation, IMT procedure), WUA level (collective management of newly transferred irrigation schemes, institutional arrangements), and farmers' level (farming and cropping systems management).

There are few studies specifically dealing with the financial functioning of ICs. Financial viability of a canal Water Users' Association (WUA)/ICs implies that it is able to generate enough income to meet its regular and emergency expenses and at the same time invest adequately in the maintenance & repair of canals (Chaturvedi, 2004). He argues that the financial viability of the Irrigation Cooperatives (ICs) is imperative and vital for overall smooth functioning and sustainability of this institution. In the initial stages of formation, the social dynamics between the various stakeholders ensure a sound initiation of any institution. However, as the institutions start functioning, they need money to cover their running cost. It is here that the financial working issues gain importance along with the social dimension. The Irrigation Cooperatives should be able to generate some surplus for coping with the unforeseen requirements.

1.1 Participatory Irrigation Management in Gujarat

In Gujarat, the implementation of the National Water Policy guidelines was initiated on an experimental basis in the district of Bharuch. The results proved so encouraging that in 1995 the state government declared a policy on Participatory Irrigation Management (PIM), along the lines of the national policy, emphasizing farmer participation in the planning, implementation and management of direct and indirect irrigation projects, and seeking the co-operation of voluntary organizations. The basic philosophy of participatory irrigation management programmes in Gujarat as in other states has been to transform irrigators from beneficiaries to partners in the planning and development of irrigation. An analysis of the experience of the programme shows that farmers' involvement in water management has indeed led to a better and smoother resolution of irrigation-related conflicts. However, the expectation that the programme would reduce state expenditure has not realized yet (Parthasarathy, 2000). Water users' associations will have to be more efficient in making allocative and investment decisions. For this, a clarification of legal rights is imperative.

When the canal water charges are based on area and crops and the tube well charges are higher than the canal water, as the number of waterings from the canal increases, the marginal utility of additional watering should be positive, while the average price (per watering) declines. However, in most of north Gujarat's villages, farmers do not view marginal utility by cost parameters alone. This is because water supply by 'tube well companies' is not only considered reliable but also efficient in terms of revenue. Many studies have shown that output is higher with the use of ground water than canal water (Dhawan 1990 as cited in Parthasarathy, 2000).

Shah (1993) points that water prices charged by owners of 'electric water extracting mechanisms' (including tubewells) are much higher in Gujarat's water abundant areas and in states like Uttar Pradesh, Haryana, Andhra Pradesh, Bihar and Tamil Nadu. Shah's analysis suggests lowering tube well water rates as and when the number of waterings from the canal improves. Farmers also consider this possibility.

Summing up, the literature on IMT points out that farmers' involvement in water distribution and maintenance systems has led to an improvement in resolving irrigation related conflicts, which were previously dealt with by government authorities. Though the IMT has led to an increase in the water fee collection rate and improvements in the O and M of the system (Parthasarathy, 2000), none of the studies show that the cost of irrigation management by the government has reduced. Importantly, there is little evidence to show that the per unit rate of water has been increased after the transfer. In fact, IIMI's study (Vermillion, 1997) on irrigation service fees in five Asian countries including Gujarat concludes that irrigation agencies with a significant degree of financial autonomy have often been able to reduce the amount of direct payment required from farmers through institutional arrangements where the agencies earn secondary income from sources other than charges on water users (Small 1987). On the other hand, the newly created user's organizations incurred managerial expenses. Perhaps based on this evidence, Johnson III (1997) suggests a need for users to establish an investment fund to sustain the transfer.

The study by Development Support Centre (2007) on cost benefit ratio in PIM reveals that there was 30- 55% increase in efficiency in water utilization, saving in cost on water in the range of Rs. 848 to Rs. 2026 per hectare. It also found the increase of the real wage income of Rs. 250 per hectare per year indicating additional employment generation. There was positive impact on livestock population and milk production of 1260 liters per animal per year. The Irrigation Cooperatives which had diversified activities were capable of generating more income as compared to those without diversified activities like Thalota Irrigation Cooperative (Chaturvedi, 2004 and Srivastav, 2007). The other dimension brought out by various studies is the increase in the demand for water for non-agricultural use. Yet, in most of the places, the legal system does not seem to specify the rights for irrigated agriculture and also fails to state how these rights can be protected against increasing demands for water from municipal and industrial users.

1.2 Background and Rationale

The study is based on two main propositions, first, in contrast to the current institutional strategies focusing on a narrow objective of reducing government costs in managing irrigation infrastructure, the study aimed at broader resource management goals. Second, the study also sought to identify a demand-driven bottom-up approach in establishing mechanisms for decentralized management of water resources and resource mobilization for the financial viability and sustainability of irrigation cooperatives. This study coincided with a policy resolve in India and several other countries in the region to introduce major reforms aimed at improving the effectiveness of water resources management institutions.

In the backdrop of the PIM policy laid down by the Government of Gujarat in 1995, the government as well as voluntary agencies had initiated a number of Water Users' Associations(WUAs) registered as Irrigation Cooperatives (ICs). The success of these farmers' institutions depends on various factors - social, administrative as well as financial. Though most of the ICs are still in their early stages, some can be identified as financially strong, and some as weak. If the analysis of the history of cooperatives, it is likely that most of the failed co-operatives are weak in their financial position. Thus, financial viability and self-sufficiency is a must for a cooperative to be sustainable and meet the regular Operation & Maintenance expense (including administrative expenses, salary of secretary, salary of operator, and maintenance & repairs of canals). It thus becomes imperative that we financially strengthen the ICs and take adequate steps to increase their revenue and control costs. This exercise gains more importance in view of the proposed legislation of the government of Gujarat, which proposes to form ICs (WUAs) by legal mandate throughout the state of Gujarat. The role of subsidies and grant by the government in ensuring the financial soundness of the IC has also needs to be analyzed. This can provide valuable inputs to the policy makers to enhance proper environment for successfully promotion of ICs by government organizations and NGOs.

The objective of this study is to use an approach to help investigate the sustainability of irrigation cooperatives with special reference to small holding and cropping pattern and ability of the farmers to pay the water fees determined by Irrigation Cooperatives/Water Users' Associations in a context of IMT, and to accompany and support decisions and actions undertaken by development operators. It promotes collective solution seeking through scenario testing. The study limits itself to use of the approach, its principles, the model's conceptual framework as suggested by Perret et al., (2002). The approach was developed in a case study scheme.

Through a collaborative effort of Gujarat Water Resource Department and Development Support Centre Ahmedabad, supported by National Dairy Development Board (NDDB), Irrigation projects covering 56,700 hectare are being developed as models of Participatory Irrigation Management. The NGO, Development Support Centre is planning to form 216 ICs in the three schemes of Dharoi (45,000 ha.), Guhai (7200 ha.) and Mazam (4500 ha.) covering 56,700 hectares of command area by March 2008.

The schemes displays features that are common to other irrigation schemes, for example, a diversity of practices and performance among irrigation farmers, generally little orientation to productivity and subsistence, a simple yet deteriorating conception of infrastructures (a gravity-fed system with dam, canals and furrows), a lack of support services, a weak agri-business environment, missing markets, and water allocation and water availability problems, especially in winter. Ever since, there has been intense sharing of experience and ideas between the NGO groups that have direct experience of working with the farmers and officers of the Water Resources Department both at the field level and at the policy level. This has resulted in developing packages of incentives for the farmers in the canal command like retaining 50% of their water fee collection and carrying rehabilitation work with financial help from government to organize themselves into Irrigation Cooperatives(IC) and take responsibilities for maintenance of the canal network transferred to them as well as for management of the irrigation water made available to them for distribution to farmer members.

1.3 Objectives

The main objective of this study was to understand, through pilot efforts, the rationale for the Irrigation Cooperatives and to help investigate the sustainability of IC the context of Irrigation Management Transfer, so that more efficient and equitable use of water can be achieved in a hierarchical society. The specific objectives of the study are

1. To identify and analyze the critical factors for financial success/ failure of canal irrigation co-operatives in the context of agro climatic conditions.
2. To assess the capacity of the farmers (in terms of water productivity) to pay and get benefit of Irrigation Cooperatives in the context of irrigation scheme and agro climatic conditions using scenario testing models.
3. To elicit conscious steps taken by supporting agencies and farmers for ensuring financial strength of these ICs
4. To develop recommendations for enhancing financial viability of the Irrigation Co-operatives while simultaneously taking adequate care of maintenance & repair of canals.

2. STUDY METHODS

For identifying the critical factors determining the success of irrigation cooperatives a detailed study dealing with financial aspect of the selected co-operatives was carried out.

2.1 Sampling

Some studies on financial viability (Chaturvedi, 2004) of irrigation cooperatives do not take into account the agro climatic conditions, choice of cropping pattern, size of land holding and income generating capacity of the farmers. Thus, it was considered useful to make qualitative study by selecting a sample that could bring out these factors, which impact financial viability of WUAs and understanding what policy measures may be appropriate when the law is enacted and a large number of WUAs/ICs are established.

The financial data of various cooperatives available with Development Support Centre was used for the study. The details on financial performance of ICs are based on consolidated financial results for 4-6 years based on the availability of data. The financially strong and weak co-operatives were identified after discussion with the senior staff of Development Support Centre (DSC), and the Water and Land Management Institute, Gujarat (WALMI). Five irrigation co-operatives were studied.

Apart from the details of performance of selected Irrigation Cooperatives, information on land type, agro climatic conditions of the command, cropping pattern, yield levels of various crops during different seasons, cost of cultivation and gross profit margins to the farmers were collected through discussion with Department of Agriculture, officials of Development Support centre and interaction with the farmers of the command area.

2.2 Data Collection

The data collection is on pilot basis and data relevant to water productivity like water procurement by each IC, gross production/value in the farm, water productivity of both farm and non farm activity is in progress. Secondary data was collected from records of Development Support Centre, Ahmedabad. The Income-Expenditure Account and Balance Sheets of the various ICs were collected from the records of Development Support Centre and discussion with Officials of Irrigation cooperatives in Dharoi Irrigation Project. Primary data was collected through focus group discussions (FGDs) with the Executive Committee (EC) of IC, and with the field implementation unit staff of DSC and various policy level actors

2.3 Data Analysis

The account books of the various ICs were analyzed for assessing the trend of revenue generated, operation & maintenance costs, and reserves & surpluses. Various steps taken for improving its financial strength were also studied. Finally, factors affecting the financial viability were elicited through discussion with the members of ICs, supporting agency and policy level actors.

2.4. Analysis of Major Issues

Apart from studying the performance of irrigation cooperatives in terms of their costs and income, the analysis involves simulations and scenario-testing on costs incurred by scheme management, the possible contributions by farmers to cover these costs, the possible charging system to be set up, and finally the impact of certain measures or decisions, or certain farmers' strategies on the financial viability of the scheme. The discussion mainly involves principles of the approach, especially, the need for a sustained and multi-disciplinary partnership during scenario development and discussion, including farmers and transfer operators (NGOs and Irrigation Agency). Such an approach shows huge potential for information and decision-making support towards transfer operators, for training, and for farmers' participation.

There are costs incurred in supplying water and water-related services to farmers, and the objective of financial viability must be pursued at scheme level (involving partial or total cost recovery). In an IMT context, this means that:

- The management entity (WUA) provides irrigation water and related services to farmers,
- Such services generate costs (capital, maintenance and operation costs, and personnel-related costs),
- The management entity charges the farmers according to a system to be established
- Farmers tap into their monetary resources (generated by irrigated or rain-fed cropping systems, by off-farm income-earning systems) to pay these water service fees.

Smallholders' agricultural and resource-management systems face a quickly changing economic, legal and social environment.

2.4.1. Implementation features

The approach implies three phases: (1) Information at household and scheme level, on one given scheme, (2) Information analysis and information-system development, which requires a typology of farmers, and (3) Running the model on a scenario-testing basis, evaluating the impact of certain measures or decisions, or certain farmers' strategies on agricultural and production features, land allocation, costs and cost recovery, and sustainability-related indicators. Developing a farmers' typology is a prerequisite, as one can neither address all farmers individually nor consider them all similar. Different farmers' strategies and practices co-exist within a scheme. Grouping irrigation farmers into several types helps representing this reality.

2.4.2. Conceptual Framework for Analysis

The model's conceptual framework (Perret, 2002) take into considerations the economic and financial aspects of the scheme's management, and addresses some technical indicators in order to check that the scenarios are realistic (e.g. water resource availability). Five input modules form the basis of the information system, as interfaces for data capturing by the user are mentioned in the figure below.

Farmer Module: A "farmer" module captures farmers' types, with their cropping systems (combination of crops that have been documented in the "crop" module), average farm size, percentage of scheme's size, willingness to pay for irrigation water services. This module generates type-related output variables (e.g. aggregated income per type, crop calendar) and scheme-related output variables (e.g. number of farmers, aggregated water demand) when combined with the "scheme" module.

Cost Module: Each cost-generating item is listed in the "cost" module. This module generates output variables that reckon the costs incurred by the scheme and its management (i.e. capital costs, maintenance costs, operation costs, personnel costs). Such information answers the question as to how much it costs to operate the scheme in a sustainable manner, regardless of who is going to pay for it.

2.4.3 The conceptual framework for Scenario Testing of Irrigation Cooperatives.

Crop Module: In the “crop” module, each irrigated crop is listed with its technical and economic features (e.g. management style, cropping calendar, water demand, yield, production costs). This module generates micro-economic output variables (e.g. gross and net margins) that allow comparative evaluation of crops in terms of profitability, land productivity, and water productivity.

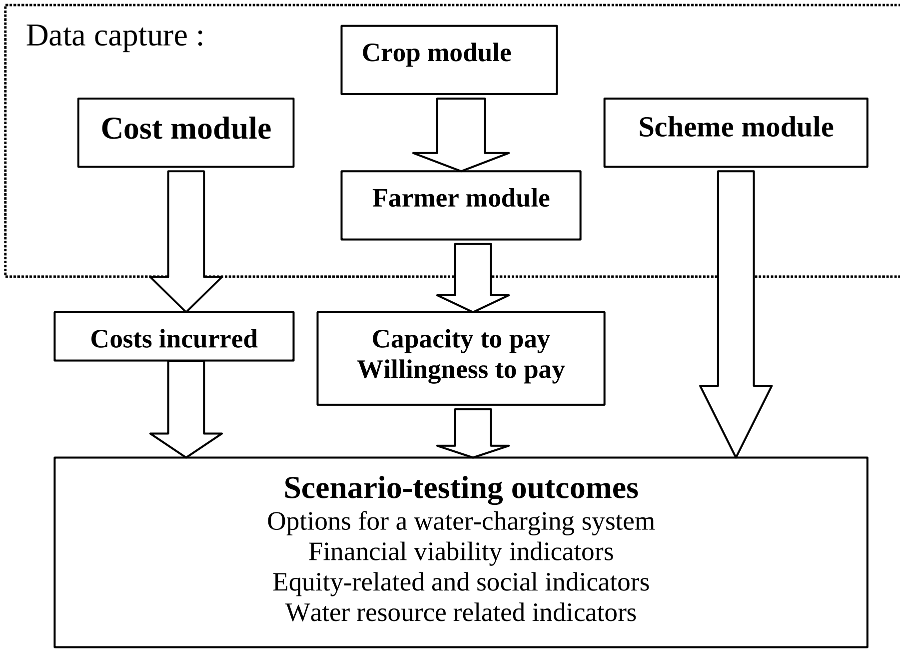
Scheme Module: A “scheme” module lists the scheme’s characteristics (e.g. size, rainfall and resource-availability patterns, and tariff structure). This module is combined with the “farmer” and “cost” modules, and generates output variables on water pricing, tariff, cost recovery rate, contribution per type. This allows answering the question as to who may pay, and how much, for water services. It also generates some social and equity-related indicators, and resource-related indicators (e.g. total number of farmers, area per type, number of farmers per type, type net income, scheme total net income, total water consumption, overall weekly water balance).

The initial inputs (real data) form the base scenario. Additional scenarios may be tested through the capture of non-real/prospective data, especially when the given scheme has not yet been rehabilitated or transferred (e.g. alternative crops and cropping systems, emerging farmers’ types, changes in scheme’s management patterns, options for a charging system, new infrastructures).

3. RESULTS AND ANALYSIS

The command area under study where the Irrigation Cooperatives are being formed (Dharoi Irrigation Project) was of mainly sandy loam and almost all area was being cultivated. The average land holding in the command is 1.1 hectare. The area receives 625 to 825 mm annual rainfall indicating that if rainfall is normal and evenly distributed, the farmer can have a better crop during the season (Annexure IV). In the scheme the farmers receive water from canal only from October that too only when the reservoir has sufficient water. During Kharif the farmers use water from tube well cooperatives. There are number of tube well cooperatives where each cooperative caters to the needs of 10-12 ha. Each farmer pays about Rs. 60/ hour and needs about 6-7 hours of irrigation for one acre. Each canal branch has about 350 ha of command indicating cultivable

Figure 1: Information System based on Different Modules



command area under each can be a minimum of 350 hectares according to topography of the land. There are number of operatives with command area as less as 16 hectare with a maximum of 890 hectares.

Cotton is a predominant crop (Annexure- II) covering 40% of the total area followed by castor (20%), bajra (15%), green gram (10%) and fodder (10%) during Kharif. The area under cotton is on the increase after the introduction of Bt cotton because of higher yields. Even though the cotton is sown during Kharif it is harvested during Feb- March covering Rabi season as well. Therefore, the farmers have to pay to both tube well cooperatives and canal cooperatives and that increases the cost of water. The Rabi crop is dominated by wheat (40%), followed by mustard (20%, jeera (20%), hybrid bajra (10%) and fodder and vegetable (10%). Normally farmers will not get water from canal cooperatives during summer.

During normal years of monsoon, farmers will get better yields because of relatively fertile soils. The average net income of the farmers works out to be in the range of Rs. 20,000 to 30,000 per year/hectare through all seasons (Table 2 in Annexure-II). As per the official Meteorological records the area has a history of drought once in 4 years. As the farmers are paying for water to both tube well cooperatives and canal cooperatives the cost of water is significant (Rs 2000 to 4000 per acre depending on rain and crop).
If the farmers are able to generate income in the range of Rs 20,000 to 30,000 per hectare, the canal irrigation cooperatives have to be extra careful in fixing the water fees over and above the government rates. There is a need to look for alternative sources of income through diversification as has happened with Thalota IC.

3.1 Minimum Canal Command under each Irrigation Cooperative

In the Dharoi Irrigation Project there are number of cooperatives with command of as less as 16 hectares, 18 hectare with significant number with less than 75 hectares. Based on the fixed cost and average variable cost of the cooperatives the minimum command area (break even area) for each works our to be 100 hectares assuming there is no drought. But with drought every fourth year and need for extra income the command area should be anywhere around 150 hectare. The fixed cost includes salary to secretary and minimum administrative expenses which has been in the range of 20-50% of total expenses as against the norms of not more than 20% 30% (Table 2 in Annexure-III (A)-2).

3.2 Factors affecting Financial Viability

Some of the factors influencing the viability of Irrigation Cooperatives are

3.1.1 Command Area per unit Length of Canal

As all the canal irrigation schemes are based on the principle of gravity flow. The ratio of command area per unit length of canal is different in all the cases. Since income is directly proportional to the command area and expenditure is directly proportional to the canal length, the difference in this ratio affects the financial viability.

3.1.2 Canal Section & Structure

If the canal structure is complex, then the number of operators required during water distribution will be higher (increasing the amount spent in salary considerably). Where as this expenditure will be substantially lower in case of a simpler network having a low number of minors or sub-minors. Similarly, greater section implies higher expenditure as the surface area increases substantially and the expenditure on jungle cutting, etc increases.

3.1.3 Water Availability

Scarcity of water means less area irrigated and hence less revenue for IC. Some factors which affect water availability are:

3.1.4 Efficient water distribution

Since the additional water charge gained is on per hectare basis, efficient water distribution will mean higher command irrigated, and hence higher total profit.

3.1.5 Subsidy or Rebate

The maintenance and repair of canal is very important and necessary for the interest of the farmers as well as the IC.

3.1.6 Average Additional Water Charges Gained per Hectare

Water charge being the only reliable and substantial source of revenue, is the single most important component for increasing the revenue of the IC. Farmers are capable of paying the fees even though the fees 30- 40% higher than government charges because it is still cheaper compared to the fees they pay for tube well co-operatives.

3.1.7 Voluntary Labour

Annual voluntary labour by the farmer members of IC can save a high amount of annual expenditure incurred by the IC, and at the same time ensure better and sustained maintenance and repair of canals. In Dharoi irrigation project voluntary labor is engaged only after the canal is rehabilitated. Even though no payment is made to voluntary labor it is included in the income and expenditure section for the purpose of showing the value of labor wages that ICs benefited.

3.1.8 Diversification Activity

Diversification activity has the potential of negative as well as positive effects. If the activity is chosen after proper planning and managed effectively, it can definitely give good returns. However, the risks associated may also be high. Thalota IC has a positive experience with diversification and input supply undertaken by the co-operative. It has yielded substantial returns to member. On the other hand, Chopadvav IC has faced losses due to diversification in the marketing of cotton. Similarly, Kakdiamba IC has also suffered some losses due to non-recovery of money from diversification activity like input supply.

3.1.9 Administrative Expenditure

Minimizing administrative expenditure is very necessary. Salary of secretary constitutes a major component of the administrative expenditure (Table 2 in Annexure III(A)). The ICs pay the secretaries even in the drought years. In the months when no water distribution takes place, the secretary has little work to do. Salary is not related to the work actually done and hence this increases expenditure. Other administrative expenditures also need to be curbed for efficient financial management.

3.3 Discussions regarding factors affecting financial viability

The factors affecting financial viability (Annexure VI) fall under different categories technical, institutional/ social or managerial. There are different ways to deal with these factors for ensuring better financial viability. Maintenance of canals is a very important responsibility transferred to irrigation cooperatives. They must attend to proper maintenance of the systems; otherwise the system would deteriorate, reducing the area irrigated and consequent fall in water charges collection leading to downhill of the working of entire cooperative. If the IC ignores this necessary expenditure on maintenance and repairs of the canal, it can lead to inefficient and inequitable water supply, conflicts, loss of income to farmers as a result of decrease in yield, opposition to the Water Users' Association (WUA), and increasing and continuous loss of income to the WUA. If the IC incurs necessary expenditure on this item, it will in lead to better service delivery, which will in turn ensure better management, member satisfaction and improved finances for the IC. Better financial health of the institution will again ensure that more money is being allocated for continuous M & R and higher reserves are being built up for maintaining reserves for meeting emergency expenses and fixed expenses during the drought years.

Better financial health of the institution will lead to improved maintenance & repairs as well as higher incomes for the member farmers, leading to an increase in the standard of living of the farmers and labour community living in the rural areas and dependent on agriculture for their livelihoods. Margin on water charge should be higher for high value crops than that of low value crops and charges on per watering basis can be levied for ensuring that farmers using higher quantity of water should pay more.

The experts of supporting centre are of the view that better management of irrigation system should be ensured to increase the command area irrigated. Some portion of yearly surplus of the IC should be deposited as fixed deposit to earn a fixed stream of money. As of now, of the rebate of 30% on the timely payment of water charge is for O & M [which includes operators' salary as well as M & R grant for the canals]. From this rebate of 30% of water charges offered by the government, some proportion should be reserved exclusively for maintenance & repairs. Norms should be evolved for ensuring adequate investment in M & R. Even if a good irrigation cooperative attends to routine and major (annual) repairs, it may suddenly need funds for meeting emergency needs. Like any other well managed organization, irrigation cooperatives should regularly save funds that they can access in emergency.

The report of an exploratory study by SC on Financial Viability says that rule conformance should be ensured for avoiding grave problem of non-recovery, and diversification should be undertaken only after long-term planning. Separate entry should be made in the book of accounts for the secretary and the operator instead of one entry under salaries for better analysis and monitoring of the expenditure. Secretary's salary should be linked with the amount of work done. During drought years, no salary should be paid to the staff. The IC should monitor its administrative expenses.

Apart from diversification activities, those benefits of IC can be increased by increased utilization of irrigation potential (which is very important for the success of participatory irrigation management). The irrigation potential created can be utilized optimally, if O & M activities are adequately financed. The costs incurred by ICs can be classified into two types, namely, capital costs and O&M costs (Annexure III A and B). The PIM policy of the Government of Gujarat, India (Development Support Centre, 1999) mentions that for meeting all major capital expenditure on rehabilitation of canals prior to transfer, the government will pay 90% of the cost and the farmers have to pay the remaining portion. The arrangement under PIM is the ICs collect the water charges and retain 20% for their administrative expenses, 30% for the maintenance of canals transferred, and the remaining 50% transferred to the government. If the cost of administration & maintenance exceeds the government grant the O & M cost has to be met by the I C themselves. The Task Force on PIM also recommends using the space available along the canals for plantation raising and hence augmenting the financial resources of the IC.

4. CONCLUSION

Some of the significant results achieved as a result of the canal rehabilitation as part of PIM in Gujarat are: More agricultural land, which was previously not under cultivation due to seepage from canal, was brought under irrigation. Overuse of water by head-reach farmers has been controlled as they were assured of getting their due share of water. Due to assured water supply, farmers agreed to pay water charges that were 40-60% higher than government rates. Equitable distribution of water, reliable water supply and appropriate water application in command area have increased wheat yields by 66%.

In the given context of large-size canal systems, and the deep-rooted social perceptions regarding the role of the state as a benefactor and that of the water users as the beneficiaries, the strategy of working towards shared management was found to be very productive. To both the state agencies and the water users, the idea of a complete management transfer to the user organizations at this stage was not readily acceptable.

There are a number of cooperatives, which are functioning well with enough income generated and are going to be self-sufficient. This may be attributed to the reasonable command area and better control on expenses especially administrative and salary component. In case of the cooperatives, which are struggling to become viable, there is a need to spend substantial amount on maintenance and repair cutting down the other expenses. Looking into the capacity of the farmers to generate more income it seems it has to do with higher income generated by Bt. Cotton cultivation in recent past. Considering the present water rates and income levels of the farmers, there is scope for review and revision. Based on the study the following suggestions can be made on financial viability of canal irrigation cooperatives.

Emphasis should be laid by the Irrigation Cooperative on increasing the command area irrigated by minimizing distribution losses. As there is lot of variation in the proportion of expenses on maintenance and repair (M&R), of the 30% rebate given by the government on timely payment of water charges (for M & R expenses including Operators' salary), the government must fix some portion specifically for M & R of canals (excluding operators' salary) and the ICs should adhere to this. Especially during the years of water shortage or drought voluntary labour should be institutionalized. Member farmers should either contribute physically or pay equivalent labour wage at the time of annual M & R of the canal and channels. Margin on water charge should be higher for high value crops than for low value crops. The water fees should also consider the income generating capacity of the farmers based on their cropping pattern over and above government rates. Charging on per watering basis should be done for ensuring that users of higher quantity of water should pay higher. Diversification should be undertaken only after long-term planning especially in case of income generating activities like input supply. This is in view of the presence of a number of cooperatives already operating in the villages led by milk cooperatives as there is a risk of duplication of operation. There is a lot of scope for Irrigation Cooperatives to diversify in the activities like Vermi compost production and marketing. As the smaller cooperatives have less official work through out the year, the Secretary's salary should be linked with the amount of work done. During drought years, no salary should be paid to the staff. The IC should monitor its administrative expenses.

The farmers know that there is no alternative to irrigation cooperative and want to be part of cooperative. But it is up to cooperatives to make farmers realize the importance of raising commercial crops and diversification. It is easier said than done as it depends more on agro climatic physical condition of the soils. Here the diversification plays important role in making farm growth and consequently irrigation cooperatives sustainable. The data relating to water productivity based on the quantum of water the ICs are getting from Irrigation

Cooperative federations are being collected to calculate the water productivity at farmers and system level (federations level).

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Annexure I (A)

Packages of Incentives for Farmers to take responsibility of Irrigation Cooperatives

Some of the important orders of the Gujarat Irrigation Department creating an encouraging environment for formation of WUAs/ICs and their satisfactory functioning are

- Canals to be rehabilitated prior to transfer, irrigation cooperatives contributing 10% of estimated cost of rehabilitation.
- General order for such construction to be offered for execution to farmers organization, then to NGO and if both decline then by the Department.
- When entrusted to irrigation cooperative 1/3rd of the estimated cost given as advance.
- Simplified procedures for the purchase of material and quality control when works entrusted to irrigation cooperatives.
- After completion of the repair work the system is handed over to ICs after signing of MoU. The ICs, which come forward to contribute Rs. 60 per hectare, are provided Rs. 540 per ha. (State and Central Government contributing Rs. 270 each) as functional grant. The functional grant is placed in a fixed deposit and interest accrued is used for running the society.
- Each farmer has to pay a membership fee to become member of the society.
- Water charges decided by Government but collected by ICs. They retain 50% of collection for maintenance and management of canals and deposit 50% with Government.
- There is a rebate of 30% on the timely payment of water charge.
- ICs are empowered to decide water charges over and above the Government rate and retain 100% of collection of excess charges.

Annexure I (B)

Progress of Irrigation Cooperatives Registered IN Dharoi Irrigation Project as on 31-03-2007

Cultivable Command Area	No. of ICs
Less than 50 hectare	17
50- 150 hectare	39
More than 150 hectare	68
Total	124
Area	25141 ha

Annexure-II

1. Cropping Pattern in the Dharoi Irrigation Project

Kharif Crops	Rabi crop after kharif	Hot weather crop after Rabi	Hot weather crop after kharif crop.
Hy.Bajri Hy.Castor CottonJowarPulses/ Fennel	Wheat/Mustard Cumin Isabgol/CuminWheat, Lucerne	Cowpea, MugJowar, Bajra.- Cowpea	BajraBajra/Pulses Hy.BajraPulses

Kharif: Cotton (40%), Green gram (10%), Castor (20%) Hybrid Bajra (20%), Fodder (10%)
Rabi: Wheat (40%), Mustard/isabagol/jeera (40%), fodder (10%)
Summer: Bajra (40%), fodder /vegetables (10-15%)

2. Yield levels of Different Crops in Dharoi Irrigation Command

Crop	Average Yield (Qtl/ha)	Cost of Cultivation (Rs/ha)	Gross income @market prices (Rs.)	Net Income (Rs)	Weightage (%)	Income to farmer/ha
Cotton	25	25,000	50,000	25,000	40	10,000
Castor	20	15,000	30,000	15,000	20	3,000
Wheat	50	15,000	35,000	20,000	40	8,000
Bajra	50	15,000	30,000	15,000	20	3,000
Green gram	10/2*	10,000	20,000	10,000/4000	10	1,000
Tobacco	10	15,000	30,000	15,000	10	1,500
Mustard	10	10,000	15,000	10,000	20	2,000
Jeera/Isabgol	10	20,000	30,000	10,000	20	2,000
Fodder/Veg	**	5,000/	-			
Total						30,500

* Kharif-3q/acre and Rabi Summer-1 q/acre
**Varies according to the crop and varieties

Annexure-III (A)

1. Water Fees Charged by Government and ICs in Dharoi Irrigation Project

Crop	Water Rate(Rs/ha) (Govt. Rates)	Rates Charged by some of ICs*
Cotton	1000	1200
Castor	750	1000
Wheat	556	900
Bajra	499	900
Green gram	499	900
Groundnut	499	900
Tobacco	750	1000
Mustard	556	900
Jeera/Isabgol	1000	1200
Fodder/Veg	499	1200

* The water fees vary from IC to IC

In addition to the water fees being paid to canal cooperatives the farmers are paying to tube well cooperatives for water during Kharif and possibly summer at the rate of Rs. 70/hour for 6-7 hours per acre. Which works out to be Rs. In the range of Rs 2000 to 4000 /acre depending upon crop and rainfall during Kharif.

2. Financial Performance

Cost to ICs

Fixed cost: Secretary salary and Administrative expenses

Variable Cost: Operation and Maintenance expenses, Operator salary, voluntary lab our, desiltation etc.

Cost component of Irrigation Cooperatives.

Component	Extent of expenditure by ICs(% of Total expenses)
Secretary's Salary	10- 22% (Rs 500 to 2000/month)
Operator's Salary	Highest component with 20-40 %(Rs. 500 to 1500/month) (1 to 3 and more operators depending on the command area.)
Administrative expenditure	5-45% (Rs 9 to Rs 116/ha)
Maintenance and Repair of the canal	Less than 50%

Source: DSC, Bopal, Ahmedabad

Annexure IV (A)

Profile of the studied Irrigation Cooperatives Profile of the studied ICs (By DSC, Ahmedabad)

S. No	Name of I C	Type of Scheme	CCA (Ha) of IC	District	Year of Start	No. of Watering years	No. of Share holders	Supporting Agency
1.	Kakdiamba	Minor	891	Narmada	1995	5	550	AKRSP
2.	Chopadvav	Minor	1460	Narmada	1993	8	444	AKRSP
5.	Rangpur	Major	617	Mehsana	1997	9	248	DSC
6.	Thalota	Major	251	Mehsana	1994	4	212	DSC
7.	Bhetasi	Major	1000	Nadiad	1993	6	789	Irrigation Department

As per Government of India Classification-

Minor Irrigation Scheme-< 2000 ha of Gross Command Area

Medium Irrigation Scheme-2000-10000 ha of Gross Command Area

Major Irrigation Scheme-> 10000 ha of Gross Command Area

Annexure IV (B)

Irrigation Cooperative Rangpur (promoted by DSC)

	97-98	98-99	2001-2002	Average
1. Area Irrigated-(Ha)	201	170	320	230.33
Income				
2. Water Charge Income (Rs.)	39812	24308	86182	50101
(198.07)	(142.99)	(269.33)	(203.46)	
a) Government Subsidy for Administrative expenses (Rs.)	*8129 (40.44)*	*5702 (33.54)*	*18284 (57.14)*	*10705 (43.70)*
b) Government Subsidy for M & R (Rs.)	*12169 (60.54)*	*8553 (50.31)*	*27426 (85.71)*	*16049 (65.52)*
c) Additional water charges (Rs.)	*19514 (97.08)*	*10053 (59.13)*	*40472 (126.47)*	*23346 (94.22)*
3. Bank Interest (Rs.)	2541 (12.64)	3321 (19.53)	12975 (40.55)	6279 (24.24)
4. Income from diversification activity (Rs.)	0	0	0	0
5. Voluntary Labour (Rs.)	10000 (49.75)	10000 (58.82)	20000 (62.5)	13333 (57.02)
Total Income (2+3+4+5) (Rs.)	52353 (260.46)	37629 (221.34)	119157 (372.26)	69713 (284.68)
Expenditure				
6. Administrative Expenses (Rs.)	1556 (7.74)	1965 (11.56)	14302 (44.69)	5941 (21.33)
i. Administrative cost (Rs.)	*1556 (7.74)*	*1965 (11.56)*	*2302 (7.19)*	*1941 (8.83)*
ii. Secretary's salary (Rs.)	*0*	*0*	*12000 (37.5)*	*4000 (12.5)*
7. Maintenance & Repairs	23960	21540	52480	32660
Expenses (Rs.)	(119.20)	(126.7)	(164)	(136.63)
i. Canal Maintenance & Repairs (Rs.)	*0*	*4550 (26.76)*	*5680 (17.75)*	*3410 (14.83)*
ii. Voluntary Labour (Rs.)	*10000 (49.75)*	*10000 (58.82)*	*20000 (62.5)*	*13333 (57.02)*
iii. Operators' Salary (Rs.)	*13960 (69.45)*	*6990 (41.12)*	*26800 (83.75)*	*15917 (69.77)*
Total Expenditure (Rs.) [6 + 7]	25516 (126.94)	23505 (138.26)	66782 (208.69)	38601 (157.96)
Annual Surplus/ Deficit [Income-Expenditure] (Rs.)	26837 (133.52)	14124 (83.08)	52375 (163.67)	31112 (126.75)

Note: The figures in bracket are per hectare of irrigated area equivalents of the corresponding figures outside the bracket

Annexure IVC

Irrigation Cooperative Thalota (promoted by DSC)

	96-97	97-98	98-99	2001-02	Average
1. Area Irrigated-(Ha)	109	163	168	170	152.5
Income					
2. Water Charge Income (Rs.)	11172 (102.49)	44923 (275.6)	30261 (180.12)	44852 (263.83)	32802 (164.4)
a) Government Subsidy for Administrative expenses (Rs.)	*627 (5.75)*	*8171 (50.13)*	*4630 (27.56)*	*10134 (59.61)*	*5890 (35.76)*
b) Government Subsidy for M & R (Rs.)	*939 (.61)*	*12258 (75.2)*	*6945 (41.34)*	*14434 (84.9)*	*8644 (52.51)*
c) Additional water charges (Rs.)	*9606 (88.13)*	*24494 (150.27)*	*18686 (111.23)*	*20284 (119.32)*	*18267 (117.23)*
3. Bank Interest (Rs.)	636 (5.83)	6849 (42.09)	7272 (43.28)	4087 (24.04)	4711 (28.81)
4. Income from diversification activity (Rs.)	-115 (-1.05)	7975 (48.93)	15079 (89.75)	16113 (94.78)	9763 (58.10)
5. Voluntary Labour (Rs.)	0	0	0	0	0
Total Income (2+3+4+5) (Rs.)	11693 (107.27)	59747 (366.55)	52612 (313.17)	65052 (382.66)	47276 (292.41)
Expenditure					
6. Administrative Expenses (Rs.)	5005 (45.92)	8755 (57.71)	17078 (101.65)	15157 (89.16)	11499 (73.61)
i. Administrative cost	*5005*	*3355*	*7878*	*5557*	*5448.75*
	(45.92)	*(20.58)*	*(46.89)*	*(32.69)*	*(36.52)*
ii. Secretary's salary	*0*	*5400 (33.13)*	*9200 (54.76)*	*9600 (56.47)*	*6050 (36.09)*
7. Maintenance & Repairs Expenses	1265 (11.6)	22409 (137.48)	8460 (50.36)	31216 (183.62)	15838 (95.76)
i. Canal Maintenance & Repairs (Rs.)	*25 (.23)*	*12259 (75.21)*	*0*	*14436 (84.92)*	*6680 (40.09)*
ii. Voluntary Labour (Rs.)	*0*	*0*	*0*	*0*	*0*
iii. Operators' Salary (Rs.)	*1240 (11.38)*	*10150 (62.27)*	*8460 (50.36)*	*16780 (98.70)*	*9158 (55.67)*
Total Expenditure (Rs.) [6 + 7]	6270 (57.52)	31164 (191.19)	25538 (152.01)	46373 (272.78)	27336 (168.37)
Annual Surplus/ Deficit [Income-Expenditure] (Rs.)	5423 (49.75)	28583 (175.35)	27074 (161.15)	18679 (109.88)	19940 (124.03)

Note: The figures in bracket are per hectare of area irrigated

Annexure-V

Agro climatic Features of Dharoi Irrigation Project

Rainfall (mm)	625-875
Type of soil	Sandy loam to sandy soils.
Soil Characteristics &	
Land use classification	Most of the area is cultivated.
Surface color	Dark brown, dark, yellowish, brown to Yellowish brown.
Depth of the soil	Deep to very deep more than 90 cm.
Predominant Texture	Sandy loam to loam.
Soil Slope	1 to 3 %.
General fertility	Nitrogen-poor, Phosphorus medium, Potash medium.
Cat Ion Exchange Capacity	Less than 20 me / 100 gms of soil.
Electrical conductivity	Less than 1 mmhos/cm.
Exchangeable Sodium %	Traces.
Order	Inceptisols, Entisols, Aridisols.
Crops	Paddy, Bajra, Pulse, Cotton, Groundnut. Tobacco, Wheat, Jowar, Minor Millet, Vegetables. Spices and condiments, Oil Seeds, Cotton

Annexure-VI

Factors Affecting Financial viability of ICs

Factor	Component Type	Comments
Command area per unit length of canal	Technical Component	Cannot be altered
Canal section &	Technical	Cannot be altered
structure	Component	
Lined and unlined canals	Technical Component	Lining the unlined canals is the obvious option as it will greatly reduce the running costs as well as huge seepage losses and other environmental costs.
Water availability	Technical Component	Not in ICs control
Interest from cash at bank	Financial Component	The ICs can deposit some portion of money (e.g.) share capital as fixed deposit to ensure a higher interest
Subsidy for Maintenance and Repairs	Financial Component	As the water rates levied by the government will increase, the subsidy will automatically increase. But a major portion of the subsidy is spent on operators' salary and the issue of proper and adequate maintenance & repairs is neglected. Hence norms should be evolved for ensuring adequate investment specifically for M & R of canals.
Avg. Additional Water Charges gained/Ha	Financial Component	Margin should be higher for high value crops and lower for low value crops. For ensuring that farmers using higher quantity of water pay higher, charges should be on per watering basis.
Number ofshareholders	Social Component	Cannot be altered
Voluntary Labour	Institutional / Social Component	Should be institutionalized. Either member farmers should contribute physically or pay equivalent labour wage at the time of annual M & R of the canal and channels. Its value should be entered in the books of accounts.
Recovery Problems	Institutional/ Social Component	This problem can only be addressed by making the institution strong and strictly ensuring rule conformance.
Efficient water distribution	Managerial Component	Better management of irrigation water to ensure effective and efficient service delivery and hence increasing the command area irrigated.
Diversification Activity	Managerial Component	If the diversification activity undertaken is technical or the risk involved is high, then either the activity should be promoted by federation if it is capable of hiring technical expert, or it should not be taken up at all.

INSTITUTIONAL AND POLICY REFORMS IN WATER SECTOR IN INDIA: REVIEW OF ISSUES, CONCEPTS AND TRENDS

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Abstract

The paper looks at the institutional and policy reforms in the context of sources and uses of water. Although the reform measures have been specific about surface water, there still is ambiguity on the groundwater situation in India. The reforms have failed to de-link the conventional linkages between right to land and right to (ground) water. Most policy reforms have been in response to the emerging crisis of water allocation, use and management. The current perspective towards water has been holistic in nature in contrast to the excessive importance to techno-engineering approach that characterized the earlier period of water sector. Further, there have been changes acknowledging the rights of farmers, women and end-users as stakeholders in the whole process of water governance. In this regards, the policy changes have proceeded hand in hand with other reforms in decentralized governance, providing greater emphasis on user participation in decision making concerning water governance.

1. INTRODUCTION

During the last one decade or so, water scarcity has emerged as one of the important themes in discussions about the socio-economic future of the world. There had been enough evidence to indicate that by 2025, nearly 1.4 billion people, amounting to a quarter of the world's population or a third of the population in developing countries, are destined to face absolute water scarcity (Cosgrove, 2003; Rosengrant, Kai and Cline, 2002; Seckler et al., 1999). The human consequences of such water scarcity, besides the environmental deterioration of water bodies, would be, what is now being termed as 'water poverty', indicating the difficulties that human kind would face in procuring adequate and reliable access to safe water for productive and consumptive purposes (see, Shah and Koppen, 2006). Further, the population projections indicate that over the next 25 years, food will be required for another two to three billion people, creating additional stress on demand for water. Irrigated agriculture, which at present consumes more than 70% of all water withdrawals, is estimated to increase another 15-20% to feed the growing population of the world (GWP, 2000). This ever increasing demand for water is likely to raise serious conflicts between utilization of water for irrigated agriculture and for other human and ecosystem purposes.

Besides population expansion, demand for water is ever increasing due to consequential effects of economic development and lifestyle changes. Over the years, there has been a substantial change in urban demand for water owing to industrialization and growth of population concentration. Further, the increasing urban water use involves the demand for better quality of water, along with the increase in quantity of water required. The demand for better quality of water in urban areas, however, involves a paradox (see, Saleth and Dinnar, 1999). On the one hand, the urban dwellers having a better lifestyle and greater political articulation, stress upon better quality of water besides the requirement of quantity. On the other hand, since growth of urban water demand means more residential sewerages and industrial pollution, every increase in urban water consumption, if not addressed properly, could lead to a deterioration of water quality. The challenges of water in terms of quantity are further magnified by the problems of deterioration of water quality in recent years. Deteriorating water quality caused by pollution, through dumping domestic, agricultural and industrial wastes

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into water bodies, also influences water usability downstream, and threatens human health and the functioning of aquatic ecosystems by reducing effective availability and increasing competition for adequate quantity of quality water.

Such being the seriousness of the problem in water sector, which till recently was commonly considered as being plentiful and a virtually free good, global discussions have exhibited varieties of view points about how best developing countries can cope up with this imminent situation. The emerging water scarcity, water conflicts at micro and macro levels, and deterioration of water infrastructures, in the recent decades, have resulted in greater policy attention being paid worldwide to institutional arrangements governing water resource development, allocation and management. The crisis in water sector, both in terms of quantity and quality, has also made explicit the inherent inadequacies of existing institutions in dealing effectively with new and emerging set of problems, which are not so much related to water resource development, rather to resource allocation and management. Such emerging problems in water sector now demand that the means and ways for water allocation, water management, and mechanisms for resolution of conflicts arising over them have to be either created or reoriented by updating the existing policies concerning water governance. Water administration and management have to now accommodate the increasing and much acknowledged role of end users associations, non-governmental and grassroots level organizations, women and self-help groups, and those promoting causes and concerns for environment. In a manner of speaking, as countries move from a state of water surplus to water scarcity, water institutions, which design rules for water resource development, allocation and management, have to reorient themselves to meet the ever emerging challenges. Such reorientation of water institutions to best suit the current situations and meet the emerging challenges and crises in water sector paves the way for water institutional reforms through out the world. To be more specific, most of the water institutions in India, being developed in a time of water abundance – especially during the colonial period – are becoming increasingly ineffective in addressing water challenges arising out of water scarcity. Consequently, institutional arrangements governing water sector are undergoing significant policy changes in the recent years.

While discussing about water sector reforms, a few fundamental questions arise, such as: what are the motivating factor behind water sector reforms, in which direction such institutional changes are heading, and what are the future implications of these institutional reforms for water sectors as a whole. While attempting to answer questions of this nature, the present paper aims to investigate the water sector institutional reforms in India. The broad objective of the paper is to analyze the trends, patterns, directions and implications of institutional reforms in the water sector in India. One of the important considerations of policy reforms in water sector is that of formation of water right arrangements, so that the water users can get an assured and secure claim over the resource. A secured right over water has significant bearing upon the resource as a whole, since an assurance that one will receive benefits from the resource will affect the incentives to invest and conserve the underlying resource (Bruns, Ringer and Meinzen-Dick, 2005). Hence, the paper seeks to investigate how the water sector reforms are working towards establishing water rights in the country by adopting a decentralized framework.

The methodology involves a review of published articles and unpublished documents on water sector in the country. The paper is divided into four sections. Following this introduction, the second section sets a ground for institutional arrangements in water sector and provides an analytical framework for analyzing water institutions and water rights. The third section describes the reform experiences of the water sector in India from a historical perspective. The fourth section then proceeds to generalize the water sector institutional reforms in India, bringing out its problems and future prospects for better water governance.

2. WATER SECTOR, WATER INSTITUTIONS AND WATER RIGHTS: AN ANALYTICAL FRAMEWORK

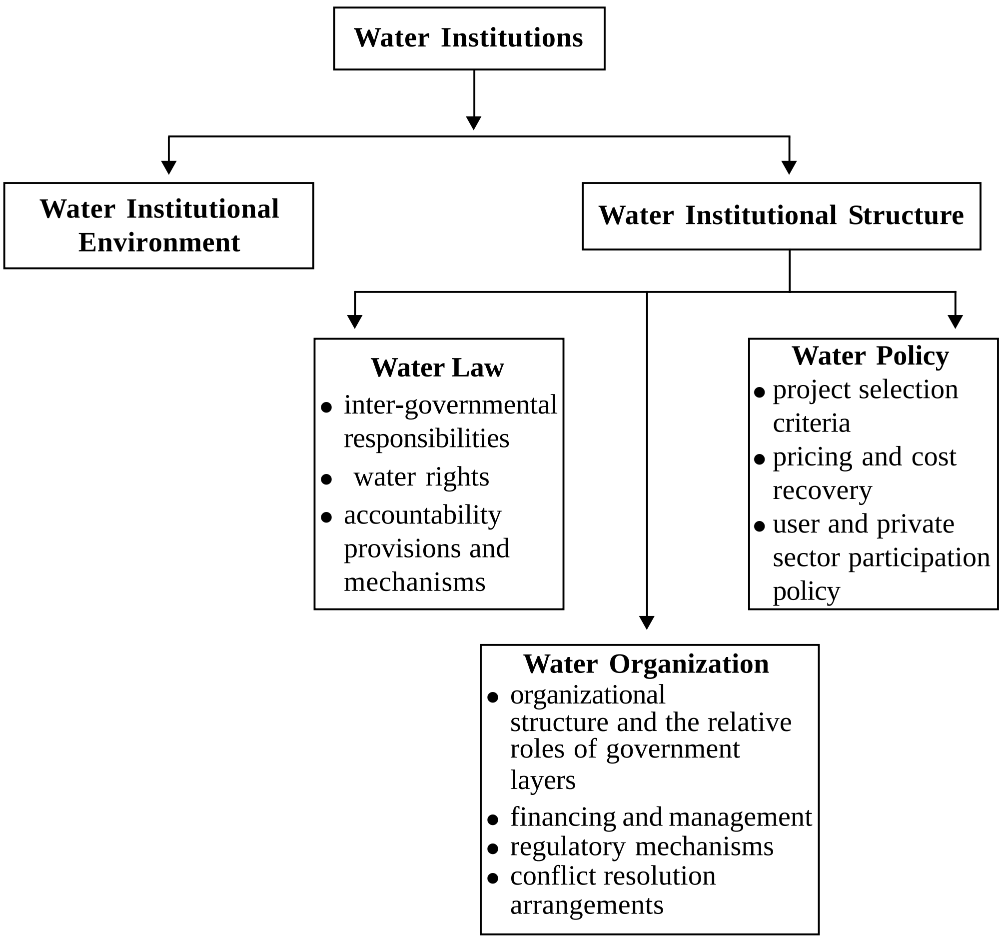
Water sector, from a broader perspective, may be considered to cover all issues concerning water from sources such surface, sub-surface, ground and recycled sources; along with other water related issues covering water and sewage treatment, management of costal and waterway engineering. However, the main focus on water sector, the policy changes of which this paper tries to analyze, is on the macro level issues of development, allocation and management of water at a national level. In order to understand the institutional arrangements in water sector, it is apt to understand what institutions mean in the context of natural resource management, including water.

A study of institutions, in the context of natural resource management, focuses on the laws and conventions that either directly allocate resources, or establish processes and constraints for its members to make allocative decisions. Notwithstanding the casual use of the term ‘institution’ in our day-to-day life, it is mostly used in reference to rules, regulation, and prescriptions to behave in a certain way. It is often defined as rules about behaviour, ‘especially about making decisions’ (Rinker, 1982: 4) and about ‘individual expression and choice’ (Pllott, 1979: 156). Within the broader framework of the institutional economics literature, North (1991) defined institutions as humanly devised systems that structure the interaction of its members in social, economic and political arenas. As an organised and well-defined system, institutions constraint some behaviours and favour or facilitate others. They enforce sanctions negatively in the form of punishments when the prescribed set of rules are violated and positively in the form of rewards when such rules are complied. Institutions exist both as formal entities through constitutions, laws and well-defined property rights; and as informal agents through customs, traditions, norms, codes of conduct, social taboos etc.

In consistence with the understanding of institutions, as it is represented in the context of natural resource management and in institutional economics literature, water institutions may be conceived as something beyond the common understanding of institutions as mere organizations or associations. Water institutions may be conceptualized as an entity, which sets the rules and defines the action sets for decision making in the realm of water sector. Water institutions are the ‘… rules that together describe action situations, delineate action sets, provides incentives and determine outcomes both in individual and collective decisions related to water development, allocation, use and management’ (Saleth and Dinar, 2005: 2). Water institutions are subjective and path dependent (see, Hodgson, 1998 and North, 1990). The subjective nature of water institutions stems from the fact that they are often constituted and also influenced by belief systems, behavioral habits and societal conventions. The path dependency nature of water institutions refer that their present status and future directions can not be separated from their earlier course and past history. Water institutions are also hierarchical in nature, being embedded within the cultural, social, political and economic context.

The New Institutional Economics (NIE) literature distinguishes between Institutional Environment and Institutional Arrangements (see, North, 1990). With respect to the water sector, the Institutional Environment would include various government agencies that directly or indirectly deal with water, international agencies dealing with water resources, and water related laws and policies of the states. Institutional Arrangements, in contrast, are the structure that humans impose on their dealings with each other’ (North 1990). In the water sector, institutional arrangements would correspond to water markets, water co-operatives, water users associations, etc. (see also, Shah, 2005). Comparing these two aspects of institutions in water sector, we can observe that while the institutional environment functions at a macro level and represent the government’s laws and policies, concerning development, use, allocation and management of water, the Institutional Arrangement function at a very micro level involving rules, practices, and conventions governing allocation and management of water at the grassroots level. In a similar fashion, Saleth (2004) distinguishes between institutional environment and institutional structure. While institutional environment is characterized by the overall physical, cultural, historic, socio-economic and political situation of a country or region, the institutional structure corresponds to the interactive effects of legal, policy and organizational or administrative components of government. The institutional environment of the water sector of a country or region would include factors determining the water situation of a country, along with other factors determining water resource conditions as well as to other water related sectors such as agriculture, environment, forest, and urban development. Likewise, the water institutional structure is defined interactively by aspects concerning water law, water policy and water administration.

Saleth and Dinar (1999, 2000, 2004, 2005), in their attempts to understand the innate nature and inherent features of water sector and water institutions, have developed the Institutional Decomposition and Analysis (IAD) framework, which becomes crucial to account for the recent reforms in the water institutions. As discussed above, water institutions, from a wider perspective, can be decomposed into water institutional structure and water institutional environment. Since the rules governing water institutions are formalized in terms of three inter-related aspects, i.e. legal framework, policy environment and administrative arrangements, Saleth and Dinar, try to decompose the water institutional structure into three inter-related components: water law, water policy and water administration or water related organisations. These institutional components, which consists of both macro level (formal) and micro level (informal) arrangements, are further decomposed to highlight some of their major institutional aspects. Accordingly, the component of water law is decomposed to highlight factors like: inter-governmental responsibilities, water rights, and accountability provisions and mechanisms. Similarly, the water policy is decomposed to emphasise: project selection criteria, pricing and cost recovery, and user and private sector participation policy. Likewise, the organizational components of water institutions are decomposed to focus on: organizational structure and the relative roles of government layers, financing and management, regulatory mechanisms, and conflict resolution arrangements. Such a decomposition of water institutions can be depicted in the following figure.



2.1 Understanding Water Institutional Reforms

Since the rules governing water institutions revolves around three inter-related aspects, i.e. legal framework, policy environment and organizational framework, any attempts to introduce reform measures in the water sector require corresponding changes in water law, water policy and water organisations. The factors that influence water sector and bring changes in the above three main dimensions of water institutions are many with diverse origins and varying levels of impacts. These factors are also country-specific, depending upon the over all water institutional environment, and the degree of formalization of the water economy of a nation. Saleth and Dinar (2000, 2005), however, identify two broad factors, i.e., endogenous and exogenous, which account for the corresponding changes in three inter-related components of water institutional structure. While the endogenous factors responsible for changes in water institutions are internal to both water institutional structure and water sector, exogenous factors lie outside the strict boundaries of both water institutional structure and water sector. These two factors capture the key features of the institutional environment and institutional structure, and the changes wrought out in them as response to societal demand and water sector crisis. While the endogenous factors correspond to physical and ecological problems of water sector, coupled with the crisis in its legal, policy and organizational frameworks, exogenous factors are mostly related to wider socio-economic problems, which influence the water institutional environment.

The endogenous factors that induce institutional changes in the water sector include water scarcity, emerging conflicts over water due to improper water laws and policy frameworks, financial and physical deterioration of water infrastructure affecting water resource development, and operational inefficiency of water organisations. Besides, the poor linkages between various components of water institutional structure (i.e. water law, policy and organisation) also forms an endogenous factor, since the performance of water institutions depends very much upon these linkages between these water institutional components (see, Saleth, 2004). The exogenous factors resulting in water institutional reforms are related to demographic growth and mounting pressure on water resources for fulfilling the increased targets of food production, economic development and technological pressure resulting in greater demand for water, reforms in the spheres of economy and polity, international pressure and commitments for ensuring sustainability, natural calamities concerning water, such as flood and drought, and changing socio-political values for ensuring equity, inclusion and justice. The exogenous factors, therefore, include the over all environment within which the water sector and water institution functions. Notwithstanding the independent impacts, these factors have upon water sector and water institutions; it is the synergy between these endogenous and exogenous factors, which determines the structure and pace of institutional changes within water sector.

The endogenous and exogenous factors of institutional change are inter-related phenomena, and do not operate in isolation, since they influence each other. For example, the exogenous factor of socio-economic and technological development puts additional pressure on water withdrawal and form the basis for water scarcity and conflicts over water. Similarly, the international pressure and commitment for sustainability may be understood as a response to water scarcity, which forms one of the endogenous factors. The inter-connectedness of these two factors makes it difficult to understand the individual roles of these factors, and thereby generalize the impart of these factors upon the pace and direction of water institutional changes. The institutional transaction cost theory, in the New Institutional Economics literature, however, tries to understand the direction and pace of institutional change by linking factors for institutional change into transaction cost and opportunity cost (see, North, 1990; Saleth and Dinar, 2004). The transaction cost of water institutional changes corresponds to the real economic and social costs of inducing changes in the water Institutional structure. In contrast, opportunity costs in the context of institutional change may be refereed to as the opportunities lost because of changes in status quo. The transaction cost theory of institutional economic literature predicts that institutional changes occur only when the transaction costs of inducing changes in institutional framework becomes lesser than that of the opportunity costs.

Extending this institutional transaction cost argument to the water sector, we may find that while the transaction cost of water institutional changes include both real and monetary costs of altering the regulatory, monitoring and enforcement mechanism related to water development, allocation and management. Similarly, the opportunity costs in water sector may include real and economic values of opportunities foregone, or the social costs of the status quo. These opportunity costs are also the benefits of water institutional reforms in the sense that, in the absence of changes in the existing water institutions these benefits can not be gained. Several studies have estimated the opportunity costs in the water sector and the expected gains from changes in water institutions or particular components of water institutions (see, Frederikson, 1992; Picciotto, 1995; Saleth, 1996; Gazmuri and Rosegrant, 1994).

Rather than being a one time affair, water institutional reforms are continuous and gradual changes over time in response to the factors identified above, depending upon the costs and benefits of reform. Since the water institutions are path dependent, the benefits from the earlier reforms smoothens the prospects for further reforms in the water sector. Saleth and Dinar (2004), in their attempts to study the pace of institutional changes in water sector, have developed a stage-based perspective of institutional change. They identify four main stages of water institutional changes, which progress as a circular process, and are mediated by information and learning, political lobbying and bargaining, organizational power and politics, and behavioural changes and performance expectations (see also, Saleth and Dinar, 2005). The first stage of water institutional changes correspond to 'mind changes' among individuals, which occur from subjective and objective evaluation of current water situation and water crisis, information feedback and learning experiences they gain from existing institutions and ongoing changes. The second stage of water institutional changes is that of 'political articulation', where intense political debates, bargaining, campaigning and counter-campaigning take place before arriving at a political agreement about details of the institutional change. The third stage is that of 'institutional change', where agreed upon changes are implemented. This stage is the most crucial stage in water institutional reforms, since, at this stage, there is every possibility of differences occurring over reform implementation and actual changes, due to financial, organizational and administrative constraints. There have been many instances where, reform implementation is reduced to procedural changes with policy declarations, creation of new organisations or remodeling earlier ones, without any actual or real changes taking place. The fourth and final stage of water institutional changes relate to actual impact of the changes implemented in stage three.

Identification of these stages of institutional change in water sector does not, however, mean that water institutional reform is a linear and unidirectional process. In the process of reform, the institutional changes may proceed to the next stage, or remain constant in one stage for a longer period, or even revert back to the previous stage, depending upon the suitability of the over all environment for reforms. Institutional change is always slow, evolutionary and continuous, sometimes involving a time gap between the implementation of reforms and the actual gains out of such reform processes. While the implementation of reforms exhibits itself in substantial behavioral as well as organizational changes, the real impact of reforms depends upon the speed and amount of influence these changes have upon allocation, use and management of water.

2.2 Understanding Water Rights

Water rights or rights to access and use of water form a crucial issue in water resource management. Water rights pertain to the micro level aspects of water sector, since these are related to water allocation and use. Water rights are determined by water allocation institutions at the local level. The institutional reforms at the macro level influence substantially the micro level decisions regarding use and allocation of water. The reform process, which calls for an inclusive, participatory and equitable water management with accountable institutional arrangements, results in establishment of new forms of water rights at the micro level. When water was abundant, establishment of water rights never formed a matter of discussion in water governance. However, with the increased scarcity of water, and the emerging conflicts, establishment of rights over water has become crucial.

In order to understand water rights, we have to inquire into the concept of property rights. Property rights can be defined as 'the claim, entitlement and related obligations among people regarding use and disposition of a scarce resource' (Furubotn and Pejovich, 1972). Bromley (1992: 2) defines property as 'a benefit or income stream', and property rights as 'a claim to a benefit stream that some higher body — usually the state — will agree to protect through the assignment of duties to others, who may somehow interfere with the benefit stream'. Thus, property right is, rather, a social relation that defines the rights of the property holder to the resource in relation to others who have a corresponding duty to respect that right. Property rights over a resource may include ownership rights, use rights of access and withdrawal, and decision-making rights to manage the resource, and exclude and alienate others accessing the resource (see, Schlager and Ostrom, 1992; K. and F. von Benda-Beckmann and Spiertz, 1996; Rout, 2005).

In agreement with the concept of property right, water rights may be defined as a secured and assured claim over access to water, which is usually backed by other agencies, including the state, coupled with corresponding responsibilities of others to accept that claim. A secured claim over water matters a lot, since the assurance that one will receive benefits from the resource in future, affects the future incentives to invest in the resource and conserve the underlying resources. Since water rights are related to allocation and reallocation of water at the field level, several alternate institutional regimes for water allocation, specifying the rights over water can be identified. Water rights regimes for water allocation may be understood as a specific kind of institutional arrangement of property right over water, which defines who will have rights to access to water and who will not. Water rights regimes structure the relationships between two or more individuals (or groups) in the sense that while, on the one hand, it ensures the interests of one party over water by assigning 'rights' over the resource, on the other hand, it makes obligatory on the part of the other party to respect that right by means of 'duties' towards that secured claim or 'rights'. In other words, water rights regimes make one's claims over water secure by establishing 'property rights arrangements', which is respected by those who are outside such arrangement, and also is protected by state or some higher authority of law.

Property rights regimes are broadly classified as public, private and common property, based on who hold the right (see, Bromley, 1992, 1999; Bromley and Cernea, 1989). In public property, the state holds the absolute right over the property, in private property, individuals or corporate houses hold the rights over property, and in common property, rights are held by a group of people together. In congruence with property rights regimes, institutional arrangements establishing water rights for water allocation and reallocation can be grouped into three broad types: user-based allocation, agency allocation and market allocation (Meinzen-Dick and Mendoza, 1996; Meinzen-Dick and Rosegrant, 1997; Bruns and Meinzen-Dick, 2005). In user-based allocation, water users join together to coordinate their actions, managing water as a form of common property. In agency allocation, water is treated as public property and the state holds absolute rights over water for deciding who does and does not receive water in accordance with bureaucratic procedures. In market allocation, which corresponds with private property, water may be allocated through private transactions, with users trading water through short or long-term agreements. The distinction between water rights under user-based allocation regime and that of market-based allocation is that, while in the former the water users enjoy use and decision making rights over water, which are backed by the state, in the case of market allocation, the individuals hold ownership, use and decision making rights over water. The ownership rights over water in the case of user-based allocation are retained by the state in principle. Possession of such ownership rights in the case of market-based allocation, generates tradability rights over water, and consequently water markets in the field level.

3. INSTITUTIONAL REFORMS IN THE WATER SECTOR OF INDIA

As discussed in section one, institutional changes in water sector have been largely a response to the emerging crisis in water resource development, allocation and management. The crisis, partly, has arisen because of failure of the existing institutional arrangements to cope up with the emerging situations of water scarcity and the increased demand for both quantity and quality of water. Often factors outside the purview of water sector, such as population pressure, economic development, economic and political reforms, etc. have contributed to the crisis in the water governance, resulting in greater pressure for inducing institutional reforms in water sector. In the recent years, public policy formulations in India have responded to such crisis by introducing institutional reforms in water sector. Though the success and pace of these institutional reforms in water sector have been ambiguous, yet, it is possible to draw some inferences regarding the nature, trend and direction of such changes. Keeping this in mind, the present section attempts to highlight the Indian experiences of the on-going process of reforms in the water sector.

India is the world's largest peninsula, second most populous country and seventh largest country, covering a geographical area of 3,287,590 km^2. The two main sources of water in India are rainfall and snowmelt of glaciers in the Himalayas. In 1990, the total water withdrawal was estimated at 500 km^3, of which nearly 92% are consumed for agricultural purposes, 5% for domestic purposes and remaining 3% for industrial purposes.

Drawing upon the arguments done in the conceptual section, we may explore the structure of water institutions in India by highlighting its three inter-related components: water organisation, water law and water policy.

3.1 Water Organization in India

The organizational aspects of the water institutional structure in India can be explained by highlighting the important agencies in the water sector. The Union Ministry of Water Resources (MoWR), which evolved from the department of irrigation under the Ministry of Agriculture is the national organization for over all planning and management of water resources in the country. The technical support to the ministry comes from important agencies working under it, such as Central Water Commission, Central Ground Water Board, and National Water Development Agency. Several research organisations including the Water and Land Management Institutes provide the research support to the Union Ministry of Water Resources. There are also important organizational arrangements, like National Water Resources Council (NWRC) and National Water Board (NWB) for inter-state and centre-state coordination. The NWRC, created in 1983, is an important policy making agency in Indian water sector, chaired by the Prime Minister, and includes the Union Minister for Water Resources and the chief ministers and governors of all states and union territories. The NWB is the executive arm of NWRC, and is chaired by the secretary of the MoWR and includes chief secretaries of all states, secretaries of the concerned union ministries.

3.2 Water Law in India

Although India does not have any separate and exclusive laws regarding water, there were water related legal provisions dispersed in various irrigation acts, central and state laws, constitutional provisions, etc. The federal political structure of the country resulted in creation of dual institutional structures in India. Most of the water resource development responsibilities and legislative powers are with the state governments as per the Entry 17 of the State List under Seventh Schedule of Indian constitution. However, the central government also has certain indirect power because of its role in project clearance, resolution of inter state water disputes, and control over several technical organisations. The central government also has regulatory roles in the water sector vide Article 252, which is related to inter-state water projects, and through the Forest Conservation Act, 1980, which requires the states to get central government clearance for executing ecologically sensitive water projects. More so, the central government has an important role in resolving inter-state water disputes as per the provision under Article 262 of the Constitution of India, and the Inter-state Water Disputes Act of 1956 (Saleth, 2004).

3.3 Water Policy in India

Most of the water related laws were either passed during the colonial period or were the amended versions of colonial law, and were outdated due to their inability to correspond to the newly created water demands and water crisis. The drought of 1987, coupled with the macro economic crisis of the late 1980s have led to some policy changes in the water sector in India. While the National Water Policy of India, which was formulated in 1987 was a response to the water scarcity due the drought situation, the reduced water sector investment caused by impact of the economic crisis of the 1980s has forced many states to raise internal resources through better cost recovery and external resources through mobilization of private funds (Saleth and Dinar, 2000).

The main goals of the National Water Policy (1987) of India are the promotion of conjunctive use of water from surface and sub-surface sources, supplemental irrigation, water conserving crop-patterns, and irrigation and production technologies. The policy has called for increase in canal irrigation water rates and promotion of user participation in canal water management (GoI, 1987). Although the water policy of 1987 has recognized the need to limit individual and collective water withdrawals and user participation in water management, it has failed to identify the institutional mechanism of such (Saleth, 2004).

The 1987 Water Policy made it explicit that water is a vital natural resource, and its effective management is crucial for livelihood and environmental security. Recognizing this, the National Water Resources Council (NWRC), the apex body of policy making in the water sector, amended the water policy and adopted the new National Water Policy in the year 2002 (see, GoI, 2002). The new National Water Policy, 2002 calls for a regulation of ground water extraction so as not to exceed the recharging potential. There has been an urge for integration of water-use and land-use policies. In a remarkable departure from previous policy, the policy of 2002 introduces participatory approach to water resource management in the field of irrigation. The policy makes an attempt to maintain the quality of water and prevent environmental pollution. Finally, the policy calls for appropriate changes, reorientations and reorganization of water institutions, in order to give effect to the planning, development and management of water resources (see, Rout, 2002).

In line with the New National Water Policy, 2002, several state governments have also amended their state water polices paving the way for user participation in management. Although many states have attempted to involve users in water distribution, cost recovery and system maintenance, the extent of actual Irrigation Management Transfer is insignificant except in some individual state experiences such as Andhra Prades, Tamil Nadu, and Orissa. Incidentally, these states under the financial assistance from World Bank through the Water Resource Coordination Projects, have not only restructured their water administration and amended their water policies, but also have made significant progress in promoting user participation in water management (Saleth and Dinar, 2000).

4. COMMON TRENDS AND PATTERNS IN WATER INSTITUTIONAL REFORMS

The institutional changes in the water sector of India discussed in the above section provide us with a scope to highlight the commonalities in such reforms in the water institutions and water sector. These commonalities correspond to changes in orientation of water management, involvement of farmer communities in management and decentralisation, establishment of water rights defining rights to access to water.

From Water Resource Development to Water Resource Management

The reform process in water sector has resulted in a fundamental shift in orientation, i.e. from water resource development to water allocation and management. This paradigm shift in water sector required a radical reorientation of the water institutions. The pre-reform era was characterized by structural engineering approach for development of water, with little or no emphasis on allocation of such water at the field level. The large-scale irrigation projects through construction of bid dams reflected the civil engineering dominance in the water sector in the periods prior to reform. However, the reform policies of recent times emphasised upon the allocation of water at the field level and the required institutional arrangements for its effective management. The Participatory Irrigation Management policies through Irrigation Management Transfer and/or Pani Panchayat Institutions in India indicate the shift in trend towards water management from water development.

4.1 Farmers' Participation in Water Management through Decentralized Institutional Structure

One of the central themes of water institutional reforms in India has been acknowledgement of farmers as stakeholders in the resource and ensure their participation in management of use and allocation of water. The shift in orientation from water development to water management, have brought into focus the potentials of decentralized institutional structures. The centralized management policies do not find place in the newly emerged paradigm, which requires decentralized institutional arrangements for promoting social justice and sustainability of the resource. The functional distinction between centralized mechanisms needed for coordination and enforcement and the decentralized arrangements for user participation and water allocation have been widely acknowledged as a result of the reform process.

The over all financial crisis and deteriorating of the irrigation system have resulted in recognizing farmers as indispensable partners and stakeholders in irrigation management, and their role in water allocation, fee collection and maintenance of irrigation infrastructure was recognized both in principle and practice. The Participatory Irrigation Management (PIM) through Irrigation Management Transfer (IMT) and Pani Panchayat Institutions aim at transferring managerial responsibilities including cost recovery, and operation and maintenance, to formal Water User Associations, forms the main mode of decentralisation in irrigation sector. The new National Water Policy of 2002, in its item 12 states that management of the water resources for diverse uses should incorporate a participatory approach; by involving not only the various governmental agencies but also the users and other stakeholders, in an effective and decisive manner, in various aspects of planning, design, development and management of the water resources schemes. However, implementation of such a participatory approach practically requires necessary legal and institutional changes at various levels. In this regard, the policy envisions involvement of Water Users' Associations and the local bodies such as municipalities and gram panchayats in the operation, maintenance and management of water infrastructures.

4.2 Water Pricing, Cost Recovery and Issues of Privatisation

One of the controversial and often described as non-populists trends of recent reform processes in water sector of the country has been that of treating water as an economic good, which is said to have been pushed through international organisations like World Bank and ADB. Contrary to the popular view that water is a public and thus, free good, the new reform measures emphasise on accepting water as an economic good, and recognize the need for revising the water rates in the face of poor financial performance of the sector. The recent reforms in water sector demand full cost recovery of operation and maintenance expenses of providing water. The Eighth and Ninth Finance Commission recommended for recovery of operation and maintenance expenses, and the Tenth Finance Commission went a step further and set the target for recovery of one percent of capital cost besides full recovery of operation and maintenance. Further, the Irrigation Pricing Committee in 1992 recommended the recovery of not only full operation and maintenance cost and one percent of capital cost, but also one percent of depreciation cost (See, Saleth, 2004).

The private sector intervention in the water sector is said to be an outcome of poor performance of the sector, such as declining irrigation environment, poor financial performance and the privatization of the new public enterprises initiated by liberalization measures of 1990s. A high level committee was set up by Union Ministry of Water Resources in 1995 to look into the issues of privatization of water, which favored a gradual, selective and state-wise process of privatization of the irrigation sector. Further, the New Water Policy of 2002 also identifies private sector as a potential partner for water resources development and management. The policy in its item 13 states that 'private sector participation should be encouraged in planning, development and management of water resources projects for diverse uses, wherever feasible'. Private sector participation in the changing context is expected to help in introducing innovative ideas, generating financial resources and introducing corporate management and improving service efficiency and accountability to users.

4.3 Establishment of Water Rights

The water rights arrangements under the reform process have become a dynamic phenomenon. The reform process by emphasizing water allocation and farmers' inclusion in water management has specified property rights over water. Under the auspices of IMT, user based allocation has become an institutional alternative to agency based allocation. Further, with provisions for private sector investment in water sector, reforms are also paving the way for market based institutional alternative for water allocation. Water rights have got wider connotations in the wake of reform programmes in water sector in India. Prior to the institutional reforms in water sector, under the top-down centralized model of water development, farmers were only possessing use rights over water, while the state retained with it the ownership and decision making rights. Further, when and how these use-rights will be exercised by the farmers was also to a greater extent influenced by the state. However, with the changes in water management orientations and priorities, farmers are supposed to possess all the three property rights, i.e. use, ownership and decision-making. The IMT process relies on WUAs, and extends all the above three water rights to farmers. Though the state retains with it the *de jure* ownership rights over water, the *de facto* ownership rights are now vested with the farmer, who by virtue of his membership to WUA gains access to the water.

The newly established water rights as a result of the reform measures have heralded several impacts both for the farmers' groups as well as water governance in India. To begin with, it has enhanced farmer groups' access to water with most of the irrigation programmes being designed on a participatory framework. At a larger level, such a right over water may be said to work towards empowerment of farmer communities, who now have got a voice over decision making pertaining to water governance. Further, water governance has got a bottom up makeover with inclusion of end-users in the matters relating to water resource development, allocation and management.

4.4 From Sectoral to Integrated Approach to Water Management

The pre-reform period in water sector was dominated by sectoral approaches to water, with little scope and platform for inter-sectoral communication. However, the recent policy changes in water sector call for integrating the sectors and agencies relating directly or indirectly to water sector. Therefore, the new National Water Policies of India call for integrating land-use policies with water-use policies. As a consequence, Integrated Water Resources Management (IWRM) has emerged as the dominant paradigm in the water sector. At policy level, Indian water sector is in the process of developing a National Water Plan for providing a technical framework needed to promote IWRM and integrated perspective to water resource management.

4.5 International (donor agency) pressure as a source of change

The endogenous and exogenous factors of institutional change had both long term and immediate impact respectively upon the change process in water sector in India. While crisis in water sector in terms of water scarcity, flood, and drought have been long term and evolutionary causing institutional change in water sector, the immediate factor resulting in such changes has been exogenous in nature. For instance, the impact of the economic crisis of 1980s may have forced India to come out with reform measures for recovering operation and maintenance charges from the farmers by increasing irrigation fee. One of the most important immediate factors contributing towards institutional reforms in water sector has been the intervention, influence and pressure from international agencies. The international lending agencies such the World Bank, Asian Development Bank, and USAID and technical organisations like IWMI and FAO have exercised profound influence on the water sector of the country and have acted as crystallizing factors for water institutional reforms. The World Bank assisted programmes, in irrigation management for instance, have emphasised farmers' participation in project design and implementation, thereby, paving the way for policy reforms favoring greater inclusion and participation by farmers' groups. Such policy reforms have generated new institutional arrangements, e.g. Water Users' Associations, at grassroots level which have operationalized participation in water governance in India. Similarly in donor agency aided drinking water programmes too, community's participation in project design, implementation, and operation and maintenance have been conceived as an integral part.

5. CONCLUSION

Since its evolution, human society has encountered many challenges, and has accordingly experienced corresponding changes to over come those challenges. However, what is important is that the speed in which the world has changed over last few decades has been unprecedented compared to earlier times. In the water sector too, there has been a profound change over the last couple of decades concerning water demands and priorities owing to corresponding changes due to globalisation, technological change, relentless competition for economic growth, rapid increase in population, etc. Thus, water policies and institutions of current times have to be significantly different from the policies, strategies and institutions that were previously in practice to meet the emerging challenges. India has accordingly approached the institutional changes in water sector in a positive manner and has under taken several policy and institutional changes. The present paper attempted to underscore such attempts, while at the same time carried out a conceptual review of terminologies like water sector, water institution and water rights arrangements.

Water sector, for all analytical purposes, was conceptualized as an umbrella term consisting of all issues concerning water from various sources, and the issues related to generation, withdrawal and governance of water. However, the important issues that were identified in water sector were macro issues concerning development, allocation and management of water at a national level. A study of institutions, in the context of natural resource management, focuses on the laws and conventions that either directly allocate resources, or establish processes and constraints for its members to make allocative decisions. Arguing in a similar fashion, the paper tried to conceptualise water institutions as an entity, which sets the rules and defines the action sets for decision making in the realm of water sector. Having carried out a conceptual analysis of water sector and water institutions, the paper proceeded further to describe the Indian experiences with respects to changes that were wrought forward in the water institutions and several common trends and perspectives were identified in the whole process of water institutional changes in the country.

Before concluding the paper, it is apt to mention about institutional and policy reforms in the context of sources and uses of water. Even though the reform measures – whether the National Water Policy, 1987 or the New National Water Policy, 2002 – have been specific about surface water, there still lies much ambiguity concerning the ground water situation in India. More specifically, the reforms have failed to de-link the conventional linkages between right to land and right to (ground) water. As a result of which the poor and land-less person's right over and access to ground water remained far from being realised. Further, in the absence of specific withdrawal limits of ground water, the sustainability of the resource has remained a question mark. Although the New Water Policy recognized the need for limiting individual and collective (ground) water withdrawals, it has, however, failed to identify the institutional mechanisms necessary for defining and enforcing such physical limits. This is definitely a matter of serious concern, given that ground water aquifer, unlike land resources, is a continuous one, where one persons withdrawal affects the chance of access and use of the other. With respect to sources of water, the National Water Policy of 2002 has attempted to prioritize water uses, with drinking water being accorded the first preference.

To conclude, the paper identified that there has been substantial change in the perspective in which water sector is approached in the country. To be precise, the country has experienced a change from water resource development perspective to that of water resource management. The current perspective towards water has been holistic in nature in contrast to the excessive importance to techno-engineering approach that characterized the earlier period of water sector. Further, there have been changes acknowledging the rights of farmers, women and end-users as stakeholders in the whole process of water governance. In this regards, the policy changes have proceeded hand in hand with other reforms in decentralized governance, providing greater emphasis on user participation in decision making concerning water governance. Finally, the paper identified that external pressure, especially from the donor agencies, has acted as an important catalyst in generating institutional changes in the water sector in India.

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POLICY INTERPLAY AND TRADE OFFS: SOME ISSUES FOR GROUNDWATER POLICY IN INDIA

S. P. Singh[1]

Abstract

The paper examines the current status of groundwater, discusses various policy interplays and trade offs and identifies some issues for the effectiveness of groundwater policy. Water policy is influenced by various related policies, such as agricultural policy, land-use policy, energy policy, food policy, price policy, environment policy, credit policy, subsidy policy, etc and its effective implementation on the ground requires the participation of local institutions, like PRIs, farmers' organization, users' groups and civil society organization, apart from the government departments and agencies. Therefore, interfaces, interplays and interlinks of these policies, institutions, and organizations and groups are crucial for better policy formulation. Region-specific policy risks and tradeoffs and tradeoff among the major policy goals—efficiency, sustainability and equity—are also required to be assessed

1. INTRODUCTION

Water is a state subject as per the provision of Indian constitution. However, central government can also assume responsibility in the mater related to regulation and development of inter-state rivers and river valleys. In case of groundwater, the regulatory and controlling power of the central government is minimal. Except for formulating a Model Groundwater (Control and Regulation) Bill, 1970 (recently revised in 2005) for the adoption of the state governments and some regulations under the Environment Protection Act (EPA) and setting up of the central groundwater Board, the development, regulation and management of groundwater is largely in the hand of state governments. It may be relevant to note that groundwater contributes about 60% of net irrigated area in India. It has emerged as the primary democratic water source and poverty alleviation tool in the rural areas (IWMI, 2002). The green revolution in India (especially in Punjab, Haryana and Western Uttar Pradesh) was mainly due to the advent of tube well technology in 1960s, coupled with government efforts towards providing easy access to farm credit, inputs, high yielding seeds and new technology and rural electrification that helped the farmers to energize their irrigation pumpsets. Apart from the state governments' efforts to popularize tube well irrigation through loans and concessions during the green and post-revolution periods, the World Bank also supported huge investment in rural electrification infrastructure to augment groundwater irrigation and raise agricultural productivity (Shah et al., 2004).

Undoubtedly, groundwater irrigation has made significant contribution in the agricultural development of the country. Unlike canal irrigation wherein investment is mainly from the state and access is restricted by the topographic constraints, groundwater is a decentralized and democratic resource, largely developed and managed by the farmers (Kumar, 2003). Its development has been accorded priority on the equity, efficiency, productivity and private investment grounds. However, due to the government policies related to agricultural credit, subsidy, inputs, and energy; and lack of effective regulation of groundwater irrigation in the country, the sustainability of this precious resource has become one of the major issues for the policy makers. Rising population, income growth, industrialization and urbanization have significantly increased the demand for water for domestic and commercial uses, apart from the agricultural uses. The increasing demand for food grains, vegetables, flowers and livestock products will put further pressure on the groundwater demand, thus leading to conflicts and trade offs among different users and stakeholders; and degradation of environmental resources. As

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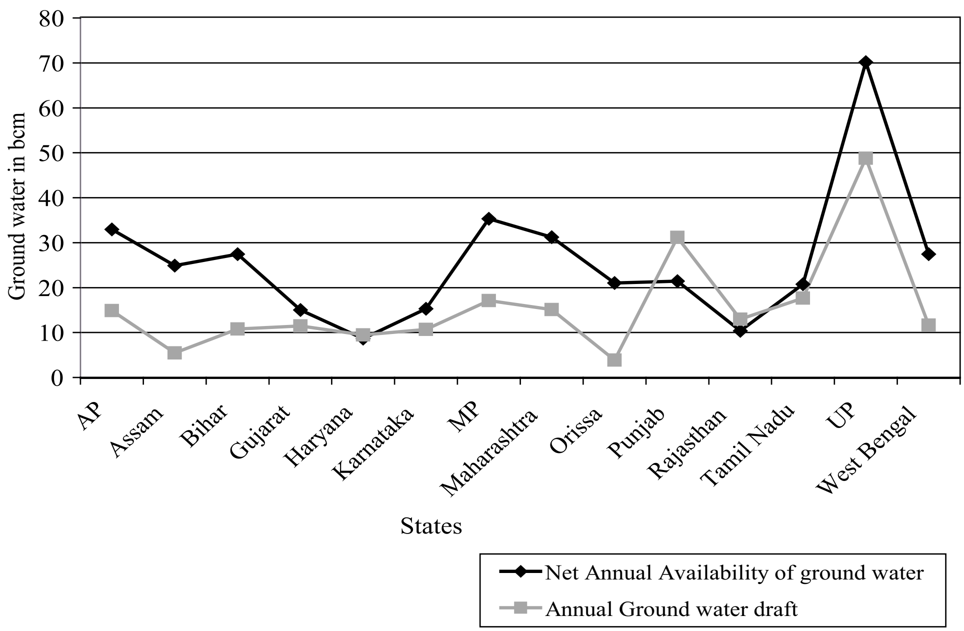
different actors and stakeholders are involved in the development, management and use of groundwater resources, there is need to study various policy interplays and trade offs for identifying some issues for effectiveness of the groundwater policy. Keeping this in the backdrop, this paper is written. The paper is divided into 5 sections. The next section is devoted to the current status of the groundwater in India. This section is written with a view to get some insights into the current status and problems of groundwater in the country. Section 3 deals with the policy interplays and trade off in context of groundwater development and management. In this section, we discuss various conflicts, trade off, policy interfaces and integration. Based on our discussion in this section, we identify some issues for the groundwater policy in the section 4 and then the paper is summed up.

2. STATUS OF GROUNDWATER IN INDIA

As per the report of central groundwater Board "Dynamic Groundwater Resources of India (2004), net annual groundwater availability in the country is 399.25 bcm and total annual draft is 230.62 bcm. This indicates that there is further scope of developing the groundwater resource as only 58% of available water resource is being used for irrigation and other purposes. However, if we look at the regional pattern of groundwater availability and its uses, we observe a significant variation across regions. Some states, such as Punjab, Haryana, Gujarat, Tamil Nadu, Karnataka, Western Uttar Pradesh, Rajasthan, have significant development in the groundwater resource and in some blocks of these states, groundwater is being over-exploited, while in others states, especially located in eastern and north-eastern regions, such as West Bengal, Bihar, Orissa, and Assam, development of groundwater has not yet taken place in a significant way.

Figure 1: State wise Net Annual Availability and Annual Draft of Groundwater (in b cm)



In the absence of well defined water rights and with rapidly growing water markets and wide spread use of modern water extraction technologies, groundwater is being over-exploited in some states, as stated above. Figure 1 shows the state-wise net annual availability of groundwater and annual extraction of groundwater. The figure clearly demonstrates that Punjab, Haryana and Rajasthan extract groundwater more than the net annual availability. The gap between availability and draft is also narrow in Tamil Nadu, Gujarat and Karnataka whereas it is quite wide in Assam, Bihar, Orissa and West Bengal. It is evident from the figure that in some states too much groundwater has been extracted, adversely affecting environment and sustainability of livelihoods of rural households.

Table 1: Status of Groundwater in Major States of India

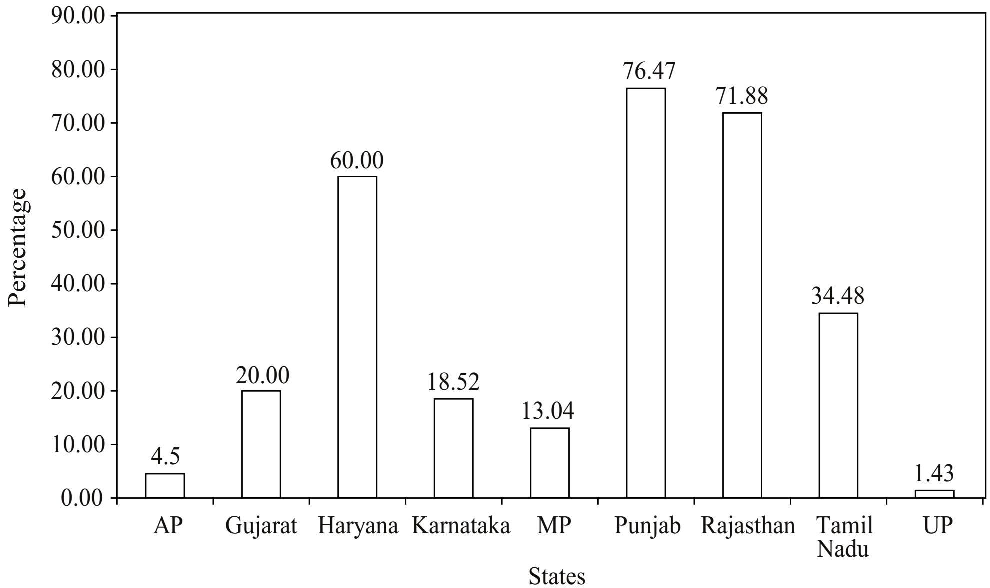
States	Total no. of assessed blocks	Status of groundwater (%)				Stage of GW Dev. (%)	% share of agri in total power	Per capita consump. for agri (Kwh)	Per capita subsidy for agri. (Rs.)
		Safe	Semi-critical	Critical	Over-exploited				
AP	1231	62	14	6	18	45	27.4	172	535
Assam	23	100	0	0	0	22	1.5	2	6
Bihar	515	100	0	0	0	39	16.1	12	74
Chhattisgarh	138	95	5	0	0	20	5.7	29	NA
Gujarat	223	43	31	5	14	76	28.5	272	862
Haryana	113	37	4	10	49	109	28.2	249	908
Jharkhand	208	100	0	0	0	21	1.1	5	NA
Karnataka	175	53	8	2	37	70	28.7	165	482
Kerala	151	67	20	10	3	47	1.5	6	45
MP	312	85	6	2	8	48	20.0	88	528
Maharashtra	318	90	7	0	2	48	12.6	105	326
Orissa	308	98	2	0	0	18	1.1	5	NA
Punjab	137	18	3	4	75	145	19.9	248	928
Rajasthan	237	14	6	21	59	125	14.6	72	393
Tamil Nadu	385	38	15	9	37	85	18.8	147	492
UP	803	83	11	2	5	70	10.9	28	76
Uttarakhand	17	71	18	0	12	66	4.6	36	NA
West Bengal	269	86	14	0	0	42	2.5	9	49
All India	5723	71	10	4	15	58	15.4	53	284

Source: *Compiled from* Dynamic groundwater resources of India (as on March, 2004), Central Groundwater Board, 2006

Table 1 provides the current status of groundwater in major states of India. It is obvious from the table that except for Assam, Bihar, Jharkhand, Orissa, and Chhattisgarh which have almost all assessed blocks in the 'safe zone', in all other states, some blocks are either in semi-critical or critical or over-exploited condition. In arid and semi-arid areas, the increased demand for water is being met by excessive withdrawal of groundwater, leading to its depletion and quality deterioration. The groundwater status in Punjab, Rajasthan, Haryana, Gujarat and Tamil Nadu is quite poor as is apparent from the percentages of safe blocks in these states. The percentage is as low as 14% in Rajasthan and 18% in Punjab. The percentage of over-exploited blocks is found highest in Punjab (75%), followed by Rajasthan (59%), Haryana (49%), Tamil Nadu (37%) and Karnataka (37). In case of critical blocks, Rajasthan stands first by having the highest percentage of such blocks, followed by Haryana and Kerala, while percentage of semi-critical blocks is found highest in Gujarat, followed by Kerala. The percentage of groundwater development in Punjab, Rajasthan and Haryana has crossed the limit of sustainability. Annual withdrawal of groundwater in these states is much higher than the annual recharge, consequently depleting the water table. Thus, pattern of development of groundwater in these states has created a number of sustainability, equity and efficiency concerns.

In order to identify how many districts in each state have more than 100% development of groundwater, we have calculated the percentage of districts with over 100% groundwater development to the total districts. The results are shown in Figure 2. Out of 18 states shown in Table 1, nine states have some districts with over 100% development of groundwater. This shows that apart from Punjab, Haryana and Rajasthan, some other states too have over 100% groundwater development in some districts under their jurisdiction. This is quite obvious from Figure 2. The percentage is highest in Punjab (76.47), followed by Rajasthan (71.88), Haryana (60), Tamil Nadu (34.48) and Gujarat (20).

Figure 2 State-wise % of districts with over 100% ground water development



Availability of cheap/subsidized electricity and flat rate system of power encourage farmers to install more electric operated tube wells. Consequently, the problem of over-exploitation of groundwater occurs as the marginal cost of drawing water from electric operated tube wells is almost zero, providing no incentive to the farmers to make rational use of water. If we look at the per capita consumption of electricity in agriculture, we find that it is closely associated with the percentage of development of groundwater in the states. Punjab, Gujarat, Haryana, Karnataka, Tamil Nadu and Andhra Pradesh have high level of per capita electricity consumption in agriculture whereas it is lowest in Assam, followed by Jharkhand, Orissa, Kerala, West Bengal and Bihar. These are the states where scope for further development of groundwater is high. Per capita subsidy for agriculture also appears to be highly correlated with the percentage of groundwater development. It is found highest in Punjab (Rs.928), followed by Haryana (Rs.908) and Gujarat (Rs.862). Input subsidies that encourage the over-exploitation of groundwater have serious implication on environment.

In order to study up to what extent the per capita power consumption in agriculture explains the variation in the percentage of development of groundwater, we have conducted simple regression analysis, taking the data on these two variables for the 18 states. The F-value (13.37) is found statistically significant at 1% level of significance. The value of R^{-2} shows that 42% variation in the percentage of development of groundwater is explained by the per capita consumption of power in agriculture. The value of slope coefficient is estimated to be 0.261, which is statistically significant at 1% level of significance. This shows that if per capita consumption of power in agriculture in a state increases by 100%, the percentage of development of groundwater would increase by 26%.

State-wise number of electric operated tube wells per 1000 hectares of net sown area (NSA) is also estimated for major states of India to assess whether the over-exploitation of groundwater is related to the intensity of energized tube wells. At all-India level, there are 100 electric tube wells per 1000 ha of NSA. The number of tube wells per 1000 ha of NSA is found highest in Tamil Nadu, followed by Andhra Pradesh, Punjab, Maharashtra, Karnataka and Haryana, while it is lowest in Assam, followed by Orissa, West Bengal and Bihar.

Figure 3: State-wise no. of Electric Tube Wells / 1000 ha of Net Sown Area

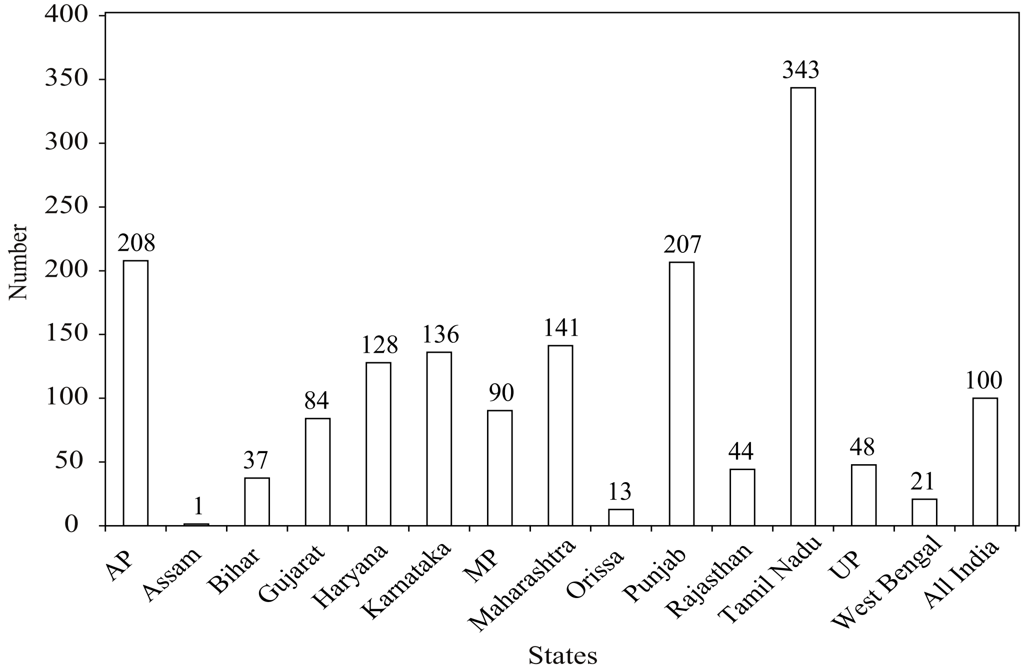


Figure 3 demonstrates that the distribution of electric operated tube wells is not evenly spread across regions. Farmers in eastern and north-eastern states do not have adequate access to the electric operated irrigation pumps whereas their counterparts in Punjab, Haryana and western and southern states have relatively better access to electric operated tube wells. In fact, these are states where sustainability of groundwater irrigation has become questionable. It has been projected that if the number of overexploited 'blocks' continues to grow at the present rate of 5.5% per annum, by 2018 roughly 36% of India's blocks will face serious problems (IWMI, 2002). Over-exploitation of groundwater increases the cost of drawing water and reduces water yields. Rich farmers can afford to deepen their wells and have larger pumps or install submersible wells to draw water while small and marginal farmers, many of whose wells are supported by shallow aquifers, often find it difficult. Therefore, over-exploitation of groundwater makes the accessibility of water to the small and marginal farmers difficult.

It may be pointed out that high intensity of electric-operated tube wells in some part of the country is one of the crucial factors in over-exploitation of groundwater. Other critical issue in this regard is the rapid growth in the number of sallow and deep tube wells experienced during the last one decade. The data shown in Appendix-1 reveal that there has been significant increase in number of tube wells between 1993-94 and 2000-01. Another interesting fact comes to light from the perusal of the data is that on an average, growth of deep tube wells is relatively higher in the water scarce states like Andhra Pradesh, Maharashtra, Karnataka, Rajasthan, Madhya Pradesh, Tamil Nadu, Haryana, and Gujarat, Punjab, where over 75% districts have crossed the sustainable limit of groundwater development, has recorded higher growth in number of deep tube wells than the shallow tube wells. The watertable in the central districts of the state, having 70% of total tube wells, is receding at the rate of 2-2.5% annually. It is estimated that during the next 10 years, practically all the centrifugal pumps will become non-functional and will need to be converted into submergible pumps (GoI, 2006). This clearly shows that the fast depletion of watertable will have detrimental effect on the sustainability of the water resource in the state.

3. POLICY INTERPLAYS AND TRADEOFFS

In the previous section, we have discussed the current status of groundwater in India. Groundwater extraction has increased significantly since the advent of tube well technology. Water being a state subject, the central government has a limited role in its regulation and management. The central government has framed a Model Groundwater (Control and Regulation) in 1970 (revised in 2005). The revised bill proposes, among other things, compulsory registration of bore-well's owners; compulsory permission for sinking a new bore-well; creation of a groundwater regulatory body; and restrictions on the depth of bore-wells. The provisions of the bill have not yet been implemented in many parts of the country. Most of the states have not enacted their groundwater acts in conformity of the central bill. Farmers and local self-government institutions usually do not have access to information about the provisions of the bill and also do not have any stake in the decision-making regarding the control and regulation of groundwater.

National Water Policy, 1987 (revised in 2002), though emphasizes the need to limit groundwater withdrawals, it does not clearly suggest the institutional mechanisms to define and enforce the limit. However, the national policy stresses on the periodical assessment of groundwater potential and regulation of its exploitation, keeping in view the recharge possibilities and social equity; effective prevention of the detrimental environmental consequences of over-exploitation of groundwater; and integrated and coordinated development of surface and groundwater resources and their conjunctive use. It also recognizes the need for a close integration of water use and land policies and a participatory water resource management approach by involving various stakeholders, including the Panchayati Raj Institutions (PRIs). As water policy affects and is being affected by various related policies and programmes, its interface and integration with them is required to avoid overlapping, risks, tradeoffs, and conflicts among various actors and stakeholders and to achieve the policy goals of efficiency, equity and sustainability.

It may be relevant to mention that policy making is a political and economic process. National water policy relates to the declared statements as well as the intended approaches of the central and state governments for water-resource planning, development, allocation, and management (Saleth, 2004). An active participation of stakeholders and end-users of water policy makes the policy more demand-driven and responsive in meeting the intended policy goals. The integration of water policy with land policy and with ecosystem conservation is essential for both environmental sustainability and agricultural productivity.

Water policy is also influenced by various related policies, such as agricultural policy, energy policy, food policy, price policy, environment policy, credit policy, subsidy policy, etc., and its effective implementation on the ground requires the participation of local institutions, like PRIs, farmers' organization, users groups and civil society organization, apart from the government departments and agencies. Effective interfaces and interplays of these policies with the water policy are crucial to assessing the water policy effectiveness. For instance, food policy has interplay with water and other policies. Several policy instruments, such as, subsidized inputs, cheap institutional credit, price supports and subsidized power may be used to achieve food security. As water is one of the crucial inputs in raising the agricultural productivity, these policy instruments would encourage the farmers to install more energized irrigation pump sets to raise the food production, thus adversely affecting the sustainability of groundwater, especially in those regions where public procurement of food grains through Minimum Support Price (MSP) mechanism is relatively high. For instance, FCI procures approximately 95% of wheat from three states: Punjab, Haryana and (Western) Uttar Pradesh and 85-90% of rice from 5 states: Punjab, Andhra Pradesh, Haryana, Uttar Pradesh and Tamil Nadu (World Bank, 2004). In fact, these are the states where problem of over-exploitation of water is quite serious.

The National Environment Policy (NEP) is closely related with the groundwater policy. The central government is empowered to regulate the groundwater on environmental grounds. The NEP suggests, among others, to assess the impacts of electricity tariffs and pricing of diesel on groundwater table; promote efficient water use techniques among farmers; and provide necessary pricing, inputs and extension support to feasible and remunerative alternative crops for efficient water use. However, these policy statements are neither supported by institutional infrastructure and mechanisms nor by enabling legislation or by supporting economic incentive structure (GoI, 2007). Due to lack of effective coordination and interface between the NEP and the water policy, the implementation mechanism of the above stated suggestions have not yet been taken place at the grassroot level. However, judiciary intervention through Public Interest Litigation (PIL) system in controlling over-exploitation of groundwater can be quite effective, as has been recently done by the High Court of Kerala in the landmark “Coca-Cola Case”.

It is pertinent to note that the input subsidy as a policy instrument has become questionable on environment, equity, and efficiency grounds. Irrigation subsidy promotes excessive use of irrigation and creates water logging and soil salinity problems. An existing flat rate power tariff system in most of the states causes depletion in the groundwater table; distorts the cropping pattern; and adversely affects the sustainability of agriculture. It benefits the big farmers more as they have relatively lower unit-cost due to larger size of farm. Price support policy is widely used to achieve multiple policy goals, including price stabilization and income support. However, the price policy also interplays with the groundwater policy. For instance, price incentives for wheat and paddy and high procurement rate of these cereals in Punjab induces farmers to follow water intensive paddy-wheat cropping pattern. Price policy, if properly interfaced with the water policy can be used as an instrument to improve the efficiency, productivity and sustainability of groundwater. As we have seen in the previous section, the development of groundwater in eastern and north-eastern states is still in the nascent stage; through appropriate price policy and an effective public procurement system, these states may be made the major source of rice production and procurement for the country. The 11th Plan also focuses on creating groundwater irrigation potential in these states. Rural electrification under Bharat Nirman would help in installing electric operated tube wells in these states. On the other hand, in Punjab where groundwater exploitation has crossed the sustainability limit, cropping pattern may be shifted from water intensive rice crop to less water consuming crops through attractive price policy support and crop-specific subsidy. It may be noted that the central government policy of MSP is uniformly implemented across regions. In context of efficient management of water resource, region-specific MSP policy may be initiated. In a region where groundwater has depleted due to water intensive crops, farmers can be motivated to shift the cropping pattern through the instrument of price policy.

While formulating a water policy, the formulators should clearly identify the policy risks and trade offs. Water policy making process is very complicated because water resource is not only required for agriculture and livestock but also for domestic and industrial uses, tourism and recreation purposes. Moreover, water policy issues are also linked with issues of other ministries and departments, such as agriculture, environment, energy, food and forest, etc. Therefore, inter-group, inter-sector and inter-ministry conflicts regarding the policy perspectives, goals and strategy are evitable, which are to be managed through building consensus. Further, involvement of different interest groups as actors and stakeholders complicates the process. There may be tradeoff between efficiency and equity, between productivity and environmental protection, between agriculture and non-agriculture uses, and between food security and water security. Tradeoffs arise due to the limited water resource and its competitive uses. Policy risks and conflicts become quite apparent when the draft policy is not widely discussed and debated, involving all interest groups and stakeholders in the process, inviting their responses and building consensus on the issues.

Policy makers may also face the risk of policy failure due to interplays and interaction of other sectors’ policies with the groundwater policy. Policy issues of one ministry/department (say energy) may have an effect on policy issues of the other (say environment). Therefore, if the process of policy formulation does not consider such mutual relationships, intended policy goals may not be completely realized. For example, if objective of the water policy is to develop groundwater irrigation in eastern and north-eastern states, it can be done through providing subsidy to the farmers for installation of tube wells and purchasing of electric pumps. However, if energy policy is such that raises the tariff on power, the policy objective for groundwater irrigation would not be effectively achieved. On the other hand, if in a state, groundwater is over exploited and the water policy is aimed to restrict the farmers to install more bore-wells, the intended policy goal may not be achieved if the state provides cheap credit and subsidized electricity to the farmers. Therefore, region-specific policy risks and trade offs are also required to be examined while making the policy. There is also tradeoff among the major goals of the water policy efficiency, environmental sustainability and equity. For instance, improving efficiency of water allocation may adversely affect non-market public goods or environmental protection may constraint some agricultural activities. These aspects are also required to be taken into consideration while formulating the water policy.

As stated above, two strong groups, politicians and professional experts, are involved in the process of policy formulation. The politicians attempt to fulfill their political agenda while professional experts see rationality of the policy in terms of its economics. As political leaders have more authority and power in the decision-making, politics always remains at the driving seat and economics at the back seat. Bureaucrats and professional experts formulate the policy proposal in such a manner that it satisfies the political aspirations of the political parties in the government. A synergy between professional experts and politicians and convergence in their opinions would help in identifying genuine policy issues and a better process to tackle them and achieving the desired goals. A particular policy options may be beneficial to some stakeholders and may be against the interest of others. This can generate conflict among them. Therefore, their involvement helps in identifying the implications of policy so that the adverse consequences for some stakeholders may be subdued at the policy formulating stage. Therefore, in the policy formulation, possible conflicts and trade-offs need to be identified. To maintain confidence and trust in the process, the trade-offs need to be made transparent through open debate and discussions so that consensus may be built with the active involvement of all stakeholders.

The above discussion clearly indicates that before initiating process of policy formulation, the formulators should clearly examine the interfaces, interplays and interlinks of various policies, institutions, organizations and groups so that their beliefs, perceptions and outlook may be clearly understood and incorporated in the formulation process. The national water policy should also incorporate region and state specific issues in the policy design. This calls for an effective coordination and communication of central government organizations and institutions with the state and local level institutions and organizations. Further, with the spread of education and awareness among masses in the modern democratic system of government, people are better able to articulate their needs and have the confidence to put them forward. In this environment, governments need to consult relevant interest groups if they are to produce the most effective water policy.

4. EMERGING ISSUES FOR THE GROUNDWATER POLICY

Water policy cannot be framed in isolation as it affects and is also affected by other policies related to agricultural development and resource management. We have discussed earlier that percentage of development of groundwater in India varies significantly across regions. Therefore, region-specific policy issues become quite relevant for evolving an effective groundwater policy. It may also be mentioned that the formulation of a suitable policy is necessary but not sufficient for achieving the intended policy goals. The sufficient condition is that the water laws and regulations emanated from that policy be enforced effectively at the ground with the active participation of stakeholders and local self government institutions. Some of the relevant issues related to groundwater policy are summarized in the following points.

1. The government policy to provide easy access to institutional credit encourages farmers to install energized tube wells. Over-exploitation of groundwater in the 'dark zones' may be restricted through regulation of institutional credit for this purpose. However, such policy intervention may create inequalities between small and big farmers as resourceful big farmers may finance themselves for installation of tube wells. It has been noticed in western Uttar Pradesh that medium and small farmers, having their own electric pump, use more water per unit of land as compared to the big farmers. It is because of the flat rate of power tariff and lack of existence of formal water market. On the other hand, big farmers have to irrigate relatively large size of farms with the limited availability of hours of electricity and thus make relatively better use of groundwater. Due to non-existence of water market, small and marginal, if they do not have their own tube wells, usually do not get the purchased water in time that compel them to have their own source of groundwater. This may be the reason why these farmers, having only 29% of total operated areas, account for 35% of total electric-operated tube wells (IWMI, June 2002). This shows that over-capitalization in small-scale agriculture and over-exploitation of water goes together. This is not only economically unviable but also environmentally undesirable.

2. Under the flat-tariff system, small and marginal farmers pay more than their big counterparts as unit cost of water per hectare is much higher for them. Therefore, how to make groundwater for them economically viable and environmentally sustainable is one of the major issues for the water policy. In this context, policy intervention for developing an informal institution of 'group farming' for a group of 5-10 small and marginal farmers who can install only one tube well to meet their irrigation water requirement may be a good strategy for achieving efficiency, sustainability and equity.

3. It is necessary to identify types and nature of data and information required for policy making. The information is required not only to assess the existing policy but also to make available necessary feedbacks to the policy formulators. Therefore, information database should be available at block level containing information on rainfall, groundwater recharge and utilization, water demand for different purposes, land use pattern, cropping intensity and cropping pattern, customary water rights, irrigation system and practices, etc. and it should be linked with national level database through MIS in the same manner as is being done in case of National Rural Employment Guarantee Act (NREGA). Access of this database to the policy implementing agency at the grassroots level would help to regulate the groundwater and reduce the environmental consequences of its over-exploitation. It would also help the policy makers to implement region-specific policy to regulate and manage groundwater.

4. Under the 73rd Constitutional Amendment Act, Rural Local Self Government Institutions have been entrusted the responsibility to manage minor irrigation, including groundwater at the village level. The National Water Policy also envisages the role of these institutions in the water resource management. The government should transfer the authority for regulating groundwater use to these institutions at the village level. For this Gram Sabha (GS) has to be made vibrant institution through capacity building measures and developing an in-built accountability mechanism. An active and vibrant GS can effectively involve the beneficiaries and other stakeholders in decision-making related to groundwater development and management. Concerned government departments and civil society organizations can help the GS by disseminating information about the water level, adverse consequences of over-exploitation of groundwater and other aspects related to groundwater economy of the village so that the GS members may be well-informed about the status of groundwater in their village and may take remedial measures to deal with the problems. Kathpalia and Kapoor (2002) suggest that the government should empower local bodies to regulate, manage and development groundwater at the gram sabha level.

5. Groundwater irrigation is largely in the private domain and the farmers bear the entire cost of installing tube well (except for small and marginal farmers who get some subsidy on sinking of bore-well in some states). However, electricity to agricultural sector is highly subsidized, leading to inefficient water use. The subsidized flat rate of power tariff is considered as one of the major reasons for the over-exploitation of groundwater in several states of the country. A rational power supply and pricing policy for pump irrigation could be an effective instrument for groundwater management and energy use. However, political economy aspects must also be taken into consideration while rationalizing the energy policy. Rationalization of prices of electricity and diesel may generate strong opposition of farmers if the canal irrigation rates are not rationalized. The World Bank and several individual researchers have suggested metered tariff for tube wells to solve the problem of groundwater depletion and improve the financial viability of the power sector whereas some researchers (for example, see IMWI, 2003; Shah, et al., 2004 and Shah, 2005) suggest continuing with flat-tariff system with rationalization of existing rates along with intelligent power supply rationing as metering system may lead to high transaction cost and strong farmers opposition. Flat-tariff rate with smaller size of farm per tube well encourages the farmers to over-irrigate the crop and thus increases the groundwater inefficiency. It may be relevant to note that raising the flat-tariff rates may help the SEBs to recover production and distribution costs, but the purpose of improving groundwater efficiency and sustainability will not be served. Moreover, intelligent rationing of power supply may also be opposed by the big farmers, especially in the paddy, wheat and sugarcane growing regions. The viable option seems to be shifting from flat rate to meter-tariff system. However, farmers should be compensated by providing subsidy on procurement of modern water saving

technology, such as, sprinkler and drip irrigation, especially in those regions where water table has significantly gone down due to over-exploitation of groundwater. This would help in improving the water efficiency and raising the agricultural output per unit of water.

6. The issue of the high transaction cost of metering system can be resolved through evolving cost-effective system of billing and collecting water charges. One option could be handing over the responsibility of billing and collection of electricity charges to the Gram Panchayat (GP). The GP should have about 10% share in the revenue collection. This would not only be a source of income for these local bodies but it would also reduce transaction cost and corruption in billing. The problem of tampering of meter, bribing of linemen and over-billing can largely be solved with the active stakeholders' participation through the institution of gram sabha and installing tamper-resistant electronic meters. Since GS represents the entire village community, the collective action of the people in this regard would be more effective.

7. There may be a possibility of failure of GP in discharging its duties of billing and collection of electricity charges, as has been noticed in its other activities, efforts are therefore required to have external intervention in the form of voluntary and civil society organizations to initiate confidence building measures at the village level. The GS and GP should be sensitized to the harmful environmental consequences of over-exploitation of groundwater. Latent social capital of the rural areas should be activated and utilized in groundwater management with active interventions of external agencies. It may be noted that GPs have already been implementing various rural development schemes at the village level, such as, NREGA, Watershed Development Programme. There should be a better synergy between groundwater policy and these programmes. For instance, under the NREGA, GP is the implementing agency of the works related to water conservation and harvesting; drought proofing; micro and minor irrigation works; renovation of traditional water bodies; land development; and flood control and protection, etc. These works also help to restore the environment resource-base and improve the groundwater sustainability through recharging the water table.

8. Both supply side and demand side policy interventions are necessary for the water conservation, development and management. Supply side measures relate to recharging the groundwater table, conjunctive use of surface and groundwater, supply regulation through registration, user's license, rationing of power supply and raising energy prices, while demand-side interventions comprise improvement in irrigation efficiency through using water saving technology and improving irrigation practices, shifting from high water-intensive cropping pattern to low water consuming crops. Integration of water policy with other related policies is required to resolve these issues effectively.

9. Unreliability of power is another issue related to the groundwater withdrawal. Due to erratic and unreliable power supply, farmers pump water whenever power is available regardless of whether crops needs it or not (Narain, 2003). Study made by the World Bank (2001) in Haryana shows that due to erratic and poor quality of power supply, farmers' bear additional cost in terms of unnecessary high-powered electric pumps, alternate back up of diesel pumps and burn out of pumps. The World Bank study finds in case of a representative sample of 584 tube wells with metered electricity connections that these tube wells consume 27% less power than the utilities estimate—and that transmission and distribution losses are therefore correspondingly higher than the utilities claim (47%, compared with the official estimate of 33%). The study further observes that in the short run, small and marginal farmers are more willing to pay for improved reliability of power supply as compared to the medium and large farmers who have their expensive backup arrangements. The groundwater policy makers should also take into consideration these aspects while reforming the policy, apart from focusing on equity, efficiency and sustainability aspects.

10. It has been found that in Gujarat, farmers with metered supply are charged 30-60% more price for water compared to farmers with flat tariff. This restricts water market by raising the cost of hiring water for the adjacent farmers (Shat and Verma, quoted in GoI, 2007). However, it may be noted that since cost of extracting water by diesel pumps is usually higher than that of electric pump, even if tariff raises the cost of purchasing water, it would still be beneficial for the buyers to buy water from electric pump owners. Moreover, flat rate system cannot be justified on the grounds of equity and sustainability. It encourages

the farmers to extract more water for sales to the adjacent farmers in order to earn profit. That approach quite often ignores the environmental consequences of over-exploitation of water because the pump owners attempt to maximize their short run profit rather than assessing the long run effect on groundwater sustainability. Therefore, developing a formal market and regulating water supply through appropriate policy-mix may not only be useful for the water buyers but also for the conservation and protection of the water resource.

11. In the absence of metered-tariff system, the energy consumption and subsidies on it are overestimated (World Bank, 1998 and 2001). In other sectors, data on consumption of electricity are available whereas in agriculture, electricity consumption is estimated by deducting the consumption of all other sector from the total production. Thus, a significant part of transmission losses and power theft is put in the account of agriculture. If meter-tariff system is introduced, actual power consumption and subsidy on it would be much lower than what is being estimated for agriculture. Further, it may also be mentioned that electricity is the only product whose production inventory cannot be maintained. The electricity department usually provides power to farmers at odd times when its demand in domestic and industrial sector is low. Therefore, estimating cost of electricity for agriculture on the basis of average cost and then estimating power subsidy for agriculture is not appropriate; instead electricity prices for irrigation pumping should be on the basis of marginal cost of production. If metered-tariff for irrigation pumping is fixed on the basis of marginal cost, the tariff would be quite low and acceptable to the farmers. This tariff fixation method would help in achieving the water policy goals of efficiency, sustainability and equity.

5. SUMMING UP

Groundwater sustainability in India has become one of the major issues for policy makers. Rising population, income growth, industrialization and urbanization have put more pressure on its demand, leading to conflicts and tradeoffs among different users and stakeholders. Keeping this background, the paper examines the current status of groundwater, discusses various policy interplays and trade offs and identifies some issues for the effectiveness of groundwater policy.

A perusal of regional pattern of groundwater availability and its uses reveals that the states like Punjab, Haryana, Gujarat, Tamil Nadu, Karnataka, Rajasthan, have a high level of development of groundwater. Annual withdrawal in Punjab, Rajasthan and Haryana is much higher than the annual recharge, consequently depleting the water table. Over-exploitation of groundwater increases the cost of drawing water, reduces water yields and detriments the environmental sustainability. While resourceful big farmers can afford to deepen their wells, it becomes difficult for the resource-poor small farmers to continue getting water from their shallow tube wells. Our study shows a significant association between per capita consumption of power in agriculture and level of groundwater development in major Indian states. The results of regression analysis indicate that a one percent point increase in the per capita power consumption tends to increase the level of groundwater development by a 0.26% point.

Water policy is influenced by various related policies, such as agricultural policy, land-use policy, energy policy, food policy, price policy, environment policy, credit policy, subsidy policy, etc., and its effective implementation on the ground requires the participation of local institutions, like PRIs, farmers' organization, users' groups and civil society organization, apart from the government departments and agencies. Therefore, interfaces, interplays and interlinks of these policies, institutions, and organizations and groups are crucial to be studied for better policy formulation. Region-specific policy risks and trade-offs and trade-off among the major policy goals-efficiency, sustainability and equity-are also required to be assessed. A synergy between professional experts and politicians and convergence in their opinions would help in identifying the genuine policy issues and a better process to tackle them and achieving the desired goals. Further, with the spread of education and awareness among masses in the modern democratic system of governance, people are better able to articulate their needs and have the confidence to put them forward. In this environment, state governments need to consult relevant interest groups if they are to produce the most effective water policy.

The paper has also identified several policy issues related to the groundwater regulation, development and management. Prominent among them are: empowering rural local self-government institutions by entrusting authority and responsibility of managing groundwater water resources at the village level; making gram sabha a vibrant institution through capacity building measures and developing an in-built accountability mechanism; creating information database linked with national level database through MIS on the pattern of database of NREGA; shifting from flat-tariff system to meter-tariff system and compensating farmers by providing subsidy on water-saving modern technology, such as, sprinkler and drip irrigation; reducing transaction cost of metering system by handing over the responsibility of billing and collection of electricity charges to the gram panchayat with a 10% revenue share; fixing power tariff on irrigation pump on the basis of marginal cost of power production; dovetailing water policy with other programmes like NREGA and watershed development programme at the GP level; developing an informal institution of group farming among small and marginal farmers; and developing a formal market and regulation of water supply through appropriate policy-mix.

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Appendix-1

Growth of Sallow and Deep Tube Wells in Major States of India
(As per Minor Irrigation Census 2000-01)

State	Sallow Tube wells (Nos)				Deep Tube wells (Nos)			
	Up to 1993-94	Up to 2000-01	Net Increase	Annual Simple Growth Rate	Up to 1993-94	Up to 2000-01	Net Increase	Annual Simple Growth Rate
AP	246770	656359	409589	23.71	32359	87482	55123	24.34
Assam	8654	78664	70010	115.57	610	760	150	3.51
Bihar	280874	651383	370509	18.84	5193	6190	997	2.74
Chhattisgarh	43557	86575	43018	14.11	3177	5227	2050	9.22
Gujarat	31277	53195	21918	10.01	47990	94182	46192	13.75
Haryana	207819	376352	168533	11.59	11703	24339	12636	15.42
Jharkhand	614	1124	510	11.87	22	28	6	3.90
Karnataka	163168	532348	369180	32.32	11	32	21	27.27
Kerala	2005	4680	2675	19.06	79	227	148	26.76
MP	97659	279024	181365	26.53	11023	36398	25375	32.89
Maharashtra	21191	59420	38229	25.77	21401	77223	55822	37.26
Orissa	12439	43881	31442	36.11	3535	4592	1057	4.27
Punjab	808475	1067117	258642	4.57	5921	9990	4069	9.82
Rajasthan	39413	112856	73443	26.62	14381	46764	32383	32.17
Tamil Nadu	107661	151250	43589	5.78	36462	84010	47548	18.63
UP	1571447	3525543	1954096	17.76	27403	35085	7682	4.00
Uttarakhand	33635	52099	18464	7.84	719	883	164	3.26
West Bengal	256545	603667	347122	19.33	4033	5139	1106	3.92

ARE WATER POLICIES A CASE OF REVERSE ENGINEERING IN INDIA?

P K Viswanathan and R Parthasarathy[1]

Abstract

The emerging water crisis calls for a paradigm shift in policies and regulatory regimes the world over, including India. However, there are serious challenges and operational level constraints needing a thorough scrutiny and understanding as regards the historical and region-specific contexts and factors within which such policies and regulatory regimes are evolving. Arguably, water policies should have been evolved based on an understanding of the social contexts within which they are to be implemented. Besides, implementation of water policies also requires creating new or fine-tuning of the existing regulatory regimes and governance systems to have the desirable outcomes on the society.

Set in this broader perspective, the paper tries to understand the emerging policy as well as institutional reforms and regulatory regimes in water sector in India, with particular reference to Maharashtra and Gujarat states. First, the paper provides a brief review of the national water policies of 1987 and 2002, followed by a detailed discussion on the water policies/ water sector reforms in the states of Maharashtra and Gujarat. Then it makes a critical assessment of the policies of Maharashtra and Gujarat with respect to their responses and sensitiveness in addressing the water sector challenges as discussed above. As emerge from the analysis, it is obvious that only Maharashtra has set up policy framework of enabling provisions and authorities with somewhat clearly defined powers. The central question that remain unanswered is, what is water right and how is it defined. So far the polices only state priorities (for instance drinking water to be first and so on) but these are clearly not with respect to the state of the resource (except in scarcity years). We argue that in many of the natural resources there is a need to intercede the management of the resource and the users' interests with clearly defined legal framework. Except in Andhra Pradesh and in Maharashtra, half-hearted attempts in many other states to reverse engineer the process of providing legal support to isolated cases of water distribution (not management) have neither led to improvements in resource management nor in legitimizing users stake in the resources.

1. INTRODUCTION

That many regions in the world are underway of severe crisis in the waterfront is no longer a stunning realization given the pace at which water resources are getting depleted. The crisis emerge in part, from the paradox that there is a burgeoning demand for freshwater resources while the quality and quantity of the same are facing alarming rates of deterioration day by day. For the most part, the crisis in the global water sector emerge from the virtual absence of effective and sustainable policies and regulatory regimes governing development and management of water resources from a long-term and holistic perspective. Apparently, while a large number of developed countries have been successful in evolving more or less effective and suitable kind of policies and regulatory regimes in the water sector, an overwhelming majority of the developing countries are hard-pressed by either the lack or poor implementation of such policy instruments or regulatory systems.

India's water sector is depicted as one of 'turbulence muddled with the crisis of governance failure' on the one hand (Kumar, 2005) and virtual absence of a holistic vision and planning for sustainable resource development and management regimes for the future on the other. Groundwater resources are in a critical state in most parts of the country as its exploitation forms the largest source of irrigation water supplies (65-70%) and 80% of the domestic water supplies (World Bank, 2005). It looms large that the country's water sector is

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fraught with a plethora of challenges, viz., a) the perceptible gap in the provision of safe drinking water across the rural and urban areas; b) state failure in appreciating water as a fundamental right; c) emergence and growth of water markets even in the rural fringes; d) non-responsiveness of the public institutional and governance systems towards the globalisation induced dynamic agrarian changes taking place in the canal commands; e) limited success of the reform measures aimed at participatory management (PIM)/ irrigation management transfer (IMT) to the user communities; f) growing inefficiency in the functioning and performance of the irrigation systems; and g) the growing environmental and human health related concerns along with socio-economic impacts of ill-conceived and poorly implemented rehabilitation/resettlement programmes, etc. to mention a few.

While the emerging water crisis calls for a paradigm shift in policies and regulatory regimes the world over, there are serious challenges and operational level constraints needing a thorough scrutiny and understanding as regards the historical and region specific contexts and factors. A major challenge confronting the water sector reforms (changes in policies and regulatory regimes) is to have a judicious balance between the policy prescriptions and their implementation. Arguably, water policies should have been evolved based on an understanding of the social contexts within which they are to be implemented. Besides, implementation of water policies also requires creating new or fine-tuning of the existing regulatory regimes and governance systems to have the desirable outcomes on the society. Given that the contexts within which water policies implemented are heterogeneous in terms of presence of powerful as well as weaker stakeholders with competing claims, it is rather difficult to have the desirable outcomes unless and until there takes place effective social mediation of the policies involving the heterogeneous actors/stakeholders. Since the water sector reforms as proposed or being implemented by a vast majority of countries, including India have been virtually failing in terms of evolving such social mediation processes, it may be argued that the water policies and regulatory regimes would continue to remain as mere prescriptions that are disjointed from the ground level realities.

Set in this perspective, this paper tries to understand the emerging policy as well as institutional reforms and regulatory regimes in water sector in India, with particular reference to Maharashtra and Gujarat states. Selection of Maharashtra and Gujarat for the present analysis is only logical as these 2 states depict extreme conditions of drought and alarming rates of groundwater exploitation. Moreover, these 2 states have also been in the forefront in terms of various state-sponsored as well as NGO initiatives and interventions at the grassroots level aimed at sustainable development, conservation and management of water resources. Maharashtra in particular has done pioneering efforts with respect to launching of various water sector reforms, which include revision in water tariffs covering 100% of O&M costs, drinking water reforms and launching of massive programme on watershed development and management.

The paper is structured into three sections. Accordingly, Section two provides a brief review of the national water policies of 1987 and 2002, followed by a detailed discussion on the water policies/water sector reforms in the states of Maharashtra and Gujarat. Section two makes a critical assessment of the policies of Maharashtra and Gujarat with respect to their responses and sensitiveness in addressing the water sector challenges as discussed above. Section three sums up the paper by posing some important concerns needing further discussion and empirical investigation for a better understanding of the dynamic space within which these policy instruments and regulatory regimes interface with the socio-economic, political, environmental and hydro-geological aspects of life in the countryside.

The methodology used in the paper is to review and document the important policy and regulatory interventions and legislative processes as prevalent or being proposed in Maharashtra and Gujarat states in recent times in particular. The paper largely draws on the available empirical literature pertaining to water sector reforms and case studies as undertaken in India by various agencies and individual researchers as the case may be. The choice of such a methodology is deliberate as the paper envisages evolving a well-founded analytical perspective for understanding the entire dynamics at work in the making of water sector policies and working of regulatory regimes in varied contexts in India.

2. WATER POLICIES AND REGULATORY REGIMES: A REVIEW

Arguably, the Indian Constitution has provided a solid foundation for evolving legal and policy frames required for the water resources sector in the country. Under the Constitution water is a state subject and 'irrigation' being entry 17 of the state list. Further, 'water rights' irrespective of the limitations due to definition and implementation are derived from the fundamental rights of the Constitution under Article 21. State governments are obviously empowered to legislate on water related matters and ensure good governance.

Water sector development, which assumed centre-stage of the planned development programmes in the country, has been perceived and implemented in a highly 'centralized and top down' framework even by the states. Water sector policies were either non-existent or rudimentary in form and content and institutional as well as governance systems have been driven by the centralist decision-making process. However, the scenario has been underway of some changes since the 73rd and 74th amendments in the constitution passed in 1992, which have empowered the Panchayati Raj Institutions (PRIs) to takeover the reigns of water sector development. Following this, there have been a series of enactments, legislations and policy interventions within the water sector (surface water, groundwater and drinking water) with a paradigm shift in the perspectives and approaches mostly oriented towards the micro level contexts of the Indian states. In majority of cases, these legislations, enactments and policy formulations have been mere refinements or modifications or additions to the pre-existing legal and regulatory regimes of the colonial vintage[1].

These legal/ policy level and regulatory reforms especially at the state levels possibly gained impetus from the national policies, viz., the Water Policies of 1987 and 2002. Following these a series of legislation and policies have been introduced by the states like the: a) Andhra Pradesh Water Resources Development Corporation Act, 1997; Andhra Pradesh Farmers' Management of Irrigation Systems Act, 1997; Andhra Pradesh Water, Land and Trees Act, 2002; The Karnataka Groundwater (Regulation for Protection of Sources of Drinking Water) Act, 1999; The Karnataka Irrigation and Certain Other Law (Amendment) Act 2000; The Kerala Groundwater (Control and Regulation) Act, 2002; The Kerala Irrigation and Water Conservation Act, 2003; Madhya Pradesh Sinchai Prabandhan Me Krishakon Ki Bhagidari Adhiniyam, 1999; The Maharashtra Groundwater (Regulation and Drinking Water Purposes) Act, 1993; The Orissa Pani Panchayat Act, 2002; Delhi Water and Waste Reforms Bill 2003; Maharashtra Management of Irrigation Systems by the Farmers Act, 2005; The Himachal Pradesh Groundwater (Regulation and Control of Development and Management) Act, 2005; the Maharashtra Water Resources Regulatory Authority Act, 2005; The Arunachal Pradesh Water Resources Management Authority Bill 2006; The Gujarat Water Users' Participatory Irrigation Management Bill, 2007.

Besides the above legislative reforms, the states have also come up with respective state water policies. Prominent among them include: Uttar Pradesh State Water Policy 1999; Karnataka State Water Policy in 2002; Maharashtra and Madhya Pradesh State Water Policy in 2003; Madhya Pradesh State Water Policy 2003; Rajasthan State Water Policy 2005 (Draft); Kerala Water Policy, 2007; Orissa State Water Policy in 2007; State Water Policy of Assam 2007 (Draft); etc.

Nevertheless, there is a clear vacuum of understanding as regards the very influence or correspondence between the national as well as state level policy reforms in the water sector. Even a cursory look at the various legislations and the policies circumscribing the water sector at the national as well as the state levels would give rise to a series of questions about the underlying causative factors triggering such a massive enthusiasm in the country towards reforming the water sector through various policies and legislations. Arguably, an overwhelming majority of these legislative as well as the proposed policy reforms in the water sector may be considered as offshoots of political as well as bureaucratic benevolence from time to time rather than genuine considerations originating from the concerns or revealed preferences cast by the society at large and other potential stakeholders. The reasoning behind such a standpoint is only logical as there is a variety of questionable concerns surrounding the emergent water sector reforms at the national as well as state levels. Given this, in what follows, we try to make a brief discussion on the various policy level as well as institutional or regulatory reforms in water sector in India with particular reference to the two national water policies, followed by the water sector reforms in Maharashtra and Gujarat states.

2.1 Water Policy 1987

The first National Water Policy adopted in September 1987 underlined that 'water is a prime natural resource, a basic human need and a precious national asset'. It was evident that this policy wanted to promote a standardized national information system, data collection, establishment of basin-wise organisations with multi-disciplinary approach to planning, formulation, clearance and implementation of projects, rehabilitation, groundwater development, water zoning, flood and drought management, R & D and training (Kumar and Seth, 2000). In the planning and operation of water resources systems, the priorities of water allocation have been broadly underlined as: a) Drinking water; b) Irrigation; c) Hydro-power; d) Navigation; and e) Industrial and other uses. The policy also addressed several areas of intervention, viz., assessment of water resources, groundwater hydrology and recharge, prevention of salinity ingress; and so on.

2.2 Water Policy 2002

Though the 1987 water policy covered wide ranging aspects of water sector, a number of challenges emerged in due course of its implementation. It has been reported that the Ministry of Water Resources (MWR) has not been well-equipped in implementing the policy[2] . In view of such discrepancies and operational problems in implementing the provisions of the 1987 policy, the National Water Policy 2002 has been announced as a modified version of the 1987 policy. The 2002 water policy was broadly set in the backdrop of the emerging water crisis and the severe droughts in the country. Given this, provision of drinking water assumed the topmost priority in the 2002 policy as well. With the inclusion of water provision for ecological services, the 2002 policy set the priorities as: a) Drinking water; b) Irrigation; c) Hydro-power; d) Ecology; e) Agro-industries and non-agricultural industries; f) Navigation and other uses. In rest of the areas and provisions, the 2002 policy appears to be a replica of the 1987 policy.

A significant change in the 2002 policy from that of 1987 has been its focus on privatization[3] . Thus, the policy puts forth supply side solutions in terms of institutional mechanisms, technological options, innovations and corporate management strategies for enhancing the financial resources. It is apprehended that this framework, if implemented, would turn out be highly skewed in terms of its distributive equality, as a major chunk of the population might be deprived of benefits even as they fail to adjust to market driven system. However, it should be noted that except for canal based water supplies, water extraction and distribution is in private domain – largely unorganized though. In any case, as earlier, the two water policies at the national level seem to be mere statement of intentions or pontifications as they have not been complemented by supportive legislations or action plans.

Notably, some states like Maharashtra and Andhra Pradesh in particular, have taken commendable initiatives for enacting legislations and put in place policy and regulatory frameworks for the water sector. Gujarat on the other hand, has for long been following a route of 'Government orders led policies' that have shown some impacts. In what follows, we analyze select state level policy reforms and institutional intervention strategies in the water sector.

2.3 Water Policies and Regulatory Regime in Maharastra

Maharashtra is the 3rd largest state in the country with a geographical area of 30.8 million ha covering a population of over 100 million (Census, 2001). The growing population together with booming industrial sector exerts great pressure on the water resources. Besides domestic and industrial water demand, the agriculture sector employing 70% of the state's labour force, demands the state's freshwater resources, particularly groundwater. The state remains as socially and politically dynamic with the presence of a powerful farmers lobby and a plethora of factors leading to several reforms in the water sector. A case in point is the 300 years old system of water management - the Phad system – a community managed irrigation system prevalent in the Northwestern Maharashtra. The state has also set up a Groundwater Survey Development Agency (GSDA). Notably, there have been four major policy and regulatory reforms in the water sector in Maharashtra in the last two decades. They are: the Maharashtra Groundwater (Regulation for Drinking Water Purpose) Act 1993; The

Maharashtra Water Policy, 2003; The Maharashtra Water Resources Regulatory Authority Act, 2003 (Mah. Act No. XVIII of 2005) and, the Maharashtra Management of Irrigation Systems by Farmers Act of 2005.

2.3.1. Maharashtara groundwater regulation act, 1993

The Maharashtra Groundwater (Regulation for Drinking Water Purpose) Act 1993 was an important outcome of the State's efforts to regulate the over-exploitation of groundwater aquifers stimulated by the tube well technology. The state had experienced extreme droughts in the early 1990s which affected as many as 30,000 drought-prone villages. Following this, the state has taken initiatives to regulate the groundwater exploitation through Groundwater Regulation Act in 1993, which emulated the Model Groundwater Bill of 1970 (Phansalkar and Kher, 2006). The Act contained important provisions of keeping a minimum distance of 500 meters between a public drinking water source and the new well constructed. This was relaxed for the construction of new wells for the provision of drinking water. The Act prohibits groundwater extraction for non-drinking purposes in locations declared as scarcity affected. Further, the state was empowered to close down a well, remove pumps, disconnect power supply in areas that contravene the provisions of the Act.

Though unique in many respects, the absence of penal conditions led to numerous instances of violations even by government sources where no effective legal actions could be taken (Phansalkar and Kher, 2006). A serious flaw in the Act seems to be the efforts of the state to over-control the customary rights provided for by the vintage easement Act for individuals to appropriate groundwater. In the case of farmers this seemed to be the only source in the absence of other water sources at least in most of the water-scarce regions.

It is also important to note that the despite the enactment, the problems in the groundwater development still continue in view of the poor implementation of the provisions of the Act. Notably, there has been substantial increase in groundwater abstraction caused by rise in number of wells and motorised pumps (lifting devices), leading to significant drop in groundwater tables (Pathak et al., 1999). There is also stiff competition between Irrigation and drinking water segments for the use of water often leading to competitive deepening and over-abstraction of groundwater sources causing depletion of the water table (Table 1).

Table 1. Fall in Groundwater Table in Districts of Maharashtra, 1999-2001

	Period	Water Fall Level in the districts	
		2-4 metres	Above 4 metres
1.	May 1999 – May 2000	Aurangabad, Jalna, Buldhana, Beed, Kolhapur, Sangli, Osmanabad, Pune, Sholapur	Aurangabad, Beed, Latur, Jalgaon, Parbhani, Sholapur
2.	May 2000 – May 2001	Aurangabad, Beed, Buldhana, Jalgaon, Nagpur, Akola, Sangli, Satara, Thane, Nanded, Chandrapur	Aurangabad,Jalgaon, Sangli

Source: Lok Sabha Unstarred Question No. 3052, dt. 09.12.2002, accessed from www.indiastat.com

2.3.2 Maharashtra state water policy, 2003

The Government of Maharashtra (GoM) has announced its State Water Policy 2003 as per the recommendations of the National Water Policy 2002 and the Maharashtra Water and Irrigation Commission's Report. The basic objectives of the State Water Policy (MSWP) are to ensure the sustainable development and optimal use and management of the state's water resources, to provide the greatest economic and social benefit for the people of the state and to maintain important ecological values within rivers and adjoining lands. The important objectives and the strategies for achieving the objective criteria as proposed in the MSWP are shown in Box 1.

Box 1: Maharashtra Water Policy: Objectives and Important Strategies

Objectives	Strategies
1. The state to create an enabling environment for equitable and productive water management in an environmentally sustainable manner to promote growth, reduce poverty and minimize regional imbalances. 2. The state to create incentives efficient use of water and empower WUA to participate in management; to grant the WUAs entitlements to water so enable them to decide on best use without bureaucratic interference. 3. The state to create new institutional arrangements at river basins to guide and regulate water management; to decentralize the responsibility at river basin and sub-basin levels 4. To place a high priority on promoting the development, adaptation and dissemination of new technology to improve efficiency and productivity 5. To enact appropriate legislation and enabling rules to effect the above strategies: For this, the State will adopt three critical items of legislation including: a) an act to authorize farmers' management of irrigation systems; b) an act to create a state water authority; c) and river basin authorities.	1. River Basin Agencies: Delineate the five river basins into 25 sub basins for integrated planning, development and management of the water resources and watersheds in respective river basins. 2. Participatory water management: To comply this, farmer management of irrigation systems has been made mandatory along with formation of WUAs. Water will be supplied on volumetric basis to WUAs only. 3. WUAs and bulk water entitlements: A new concept of 'bulk entitlements' has been introduced signifying that water allocations are to be made only through the WUAs. WUAs hold bulk entitlement to water use on behalf of their members. WUAs will be federated at the distributory and project levels and these federations will be responsible for operation and maintenance of their respective canals and appurtenant structures and facilities. 4. Water for domestic and industrial use: To launch a perspective plan to integrate the provision of drinking water both to the rural and urban sectors with the multi-purpose projects. Suggests a pricing policy to cover least the O&M costs of the water supply. 5. Private sector participation: Encourages participation of corporate, commercial enterprises and water service providers in preparing the river basin plans. Similarly, partnerships encouraged between the state and the private sector in financing for and introduction of new technologies. 6. Priorities in water allocation: Water allocation priorities include: a) domestic use for drinking, cooling, hygiene and sanitation needs including livestock; b) industrial, commercial use and agro-based industrial use; c) agriculture and hydropower; d) environment and recreation uses; and e) all other uses. 7. Transfer of water use entitlements: "Transfer of all or a portion of water entitlement between entitlement holders in any category of water use and priority shall be permitted on both annual and seasonal basis based on fair compensation of the entitlement.

2.3.3 The Maharashtra water resources regulatory authority act, 2003 (MAH.ACT No. XVIII of 2005)

Two of the important regulatory instruments as suggested in the state water policy are: a) establishment of a state water resources regulatory authority and river basin authorities; and b) an act to authorize farmers' management of irrigation systems. Accordingly, the state passed the Maharashtra Water Resources Regulatory

Authority (MWRRA) Act, 2003 (Mah. Act No. XVIII of 2005) and adopted in 2005. It is considered that the MWRRA will regulate water resources within the state, facilitate and ensure judicious, equitable and sustainable management, allocation and utilisation of water resources, fix the rates for use of water for agriculture, industrial, drinking and other purposes, and matters connected therewith or incidental thereto. The MWRRA Act suggests the need for setting up of the River Basin Agencies (RBAs) or River Basin Development Corporations. Accordingly, Irrigation Development Corporations (IDC) have been established for the five regions. The important functions of these river basin development corporations are given in Box. 2

Box 2: Functions of Water Resource Regulation Authority

Irrigation Development Corporations	Functions
1. The Maharashtra Krishna Valley Development Corporation was established under the Maharashtra Krishna Valley Development Corporation Act, 1996; Mah. XXVI of 1997 2. The Vidarbha Irrigation Development Corporation established under the Vidarbha Irrigation Development Corporation Act, 1997 Mah. III of 1998 3. The Konkan Irrigation Development Corporation established under the Konkan Irrigation Development Corporation Act, 1997 Mah. IV of 1998 4. The Tapi Irrigation Development Corporation, established under the Maharashtra Tapi Irrigation Development Corporation Act, 1997 Mah. XXIII of 1998 5. The Godavari Marathwada Irrigation Development Corporation established under the Maharashtra Godavari Marathwada Development Corporation Act, 1998	1. Determine and distribute water entitlements for various categories of use 2. Establish a water tariff system at sub-basin, river basin and State level based on consultations with stakeholders. Water charges so fixed should reflect full recovery of the cost of the irrigation management, administration, operation and maintenance of the project 3. Administer and manage interstate water resources if the state 4. Review and clear water projects at the sub-basin/ river basin levels and ensure the proposal is in conformity with Integrated State Water Plan 5. Review entitlements after three years. In the event of water scarcity, the authority shall adjust the quantities of water across all Entitlements and permit temporary transfer of water entitlements between users and categories of users 6. Establishing a system of enforcement, monitoring and measurement of entitlements 7. Determine and ensure that the cross-subsidies between categories of use are totally offset 8. Develop the state water entitlement database

As mentioned in Box 2, the MWRRA is designated to issue the Bulk Water Entitlements (BWE) to Water User Associations or other entities. The allocation would be the portion of entitlement declared annually or seasonally by the MWRRA. The MWRR Act lays down a very detailed narrative on the criteria of allocation and provision of the water entitlements to the user communities and other entities. The entitlements issued by RBA would be based on the category of use and subject to the priority assigned. Further, BWEs will be issued by RBA for irrigation drinking, municipal and industries to relevant user entities. Individual water entitlements will be issued by RBA only for the construction and operation of individual lift irrigation schemes using surface water sources through bore-wells, tube wells or other facilities for extraction of sub-surface water. In all cases the BWE will be measured volumetrically and with respect to time of delivery and flow rate of delivery.

The Act also suggests criteria in matters of transfer or trading of water entitlements to be administered by the MWRRA. The Act lays down many procedures for a change in the use or volume of any entitlement, for example the entity must demonstrate in a public hearing before the authority that it has exhausted all attempts to conserve, increase efficiency and manage its demand of water within its entitlement. However, BWE are transferable within the respective category of use as long as such transfers are compatible with the operation of the specific water resource facilities involved. Evidently, these provisions of a regulatory mechanism would catalyst private participation.

On water distribution for irrigation, the MWRRA fixed quota at the basin level, sub-basin level or project level should enable every land holder in the command area to have a quota. The quota in turn will be fixed on the basis of the land in the command area, provided that, during water scarcities each landholder shall, as far as possible, be given quota adequate to irrigate at least one acre of land. Interestingly, the authority has taken upon itself to ensure that the principle of "tail to head" irrigation is implemented. The typical case of mixing up many objectives is the proviso that a person having more than two children shall be required to pay one and half times of the normal rates of water charges.

2.3.4 The Maharashtra Management of Irrigation Systems by Farmers Act 2005

The second and the most important legal instrument as prescribed by the 2003 Water Policy in Maharashtra has been the Act to authorize farmers' management of irrigation systems in the state. The State Water Policy (2003) has urged the need for involving farmers, the dominant segment of the water users, in the process of management of water sector development. The perceptible gap between creation and utilisation of irrigation potential has been and continues to be one of the serious dilemmas of water sector development in India. An important policy and institutional measure tried by countries including India for bridging this gap has been formation of WUAs adhering to the principles of irrigation management transfer (IMT) as well as participatory irrigation management (PIM) in irrigation systems.

While there are serious apprehensions about the effectiveness of such participatory interventions even in India, the government of Maharashtra has taken a bold step of making legislation for farmer management in irrigation systems through the Maharashtra Management of Irrigation Systems by Farmers Act 2005 (MMISF). The important objectives of the MMISF Act and the institutional arrangements for implementing the objectives are shown in Box 3.

Box 3: Objectives of MMISF Act and Institutional Structure

Objectives	Activities
1. Promote and secure equitable distribution of water amongst its members 2. Maintain the irrigation systems, and ensure efficient, economical and equitable distribution 3. Protect the environment and ensure ecological balance 4. Actively inculcate amongst members a sense of ownership of the system 5. Safeguard and promote the common interests of its members pertaining to irrigation and agriculture in the area of operation	• A canal officer may delineate lands and declare it to be an area of operation of Project Level Association (PLA) The area may include both surface and lift irrigations • On delineation of the command area of WUAs water will not be supplied by MWRRA to individual holder and the system of supply of water through WUAs shall be binding on all holders and occupiers • Management transfer to WUAs would be done after a joint inspection of the system within three months from the date of signing the agreement • The WUAs can introduce drip and sprinkler system, develop farm ponds and community projects for exploiting groundwater, and engage in supplementary business like dairy and fisheries

MMISF Act also deals with Lift Irrigation Water Users' Association (LIWUA). The canal officer would regulate water supply to all LIWUAs. An important provision that has been a sore point in the extant canal systems is ensuring no permission to lift water directly from the main, branch and distributary canals. A comparison of the powers and functions of the WUAs in Maharashtra and Gujarat would be appropriate in this regard and the same is provided in Box 4.

Box 4: Powers and Functions of Water Users' Associations in Maharashtra & Gujarat

Maharashtra	Gujarat
• WUAs controls: a) Applicable Water Use Entitlement (AWE) of its members; b) plans the number of rotations; c) fixes irrigation intervals; d) maintains its record and pass it on to its members from the Upper Level Association or the concerned canal officer • Prepare water distribution programme or Rotational Water Supply (RWS) before every rotation and ensure volumetric supply as per entitlement • To meet before each season to guide and help the members regarding: a) Canal operation schedule and water distribution; b) maintenance of canal system before the season • Enable the government to publish the Annual Irrigation Status Report, furnish to the canal officer, the requisite information as prescribed in time	• WUAs enters into an agreement with the state government • Ascertain the demand for water of each holder of land in the service area • Ensure distribution of the water and the water supply system is left to individual WUAs • To prevent unauthorized use of water or waste of water or damage to the canal • To carry out normal maintenance and repairs of minor canal • To collect and remit water charges at the rate of 50 per cent of the prescribed charges to the government. And the WUA is free to determine water charges for its members

2.3.5 Annual Tripartite Agreement

An Annual Tripartite Agreement is prescribed under the Act between the WUAs, canal officer and the private bodies. The private agriculture water users will be given water quota by consent of all the members.

2.3.6 Mobilisation of financial resources by WUAs

MISF Act describes various sources of generating funds. The funds of WUAs shall be raised through sources such as: a) water charges; b) deposits from members; c) interest on deposits; d) borrowings; e) donations; f) contributions by members; g) grants; h) penalty and penal fees from members; and i) fees for the services rendered.

2.3.7 Water Budgeting at Project Level

The Project Level Association is responsible for water budgeting and in its absence the concerned canal officer will be responsible.

2.4 Water Policies and Regulatory Regime in Gujarat

The state occupies about 6% of the country's land resources, roughly 3% of the country's freshwater resources, and 4% of the country's population. The state is less advantaged in terms of per capita rainwater availability as compared to several other states in the country. Most parts of the state remain "water starved", as nearly 70$ of the freshwater resources in the state are concentrated in south and central Gujarat. Water problems are manifold in the state and are manifest in the form of depletion and pollution of groundwater aquifers, pollution of water bodies, water-logging and salinity in canal commands, salinity ingress in coastal areas, growing competition between conventional and non-conventional water consumptive sectors for use of the scarce water resources.

Water use for irrigation accounts for as high as 89%, followed by domestic uses (7%) and other uses (4%). The paradox of water sector development in the state is that despite heavy public investments being made for development of surface irrigation systems, groundwater contributes the single largest source of water contributing as high as 78% of the total water used for irrigation and domestic purposes.

The water future of the state is slated to be bleak in view of the emerging conflicts between and across the various sectors. Water pollution caused by industrial effluents is yet another serious problem. In fact, there has been a surge in empirical research at the levels of institutional agencies, including government and International agencies, such as the IWMI as well as individual researchers highlighting the magnitude of the impending water crisis in the state over time. While a review of the various studies[4] is beyond the scope of the paper, all that need to be noted in this regard is that there has been a consensus on the clear vacuum of overarching policies and legislative processes governing the water sector in the state in particular.

Of particular reference in this regard has been the White Paper on Water in Gujarat prepared by IRMA/ UNICEF in 2001, which had made a pioneering attempt to bring out the status of water resources in Gujarat. The white paper made earnest efforts to identify the pertinent issues and the emerging challenges in Gujarat water sector and outlined practicable strategies for resolving the issues including identification of options for future action for drought-proofing of the state (IRMA/ UNICEF, 2001).

The white paper underlined that the state needs to expedite the announcement of a Water Policy, which is to be backed by a facilitating law, and buttressed by an appropriate organisational structure and governance system. It had also been suggested in the White Paper that the main goal of the State Water Policy should be to attain water security for all and forever through restoring, developing, conserving, utilising, and managing the surface water and groundwater resources of the sate in the socially optimum and ecologically sound and sustainable way. Further, it was suggested that an autonomous Water Development and Management Board may be set up at the state level, to plan, coordinate and direct water management projects (IRMA/ UNICEF, 2001).

There was a clear case as put forth by the White Paper on Water in the state for formulating a State Water Policy, so far there has not been any such drive towards developing a comprehensive policy or legislative framework to address the woes of the water sector. There is virtually no legal control for the state over surface water resources and regulation of groundwater use is done through restrictions.

However, of late, there are some changes taking place in the state in terms of efforts at initiating legislations and policy instruments in the water sector in the state. Accordingly, the state is introducing two specific policy cum regulatory interventions within the state's water sector. These two pieces of policy or legislative instruments are known as: a) Gujarat Water Regulatory Commission (GWRC); and b) the Gujarat Water Users' Participatory Irrigation Management (GWUPIM) Bill, 2007, respectively. In what follows, we attempt at a brief discussion on each of these instruments.

2.4. 1 Gujarat Water Regulatory Commission

The state is in the process of setting up of the Gujarat Water Regulatory Authority following the Maharashtra Water Regulatory Act (MWRRA Act 2005). The Government of Gujarat (GoG) with the help of the Tata Energy and Resources Institute (TERI) has prepared draft legislation for independent regulation of the water and sanitation sectors. The Gujarat Infrastructure Development Board (GIDB) is currently overseeing the same. The Gujarat Water Regulatory Commission Bill 2006 aims to bring different departments under one umbrella for purpose of water distribution, rationalise water supply and fix tariffs. It is claimed by the officials that the proposed regulatory framework will bring clarity to the roles of various government bodies involved in water distribution, boost private sector investment, improve productivity and efficiency in the sector and also address the cost aspects. Aiming at an economic costing of water, the Bill includes municipal bodies and industrial users in its ambit. Apart from the Gujarat Water Regulatory Commission (GWRC), the Bill also provides for the setting up of State Water Regulatory Council (SWRC) (chaired by the Chief Minister, with 10 other ministers as members) and a State Water Regulatory Committee (chaired by the Chief Secretary, with 13 other secretaries).

While the State Water Regulatory Council will lay down the broad water management policy, the State Water Regulatory Committee will assist the council in the discharge of its functions, including formulating an Integrated State Water Master Plan. The draft Bill also has provision for fifteen-member consultative committee drawn from local bodies, academia, industry, the agriculture and labour sectors, civil society organisations (CSOs) and research bodies to advise the GWRC on policy and tariffs, and to protect the interests of consumers. While no timeline has been set for the formation of the commission, it is anticipated that the Bill may be introduced soon.

However, it may be observed that the Water Regulatory Authority if established would not be effective in addressing the challenges facing the water sector in Gujarat, as the Bill is very confined in its style and content so as to implement a definite agenda of privatisation of drinking water supplies especially in the urban areas. If the Bill is implemented, it is likely that the proposed water regulatory authority would assume the status of 'monopoly provider', thus questioning the legitimate right of the PRIs (as provided under the 73rd and 74th constitutional amendments) to have access and control over the local water resources. By and large, the Bill calls for a radical transformation in the existing legal, regulatory, financial and administrative frameworks to facilitate private sector participation in the provision of drinking water, especially in the urban areas. The proposed Bill It then commits to provide adequate returns through creating an attractive tariff regime that would facilitate the massive entry of private sector players in the water sector in the state.

2.4.2 The Gujarat Water Users' Participatory Irrigation Management Bill, 2007 (Gujarat Bill No. 24 of 2007)

The second instrument of policy reform in the water sector is the Act called the Gujarat Water Users' Participatory Irrigation Management Act 2007. While the Act has been framed, rules and regulations are yet to be announced.

As per the Act, WUAs shall be formed by the competent authority for each service area, consisting of holders of land in command area. Interestingly, membership in the WUA is not binding: if the association represents 51% of the holders of land in the service area and the aggregate area of land held by such holders of land is not less than 51% of the service area, a WUA can be formed. A joint committee of officials and office-bearers of WUA would inspect and estimate the repairs needed in the canal. And repairs would be carried out before being handed over to the association. The cost of repairs to the minor canal and watercourse shall be borne both by the state government and the association would contribute a nominal percentage of the total cost.

3. WATER SECTOR POLICIES: RESPONSES AND OUTCOMES

In this brief section, we try to bring in some pertinent issues that may have serious implications on the functioning and performance efficiency of the existing and proposed policies and regulatory regimes in the water sector in the country. Moreover, there is an urgent need for further empirical investigations so as to understand and reflect upon the grassroots level implications of the emerging policies and governance systems in the water sector.

A serious missing in the water policies at the national as well as the evolving policy frames at the state levels (particularly, Maharashtra and Gujarat) is that these policies do not make much headway in changing the perspective on water as a national resource and an asset owned by any state, whether riparian or others. The policies and regulatory regimes as they emerge show a clear trend towards appropriating the water resources and taking it out of the reachable limits of the poor and water starved communities. To that extent, the communities are deprived of their rights over water (facilitating multiple services) around which they build up their livelihoods.

As emerging from the review of the water sector policies both at the national as well as state levels, there has been taking place, a significant switchover in prioritization of water allocations. While the policies demonstrat a clear shift from 'water for irrigation' to 'water for drinking, ecological services, industry', etc., it remains unclear as to what type of institutional mechanisms or regulatory processes have to be put in place to achieve the broad goals of new prioritization strategies. For one, it becomes clear from the very functioning of the drinking water supply programme as envisaged under the Narmada Pipeline (NP) project that the policy miserably fails in terms of suggesting strategies for conserving the local water resources. In this regard, the most recent study by Hirway and Goswami (2008) shows that with the availability of Narmada water supplies, there has been an outright neglect of local water resources even in villages which suffer from serious water shortages. The study also hints at the serious flaws in the NP project as it is not clear as regards the institutional mechanisms and technical designs required for the implementation of the programme. This scenario of laxity in policy and institutional vacuum is also applicable in the case of most of the irrigation projects in the two states which are launching for successful implementation of the drinking water provisions as per the new policy framework.

As discussed above, significant attempts have been made in the Gujarat, Maharashtra and Andhra Pradesh as regards the implementation of PIM principles, which are directed toward introducing better methods of water control. The importance of institutions in all these aspects is obvious; yet there are relatively fewer attempts to relate the structure of these new institutions and their working to the larger context of decentralisation initiatives.

In Gujarat and Andhra Pradesh, the government have taken the initiative in sponsoring irrigation management transfer (IMT) but the approach and process have been different (for details see, Parthasarathy 2005). There have been efforts to make the WUAs financially viable. Though charging economic rates for water had been a very difficult task in all the states, the WUAs in Gujarat at least had begun fixing and collecting water charges from member farmers. There are also attempts to strengthen the finances of the WUAs by the government. In Gujarat for instance, there are two types of grants for the WUA. The first is related to the performance, where the WUA retains 30% of the water charges collected toward O&M expenditure and another 20% of the total water charges collected for administrative expenditure. The second grant consists of a contribution of Rs. 250/ha from the state government, Rs. 200 from the central government and Rs. 50 from the members of the WUA. In so far as the first type of grant is based on a proportion of the total water charges collected, there is an incentive for the WUAs to raise the water charges (see for details, Parthasarathy, 2000). In Andhra Pradesh too, funds for repairs have been disbursed to all the WUAs and federating bodies albeit through the Irrigation Department. In 1997-98, the actual amount to be spent on maintenance works was fixed at Rs. 100/acre and a total of Rs 10.6 million was allocated for repairs and rehabilitation. The lump sum grant was shared in the following way: 50% to the WUA, 20% to DC, and 20% for the PC. Importantly, the remaining 10% was earmarked for the village panchayat to undertake development programmes.

Thus, there has been some attempt in Andhra Pradesh to bring about a link between the new water management institution, WUA, and the panchayat[5]. The fact that Andhra Pradesh Act is touted as the model of irrigation sector reform, it is possible that other states, which use the Andhra Act as basis, would also try and forge similar links with the panchayats. It is recognized that taking part in the panchayat activities is not the same as involvement in party politics, yet, there is a fair play of party politics at the panchayat level that should be kept in view. This sort of linkages if sustained proves that decentralisation is not an exclusive or static process or that the newer institutions "encroachment" into panchayats' "space" is necessarily a competitive phenomenon. Few institutions in a developing democracy can be viewed as sacrosanct to the extent that parallel or competing institutions should be forbidden. It is plausible that panchayats, may view the newer institutions in its area as beneficial additions since they not only bring in additional resources but take away the management responsibilities in to small 'homogenous' groups. The challenge, therefore, is to find a proper balance of institutional arrangements at the local level that promote development effectively. This balance is not easily determined as they shift in tandem with the performance and changes in the new institutions (Parthasarathy, 2004).

The structures of PIM in Gujarat and in Maharashtra are different from that in Andhra Pradesh. In Gujarat, each WUA is a single unitary organisation. The Irrigation Department enters into agreements with a single WUA (Co-operatives) for the purpose of management and distribution of water and collection of water cess. But in the Andhra Pradesh model, WUAs are nested in distributary level farmers organisations, which in turn are nested in the project level farmers organisations. The latter could not be constituted for more than a decade now. The nested organisations have an advantage over the unitary organisation in terms of collective bargaining and achieving water use efficiency at the system level. This, however, also requires that the higher-level organisations provide necessary support for increasing efficiency and are capable of holding the department accountable for any mismanagement. In this context, the policies and Acts that Maharashtra has proposed seem to be comprehensive and ensure legal protection to users and managers (See Parthasarathy and Pathak, 2006 for a related discussion).

A greater challenge confronting the emerging water policy and regulatory regimes in the country in general and Maharashtra and Gujarat in particular is their complete lack of appreciation of the multifarious water sector interventions by the grass roots level agencies, especially, the NGOs and other civil society organisations. It would also be interesting to ponder over the issue that given their vast development experience, whether the grassroots level development agencies and the NGOs be considered as important stakeholders in the process of devising the water policies of the country and the states in question.

There are plethora of other issues for which the existing or proposed policies do not provide adequate explanations. Some of them, inter alia, include:

a) What are the specific legal/ ethical/ political/ socio-economic, agriculture and external trade policy environments within which water laws and state-specific water policies have been evolved and operating?

b) How best the water laws/ policies are informed to and understood by the varied actors/ stakeholders and how these actors respond to varying scenarios of water governance and institutional regimes?

c) How realistic and cohesive have been the national as well as the state-specific water policies in respect of context-specific choice of technological solutions, institutional forms and allocation and pricing instruments and regulatory mechanisms?

d) Whether the water policies/ regulatory regimes take a well thought out and well informed implementation strategy as regards rehabilitation and resettlement of PAP within or outside the geographical confines of the water projects?; and how the genuine concerns of the PAP get resolved in terms of getting a fair deal in the R & R package without compromising on their (pre-R & R) livelihood pursuits and kinship relations in the post R & R scenario?

e) Do the state-specific water policies adequately capture: (i) the gender roles/ gendered dimensions of water management, access to water and control over the decision making processes; and (ii) spatial vs. temporal vs. inter and intra-generational distributions and concerns of equity and sustainability?

4. SUMMING UP

Until about 1997 when Andhra Pradesh introduced APFMIS Act, there were WUAs formed largely by NGOs, on some occasions blessed with a Government Resolution giving specific concessions. Even when, states like Gujarat and Tamil Nadu formally announced policy supporting PIM, even the intentions were nebulous. The sporadic WUAs so formed were largely unrelated to each other and hence water management remained, and in many cases remain a distant dream. Irrespective of PIM there has been a felt need to improve irrigation efficiency as well as manage the water resources rather than just being engaged in distributing. Participatory irrigation management programme as a prelude to irrigation management transfer to users is being set up by many states now. Though it is recognized that the government should no longer be in the business of retailing water to individual consumer, the PIM policy in all the states lacks the sharpness to catalyse farmer management as a cutting edge to water sector reforms. There are evidences to suggest that the demands at the village level, stated but often muted for users' involvement in managing at least the local level distribution arrangements. In fact, local level participation does not preclude other forms of arrangement like private sector participation. In fact, tubewell 'companies' in north Gujarat show that even private management of resource would also need to involve communities that eventually determine allocation and profits. This would need recognizing water entitlements, creating and managing 'rights' to users. A necessary (though not sufficient) condition for rights to be recognised is provisioning of legal scaffolding by the state. From the foregoing discussions on the water policy and institutional reforms underway in India, it is obvious that only Maharashrta has set up policy framework of enabling provisions and authorities with somewhat clearly defined powers. The central question that still left unanswered is, what is water right and how is it defined. For water rights to be defined two other concepts have to be defined on operational terms: one is access to water (for definition related to irrigation see, van Koppen et.al., 2002) and the other is allocation principles of the resource. So far the polices only state priorities (for instance drinking water to be first and so on) but these are clearly not with respect to the state of the resource (except in scarcity years).

With a lack of clarity on vital elements of managing water resource, the state setting up a plethora of institutions may apparently make the concept of peoples' participation a casualty. We argue that in many of the natural resources there is a need to intercede the management of the resource and the users' interests with clearly defined legal framework. Except in Andhra Pradesh (in the first phase of APFMIS Act, certainly not in the present form) and in Maharashtra, half-hearted attempts in many other states to reverse engineer the process of providing legal support to isolated cases of water distribution (not management) have neither led to improvements in resource management nor in legitimizing users stake in the resource. In the present circumstances therefore, seeking involvement of private sector in water resource development and management would only be seen as a means to minimize government expenditure and worse as pontification.

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Notes**:**

[1] For instance, the pre-existing enactments which have undergone amendments were the Bombay Irrigation Act (1879) for the western region, covering Gujarat and Maharashtra; the Northern India Drainage and Canal Act (1873) for the northern region governing states of Uttar Pradesh, Punjab, Haryana and Rajasthan; the Bengal Irrigation Act (1896) as applied to West Bengal and Bihar; Madras Irrigation Cess Act (1865), Irrigation Tanks (Improvement Act, 1949) and the Tamil Nadu Panchayats' Act, 1958 for Tamilnadu state (Cullet, 2007).

[2] This has also been revealed by Ramaswamy Iyer, who has been instrumental in drawing out the 1987 water policy. Iyer observes that "when we worked on the National Water Policy in 1985-86, we had a vague idea about shifting attention from big projects to a unified, focused water policy. Having converted the Department of Irrigation into the Ministry of Water Resources, we discovered that the National Water Resources Committee, set up in 1980, had not met even once. We had a meeting, and that's where the National Water Policy originated. ..While the National Water Resources Council approved the National Water Policy in September 1987, there was no accompanying blueprint for making it operational, as originally envisaged….We did try to address the question of institutionalization through periodic meetings at different levels, but over a period of time that initiative petered out, unfortunately" (Iyer, 2007:8).

[3] The policy document observes that: "private sector participation should be encouraged in planning, development and management of water resources projects for diverse uses, wherever feasible. Private sector participation may help in introducing innovative ideas, generating financial resources and introducing corporate management and improving service efficiency and accountability to users. Depending upon the specific situations, various combinations of private sector participation, in building, owning, operating, leasing and transferring of water resources facilities, may be considered" (GoI, 2002).

[4] The literature examining the critical issues affecting the water sector in Gujarat is very vast indeed. Prominent ones in this regard are the studies, viz., IRMA/UNICEF, 2001; Kumar and Singh, 2001; Dubash, 2002; Mehta, 2003; Ranade and Kumar, 2004; Kumar, et al., 2004; Prakash and Sama, 2006, etc.

[5] In the subsequent year though the government had planned to maintain this level of grant for maintenance works, a new dimension of farmers sharing/contributing 15 per cent has been added. Like in Gujarat, in Andhra Pradesh too, no fixed commitment of grants for the PIM programme has been made (except the first two years in Andhra Pradesh).

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MAKING WATER POLICY AND WATER LAWS DEMOCRATIC: LESSONS FROM SOUTH INDIAN STATES

Jos C Raphael[1]

Abstract

The present attempt is to propose local people's involvement in Water Policy and Water Law formulation in Indian sub continent on the growing realization that policies and laws the state governments have so far either visualized or implemented seems remain paper tigers. It examines the existing water laws and its implementation from 3 south Indian states viz., Kerala, Karnataka and Tamil Nadu for this purpose. Analysis shows that Water laws mainly are centred on participatory irrigation management and water user associations. Groundwater laws are given lowest emphasis by the state governments where as majority of the Indian population depends upon it especially for domestic use. Indiscriminate sand mining is seen an emerging threat for river hydrological system that has accentuated by income tax rebates and gaps of housing policies. It indicates that the entire process of evolving water policy and laws is devoid of its stakeholders' participation particularly from the grassroots level. Institutional framework to facilitate local people's participation like Gram Sabha and Panchayati Raj Institutions are grossly underutilised for this purpose. On this background it examines the recent attempt of Kerala government in facilitating stakeholders' participation in law formulation in water related Bill, called The Kerala Conservation of Paddy Fields and Wetlands Bill 2007.

1. INTRODUCTION

Policies and institutions in the water sector respond indifferently to sustainable water use in many Indian states. Often institutions backed with law and regulations follow a fragmented sectoral and supply side approach. They seem centralized in nature, top-down in approach and vague in planning water development, water allocation and management either at higher echelons or at grassroots level (Kumar, 2001). Such vacuums in water institutions and lack of coordination in water administration calls for people's water policies and water laws which have not been tried out in India. In this backdrop the present paper attempts to examine the existing water laws and its implementation from three south Indian states viz., Kerala, Karnataka and Tamil Nadu and suggests recommendations for policy adoption by state and national level government planning agencies towards democratizing the process of water policies and laws.

2. THE CONCEPT

Water Policy is a blue print of a nation state with the broader goal of water resources management and development. This may lead the state towards water welfare or water security and it paves the ways for water law making. The water policy has to be supported by water laws and associated sector laws such as groundwater laws or laws of natural resources extraction and replenishments. The water policies can be created by a political entity like a nation state or a political party and economic activity such as a production unit or firm at their respective levels. This can also be made by social entity of people's groups or a family or farmer depending upon whether the actions taken affect others or not. Whereas making water laws and associated laws is the sole function of a nation state, this functional role distinction differentiates a water law from water policy. Generally, action plans will follow water policy and water laws, to implement the same at the practical level. Thus, the policy, the law, the institution of implementation, the plan and programme of action and actual implementation

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in a sequence, complete the picture of the system of governance, in an ideal situation (Ramesh, 2001). Policy is broader in dimension whereas water laws are specific to the subjects. Sometimes orders of senior government officials also can have the resemblance of law with or without the back up of law and policy.

3. LAW AND POLICY-MAKING PROCESSES

Normally a law is the mother of a felt need, inadequacy or vacuum in the existing situations that cause problems to society. Legal solutions may emerge after a process of consultation and consensus among the affected community. The government in such situation aware of the problem may dictate to solve such issues through legal means conforming to the constitution of a nation. How long consultative process will take and with whom it takes place is of importance. Whether the affected people at large are consulted during the process of law making deserves particular attention in democratic nation like India, especially with ground water laws since major population in the country depends mainly on groundwater for drinking purpose.

In India water laws were initiated before Water Policy of 1987. Water (Prevention and Control of Pollution) Act, 1974 and The Water (Cess) Act, 1977 are only a few examples of putting cart before the horse. At times, inspirations from the west have contributed to water laws in India. Water (Prevention and Control of Pollution) Act, 1974 was a modified version of a Scottish law of 1950s without acknowledgements which the Scott repealed in 1973. Indian law makers however clothed it with tri-colour and resurrected it. Legislative effort of water sector are inter related with other sectors such as agriculture, power, credit, land and environment at large yet consultative and coordinated efforts are not made with other sectors or ministries before formulating a policy and laws. And there are policies without law and laws without policies in the related sectors. Often these processes are not transparent and open. The process of policy and law formulation hardly seeks opinion, critiques and comments but adopt highly secret and confidential cabinet note mode until it is presented in the legislative floor. Obviously they are bureaucratic product models and designs. And law experts get less significant role in giving opinions. Occasionally there is consultations of bureaucracy with the law experts before making laws which gives the impression that the comments of the law experts are well taken. Instances of such enthusiastic consultation process with law experts have met with rejections in the actual bill presented in the legislature even when the comments were given in writing. It seems entire process of evolving policy and law in the subject of environment, in the Indian sub continent is a flawed one (Ramesh, 2001). This dismal picture validates the process of policy and law making. Required consultations, appointment of experts, formation of select committees and duration of the process remain without a standardised procedure followed through a transparent, democratic and holistic approach.

3.1 Emerging Queries

This raises the crucial questions of “who prepares the water policies and water laws of state and how democratic are they? Is it still a bureaucratic exercise? How the farmers’ and users’ views are incorporated in the water policy? If it has taken note of the above section, how far their views are represented in the water law making? Further, it is worth studying how these are implemented? Is there any conformity between National Water Policy and state water policies? Or in other words does water policy of a state contain the inevitable constituents such as water resources planning, water conservation, judicious use, recycling, pollution control, river management, IWRM, gender, positive discrimination or reservations, water quality, groundwater extraction and recharges, governance, justice, awareness and education? If yes, what is their application at the field level and what is the success or failure rate? What are the supportive acts and policies related to water sector in place in the state? And what is their status in practice? Does any political party have political stands on water and related policies in any state? Are the water acts and policies communicated to common people through audio and visual media? Is the water policy document in the form of a printed book or government order? What is the language in which it has been prepared? Is it accessible and readily available from market to read for the common person? More over, what are the structural gaps and functional gaps of water laws in states? Hence a plethora of research questions arise while deal about water policy and water law making.

Shah (2002) who was one of the members of National Consultative Committee on water, to incorporate the views of voluntary sector on water policy 2002 says, "none of the final recommendations made by this committee find a place in the new water policy". Further, this committee had recommended "Since all water resources have a common property character, private sector participation in planning, development and management of water resource projects, must be subjected to careful social scrutiny, based on well-developed mechanisms of accountability and regulation." It makes many other suggestions, which were rejected by the government. It seems either private sector had enough interest to lobby the bureaucracy or it could be the apathetic view of bureaucracy to include the views of common people.

People's participation in the development planning process from the grassroots level is the key to democratic pattern of development in the country. 73rd and 74th Indian Constitutional Amendments empowering rural and urban local governments popularly called as Panchayati Raj Institutions (PRIs) and Nagarapalika Institutions respectively, is an opportunity opened for ensuring local people's involvement in water policy and law formulations. Hence, they can play a significant role in the water policy and law making to take up the upcoming hydrological and social challenges (Maria Saleth, 1996 and Philip Cullet, 2006). Thus challenges of including under privileged groups in the society and women in the water policy and law formulation process can be in favour of water poor and needy. In other words, all stakeholders - stake-losers and stake gainers - can take part in the total process. The existence of grassroots level institutions like gram sabha facilitate all citizens of the country to take part not only in planning process but also debate and direct the higher tiers of people's bodies whether it is PRIs or state legislatives in the formulation of water policies and laws in India. However, the idea has not been tried out so far in the Indian water context.

Ancient kingdoms and civilizations had water policies and laws in the form of unwritten constitution or mutual consensus among people including in the Indian contexts (Vani, 1991). The British Indian colonial periods brought out Famine Commissions and Irrigation Commissions which were the seeds of water policy by the British empire. However, independent India took nearly four decades to formulate a national water policy. As mentioned earlier, the associated sector policies of agriculture, irrigation and forest etc were the forerunners of the water policy. India's first national water policy was in 1987 though few water laws had been promulgated in 1950s and 1970s such as The Inter-State River Water Dispute Act-1956, The Water (Prevention and Control of Pollution) Rules 1974, Water (Prevention and Control of Pollution) Cess Rules, 1978.

The realization of the fact that water is one of the most crucial elements in development planning, the country had to prepare itself for water challenges while it entered the 21st century. Common issues emerged in irrigation projects across the nation like environmental protection, rehabilitation of project-affected people and livestock, public health consequences of water pollution and dam safety. This inspired national planners to shape a National Water Resources Council in 1983. The council lay down a National Water Policy and reviewed it from time to time. The Council in its meeting held in September 1987, adopted first National Water Policy. However, various untouched issues and areas of the 1987 policy anchored for a newer policy by 1998. Since then number of problems and issues emerged in the development and management of water resources that led to the National Water Policy of 2002. It looks this 2002 policy is a white washed policy of the former policies. According to Iyer (2002) "the revision of the National Water Policy was wholly internal governmental exercise, with no consultations with people and institutions outside. Further, it was a mere 'amendment' exercise, and the resulting document can hardly be described as a new policy.

A study conducted by IWMI (2006) about water governance in Mekong region tells that top-down state policies based on blueprints are widely applied in a one-size-fits-all approach, without taking local realities into account. Water planning is still largely expert-driven, and focused on procedures and targets. There is little room for decision-making that is based on negotiations between users, line agencies, NGOs and politicians. The study was conducted in 6 Mekong countries of China, Laos, Thailand, Vietnam, Myanmar and Cambodia that give tips of driving forces behind the water policies of different types. Often these policies have adopted Bank driven approach with funding from Asian Development Bank. They move around with the buzz words or modern principles such as, participation, water charges, IWRM, control on water uses and multi-level body decision making. Water policy making at functional level often remains without public scrutiny and in secrecy. For example, there is little scope for the democratic approach of water policy making in China and Laos since they are not allowed to. The strong resistance from bureaucracy also stands against popular water policy making as it happened in Thailand. The study says that Thailand and Cambodia have drafted new legislation. Myanmar still has to update its older water laws. Vietnam, China, and Laos have passed new laws in recent years. Invariably, civil society has had no input in the creation of their water laws. Often water sector reforms are largely designed by Bank consultants outside the country that may undermine or override the traditional norms, rights and rules. Sainath (2006) observes that multi national corporations influence water policy making of Latin American countries. The paper says Maharasthra Water Resources Regulatory Authority 2005 is based on a World Bank mooted water law passed in haste through Maharashtra state assembly to get sanction for a billion dollar project in the state[2].

Once the Water Policy of state is promulgated, enabling laws are to be created by the state. The related water laws are generally implemented through people's multi-level bodies, Water User Organisations, legal and regulatory frameworks, for instance, Maharashtra Water Resources Regulatory Authority and Dam Safety Authority Kerala acts. Sometimes they are implemented by a government order of a concerned senior bureaucrat. Quite often they have no role in water resources planning, allocation and regulation. Command Area Development Authorities of different states had such farmer organizations for nominal sake (Maloney and Raju, 1994). Thus it is most important to study the water policies and water laws which are actually put under operation at field level.

Why the acts are not implemented at the grassroots is indeed pertinent. There are varied references of the wide gaps in the implementation of water laws. Some water laws may be conceptually good but difficult to implement. Such law formulation could be based on the views of people's political representative party in the state assembly and not necessarily reflect the views of local population. Such hasty laws may undermine the traditional water consensus and rights of local population. Alternatively, water law prepared by a political regime may not be acceptable to the next ruling regime. Interdisciplinary approach in law formulation may be the missing link for practical application of water laws at the field level. Often limited publicity about a water law may make the people unaware about the particular law. In some others cases, existing water laws might be outdated, inadequate and inappropriate. Political willingness to implement the law is vital. Rainwater harvesting and ground water recharge activities taken up by Jayalalitha government in Tamil Nadu in the recent years is one such example. Political regimes may find it difficult to implement water laws due to various pressures, votes and possible economic losses. Indiscriminate sand mining from Kerala Rivers is an example of the power of local mafia over existing law and order enforcement system of the Kerala Protection of River Banks and Regulation of Removal Sand Act 2001.

There are major hurdles from the bureaucracy in implementing water laws at the operational level. Some bureaucracy is not receptive to change in the water related sectors. In the institutional frameworks to implement the water laws, the bureaucracy is ill equipped, inadequate in number, under trained and often with low morale. Some staff may not have any water subject orientation. Fund flow from the state headquarters to the water institutions may be slow. Competent water oriented staff on contract may find it difficult to work with the government officers on deputation. Also problems like accumulation of staff in the apex level institutions and lower allotment of staff in the lower tiers can be seen in water development projects. There may be difficulty in identifying suitable NGOs to work with water sector.

Projects under water sector reforms use to be implemented in time bound project manner or on pilot basis while the participatory learning process is time consuming. Social development is a gradual process particularly in the developing country context that may take more time. Therefore, experiments in water sector development cannot be written off even after the project periods ends, or once the donor aid is off.

Finally, every state water policy talks about promoting economically efficient use of water; but no one is ready to price canal water or meter electricity used for pumping groundwater. Also, the some state water policy documents talk about using river basin as the unit for planning WRD& M. But, no one has so far made any progress. Planning and implementation activities are carried out in isolation by different wings of irrigation department.

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[2] As per this act those farmers have more than two children will have to pay one and half times new rates for irrigation.

From the above discussions, it can be seen that there are plenty of problems and issues with water policy and water act formulation and implementation. The gap between water laws and operational flaws of these acts in different states opens the scope for water policy research. To address these issues field studies were conducted in three south Indian states viz. Tamil Nadu, Karnataka and Kerala in order to understand and reflect upon the contradictions (if any) with respect to formulation of water policies, laws and its implementation at the grass roots level. Closer interactions held with the multiple stakeholders ranging from irrigation department officials at the various levels to farmers, water users, local community leaders, NGOs and resource persons in the subject, to understand the bottlenecks in implementing policies and acts.

4. WATER POLICIES AND LAWS IN KARNATAKA, TAMIL NADU AND KERALA

Water Policies and Laws of Kerala, Tamil Nadu and Karnataka are studied in pursuit of democratic dimensions of water policy and law applications at the ground level. Field investigations and data shows that these states have embarked upon water policies at one point of time or other. Tamil Nadu formulated water policy in 1994 in response with National Water Policy 1987 and lag behind the other 2 states in updating the same in continuation with National Water Policy of 2002. Karnataka and Kerala issued their water policy in the year of 2002 after the national policy. Karnataka also has a water policy for Urban Drinking Water and Sanitation 2002.

Field insights give the impression that water policy formulations is a contribution of bureaucracy and some technical experts. Indeed the minister in charge of water might have gone through the policy document. Inter disciplinary or participatory approaches were less or nil obviously in the water policy formulations in the case states. Hence stakeholders' involvement in formulation was not very democratic in approach. States can have water policies as and when they require on which people are less concerned than the water laws. Again there too experts and bureaucracy dominates and the draft water bills get passed in the state legislature, truly people's representatives' body than local people. However, a convincing change in favour of water policy and water law formulation took place in Kerala from the present rule of LDF at state legislative assembly since 2005. Kerala's all new water policy drafted in 2006 by Centre for Water Resources Development Management (CWRDM), Calicut, which is the state owned water research agency. This had been discussed by NGOs (partially left centred) and sought for meticulous modifications. It has a select committee of experts to learn people's views. The final draft version of this water policy which has to be termed the year 2008, is available from website that seeks public opinion. The policy is under debate for the past two years[3]. In the same manner, new water related law of the state is in draft stages with wider democratic consultation process across state which will be discussed in the later part of the paper. But what is more important is how these water policies led to suitable water laws considering particular situations of states in context and how the enacted laws are implemented at ground level in its fuller spirit and meaning. And therefore it is worth assessing important water acts briefly which have been formulated and enacted across these states (see Table 1).

In the irrigation scenario Karnataka has updated their irrigation act of 1957 to The Karnataka Irrigation and Certain Other Law (Amendment) Act 2000. Tamil Nadu emphasizing more upon farmers, Water User Associations (WUAs) and PIM enacted Tamil Nadu Farmers' Management of Irrigation Systems Act, 2000. Three years later Kerala, which spends nearly 60% of its budget on irrigation and hydro power with low agriculture output, enacted The Kerala Irrigation and Water Conservation Act 2003. The act claims that all water resources belong to the state and is a common property resource. It is silent however, on conservation of water resources particularly the homestead open dug wells of Kerala. Indeed irrigation components, dam safety authority and limited PIM introduction in the state are a reflection of this act.

WUAs, which involve local people in water distribution and uses in the irrigation and domestic water sector have become relevant in the past few decades and attracted a lot of donor support. Byelaws, constituent people's water general bodies, water charges of the past history with which they managed their own unwritten constitutions, mutual respect and value systems for water management were lesser known to the traditional

[3] No doubt all these documents of water policy are available in the website in English than in any easily available outlets down to the district levels in local language. Tamil Nadu water policy of 1994 is still not available even from websites.

irrigation social capitals (Ostrom, 1992, Uphoff,1991). In Karnataka and Tamil Nadu, grassroots level WUAs are in place under each reservoir related projects and under the traditional tanks systems. Initial enthusiasm does always remain though. Follow up and monitoring from the higher level is a missing component in both states. Formation of distributaries level WUA committees, project level committees or federations and Apex level committees has not been done in all the areas particularly in Tamil Nadu and southern parts of Karnataka. Project level federations have been formed by NGOs such as Jalaspandana in the north such as Ghata Prabha and Mala prabha sites. It looks that there is no one to co-ordinate these WUAs at any level. Organising the farmers is the most vital component of PIM which is lacking in both the states.

The field information from case states shows that irrigation field structure of command area development schemes of 1980s are dilapidated, as are their canal committees. It is learnt from the discussions with the survey respondents that some WUAs perform well whereas others do not work as envisaged due to various reasons such as leadership qualities, caste and political party homogeneities, monsoon etc. Some of them may work as long as the project implementing agency or NGOs support them and once this is over WUAs often work passively.

Table 1: Water Policies and Water Laws in the Case States

Policy/ Law	Karnataka	Tamil Nadu	Kerala
Water Policy	2002 and 2003 (urban drinking water and sanitation)	1994	1992, 2002 and 2008 to be declared shortly
Irrigation	The Karnataka Irrigation And Certain Other Law (Amendment) Act, 2000	Tamil Nadu Farmers' Management of Irrigation Systems Act, 2000	Kerala Irrigation & Water Conservation Act, 2003
Ground Water	1) The Karnataka Ground Water (Regulation for Protection of Sources of Drinking Water) Act, 1999 2) The Karnataka Ground Water (Regulation and Control) Bill, 1996	1) The Tamil Nadu Groundwater (Development and Management) Act 2003 (not implemented) 2) The Chennai Metropolitan Area Groundwater (Regulation) 1987	Kerala Ground Water (Control and Regulation) Act, 2002
Domestic Water	Karnataka Municipal Corporations (Water supply Rules 2004)	Tamil Nadu Water Supply and Drainage Board Act, 1970	Kerala Water Supply and Sewerage Act, 1986
Rain Water Harvesting (Rooftop)	Attached with Building Byelaws of Harvesting Municipal Corporation	Amendments with Laws of Municipality and PRIs	Attached with Building Rules of Municipality and PRIs
River Protection (Rooftop)		Tamil Nadu Minor Mineral Concession Rules, 1959	Kerala Protection of River Banks and Regulation of Removal Sand Act, 2001
CADA	Karnataka Command Area Act, 1980		Kerala Command Area Act, 1986
Other Laws		Tamil Nadu Protection of Tanks and Eviction of Encroachment Act, 2007	Kerala Conservation of Paddy Fields and Wetlands Bill, 2007

Field insights show that the Revenue Department, which has to support WUAs in providing land records for assessing the crop yield, fixing water rates and settling CADA disputes, is slow in action. Settling disputes is a hurdle when WUAs approach the Police department[4]. Some WUAs feel that the training given to them is not very intensive. There is lack of coordination among the departments because of which WUAs loose out.

Karnataka WUAs are registered under Cooperative Societies Act though they find it difficult to work in like a company. Whereas in Tamil Nadu, WUAs are elected constituent bodies that do not require any renewal of registration. This leaves scope for mal adjustments in Tamil Nadu though some WUAs find it convenient. They hold that WUAs in Tamil Nadu are not empowered to settle disputes and often have to approach administrative hierarchy and District Administration to settle issues and for development related requirements, which is time consuming and tedious. Problems with WUAs are often site specific which requires micro level treatments that may not be possible because of bureaucratic inflexibilities. In Kerala, Paddy Farmers' Associations popularly known as "Padasekhara Samithies" and Krishi Bhavan (micro level government agriculture office) comes under a grama panchayat in the absence of proper water user association.

In terms of ground water laws - Kerala was the first to implement them. The Kerala Ground Water (Control and Regulation) Act 2002 was implemented and Ground Water Authority (previously called ground water department) was established. It constitutes a governing body with 13 members and a chairman. Secretary to Government Water Resources is the chairman and director of groundwater department is the secretary. Chairman and secretary of this people's committee are from bureaucracy and rest of the governing body members are people's representatives. No democratic norms or specified qualifications have been suggested to this nominated people's body. Indeed, it gives ample scope for "putting party political activist first" to this committee. Much acclaimed Plachimada Coco Cola factory issues of groundwater exploitation versus Perumatty Grama Panchayat, Palghat district, Kerala is no doubt attributed to the weak content of the law. (Koonan, 2007, Bijoy, 2006) As per this Act, well owners were requested to register HP specifications in the district groundwater departments[5]. It evoked little response in the initial years due to limited publicity but improved with wider newspaper coverage, deadlines and fine structure. In Karnataka, groundwater law for irrigation is still in the form of a bill since 1996. Nevertheless, The Karnataka Ground Water (Regulation for Protection of Sources of Drinking Water) Act, 1999 calls for attention of well diggers not to construct wells closer to the public drinking water sources of the government schemes. The Tamil Nadu Groundwater (Development and Management) Act 2003 is more far sighted since the former issues license for drilling units. However, they have not yet implemented the same because of resistance from various corners. Due to acute water scarcity in Tamil Nadu the residents of Chennai implemented The Chennai Metropolitan Area Groundwater (Regulation) Act 1987 in 1987.

Considering the water over draft situation in all three states, rainwater harvesting particularly roof water harvesting has emerged as a new approach in cities particularly in Chennai. Even though Tamil Nadu has not produced a water policy after 1994, the state has vehemently implemented water recharge components mixed with amendments as rules of municipality, municipal corporations and PRIs in 2003. Coupled with good rainfall during the past two years, Tamil Nadu to a considerable extent is successful in improving the water situation with the help of rainwater harvesting. However, the methods used and how genuinely they were implemented needs research. Observation from rural farmers is that roof water harvesting for groundwater recharge may not be useful as visualized. Implementation of such stringent rules for rain water harvesting are an exception for water law implementation in the recent history of south Indian states. However, these recharge efforts may be insignificant in the absence of the required ground water extraction laws in rural areas. Following the steps of Tamil Nadu, Kerala amended the building rules of urban local governments in 2004 and for rural areas in 2007 in favour of roof water harvesting. Field studies however show that it has raised issues of corruption matching numbers. In the absence of standard norms in rooftop harvesting structures, newly built houses and structures cannot get building number. The state thus assigned a building number when the house

[4] According to WUAs the Police are not involved with these activities as they have not received any order from government in Tamil Nadu

[5] Act that requires the open dug well owners who make use electric motor pump with more than 1.5 HP and tube well owners with above 3 HP to register their wells in the District Ground Water office concerned.

is constructed. Bangalore Mahanagarapalika Building Byelaws mandates rainwater harvesting for new buildings based on plinth area. Panchayati Raj and Rural Development department of the state are also piloting rainwater harvesting in the rural areas.

National government's effort for establishing CADA across states has contributed to the enactment of CADA acts in the three states. Other related water laws exist in Tamil Nadu and Kerala related to the protection of water bodies viz. tanks, rivers and wetlands. The Tamil Nadu Protection of Tanks and Eviction of Encroachment Act, which became effective in October 2007 aims to prevent illegal encroachment of the tank sites. Complaints from different corners arise that it is anti-poor. However, the intention of such laws for protection of natural resources deserve attention. Donor aid is also flowing in for this reason in Tamil Nadu and Karnataka.

Regarding water administration, no coordination for any water resources planning and management occurs either at the bottom or at top level in the three states as well as in studies from other states. Piecemeal approach to water development is quite common (Kumar, 2001). Different water sector related development departments plan and implement their own schemes. Officialdom of water administration is spread across departments as usual except for certain donor aided projects with multi disciplinary projects in the case states.[6]

5. REASONS BEHIND THE NON IMPLIMENTATION OF ACTS

Groundwater laws lag behind in enactment and its implementation. National Water Policy emphasises more on surface water and attaches little attention on groundwater withdrawal though nearly 90% of the drinking water needs in the country are met mainly by groundwater (Nagraj 2007). The Karnataka Ground Water (Regulation and Control) Bill 1996 is long pending for more than a decade that could not be enacted in the legislative assembly which shows the apathy of state in conserving the groundwater resources of the state. The Bill is meticulous on grant of permit to extract and use groundwater. Reasons for non enactment are many. A Groundwater law will badly affect the sinking agencies to get licences and to conduct their unchecked operations. A similar reason is in force in Tamil Nadu where farmers are reluctant to loose their right to harvest the groundwater from the land portion belonging to them. When the law becomes against the common understanding of right to dig a tube well and to draw water from it, public feeling normally will be against such law and the precious votes of elected representatives. It is essential to make the people aware of the rules in favour of appropriating groundwater as common property resources optimally in the society. Such water education is absent in all National Water Policies.

Given the poor literacy rate in India, law application and its acceptance in the society is a gradual social development process that takes more time than in the developed countries perhaps. If at all a restrictive law is implemented in any state, such as the groundwater extraction and patrolling, it is a difficult task for the government. The problem is aggravated because of the highly subsidised power supply for groundwater irrigation. Also irrigation administration is hesitant to give out their powers to the farmers.

Irrigation Acts have been implemented in all three states. However, follow up and monitoring of the implementation of the law depends upon Irrigation Administration of these states. It is better to term them as acts for participatory irrigation management. Accountability of the irrigation agencies with regard to water delivery to WUAs in government managed irrigation systems is essential for successful irrigation management transfer and these feature should be reflected in the law (Raju, 2004). All problems commonly found with PIM approaches are applicable to the irrigation laws of these states. As long as the irrigation administration is passive in organising, monitoring and supporting the WUAs or farmer organisations, there can't be much change in irrigation management. WUAs of the case states are not empowered fully to become financially sustainable. Political will to support the farmers and WUAs is essential but missing in most cases. Change of governments in the state legislative assemblies or sometimes presidential rule as in Karnataka gives less scope for required support from the apex level. The fall of River Boards of Tamil Nadu substantiates this fact.[7] The PRIs also work

[6] Instances of deputing Chief Engineers of Building Organisation (PWD) to Water Resources Organisation both come under same PWD of Tamil Nadu who may not know much about water as part of their inter departmental transfers and convenience factor of officialdom to be seated at state headquarters is common.

together at the grassroots level with WUAs in the case states when NGOs supports them. (Shivanna and Reddy, 2006) Major donor aid agencies too give less importance to push such notion of blending PRIs and PIM in water sector reforms.

Common public ignorance on enacted water laws down to the grassroots level is a major vacuum in the implementation of water law in Kerala. Public awareness on The Kerala Irrigation and Water Conservation Act 2003 was almost zero even amongst the media who ignored the component of conserving open dug wells. If this is the case of literate Kerala, it is assumable how far a water law is disseminated to a common farmer in the rural areas of Karnataka and Tamil Nadu. Website information does not help the poor farmer to learn about water laws. Availing information on water laws published in local language for reasonable price "in time" remain a dream even for scientists work upon the subject, let alone the local farmers. In Chhattisgarh, the strategy of giving awareness to the public on Participatory Irrigation Management Act of Chhattisgarh, 2006 on various modes is an exceptional example of giving mass education on a water law in the country. It can be replicated in other states.

Illegal and unchecked sand mining activities across the states can be observed even after the implementation of regulatory law against sand mining. This is mainly worked out with the help of sand mafia, unholy nexus of people's representatives and administrative mechanisms and by the help of local wage earners residing near the river beds. Unless a suitable alternative is found for sand for construction, implementation of law may not always be successful. Sometimes stringent implementation of a law in time stipulated manner can jeopardise the water law implementation as happened with Tamil Nadu roof water harvesting rules during 2003. Groundwater recharge experts overnight installed roof water harvesting structures across the state to escape penalisation that helped little in ground water recharge according to the study finding by Rain Centre Chennai. (Raghavan, 2005)

Right to harvest rainwater and conserving it with individual farm lands with help of local check dams on individual basis or on farmer collective actions can reduce the water flow to the tank systems and system tanks as seen in Tamil Nadu and Karnataka. Here the rainwater harvester becomes a culprit that makes enough space for controversy particularly in the low rainfall areas of case states except in Kerala. Roof water harvesting laws applied in the rural and urban areas of Tamil Nadu and Kerala which is already weak in implementation either does not contribute much for improving the tank systems than the drinking water resources nearer to the human settlements in villages. Technological boost for digging tube wells makes the farmers less dependent on WUAs and undermines community initiatives. In the absence of required ground water law implementation in Tamil and Karnataka, there is scope for complete dilution of WUAs and collective action.

6. STAKEHOLDERS' PARTICIPATION IN WATER LAW FORMULATION

6.1 The Case of "Kerala Conservation of Paddy Fields and Wetlands Bill 2007"

From the foregone discussion it can be seen that people have a limited role in water policy and water law formulation. This is the biggest bottleneck in enacting and implementing water laws. The governments are afraid of resistance from public in general. Although WUAs and PIM approach is involving interested farmers in the water discourse, their role in policy and law formulations is nil unlike decentralised planning process of rural and urban development in the country. Majority of such projects are imposed from above and many of them are donor aided drawn from somewhere for replication after pilot testing. Institutional framework to reflect the people's view created by the 73rd and 74th constitutional amendments for rural and urban development is thus grossly underused making them (gram sabha) venues of scheme distribution. The following example from Kerala, though not reached the grassroots level and involved local governments, has facilitated stakeholders' participation at the district level in water law formulation

The Kerala Conservation of Paddy Fields and Wetland Bill 2007 intended to conserve the paddy cultivated areas and wetland systems and to restrict the conversion or reclamation thereof in Kerala. It is a state that does not produce even 25% of the total food grain requirement and depends on nearby southern stated for food

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[7] World Bank aided River Basin Boards were in existence for two years in Palar and Thambaraparani basins of Tamil Nadu from 2001 to 2003. They remain with a single staff in Chennai.

items. Environment flaw in the local hydrological upset the open dug wells badly particularly in the summer. To avert this growing menace of water and food, the present ruling LDF government brought forth The Kerala Conservation of Paddy land wetland Bill 2007, which is currently debated in the state at public forums.

The bill is relevant in its "water law formulation process" which invites all stakeholders that will be affected when it becomes a law. As part of this process, the state government and revenue department informed the media about holding the district level meetings of all stakeholders were given in the local newspapers with time, place and other details of such public hearing. Since the date and timings of this meeting were circulated well in advance, the venues mainly Town Halls were full with stakeholders on the day set for respective districts. The farmers, farmer unions, clay mining industries, clay mining industrial labour unions, real estate firms, NGOs, social and political activists and public in general gathered in such gatherings and aired their view on the drafted bill. It started from Trichur district where ministers, district collector, people's representatives and other district level bureaucracy were present All who had attended this public hearing were given a copy of the draft bill in Malayalam language with a questionnaire printed in Malayalam seeking pros and cons of such a bill to be submitted within December 31st 2007. This process was repeated in 14 district headquarters. Apart from this, local newspapers had facilitated this discussion at length from stakeholders as well as from the experts in this field. Currently this bill is scheduled to be presented in the ongoing legislative assembly sessions of Kerala government (March '08).

There are apprehensions on type of expert groups who will be vetting the bill after hearing the stakeholders' opinion. Besides who will coordinate the responses of filled up questionnaires and how far it will reflect in the law. Whether the opinions of the stakeholders' have been seriously considered or not, in the redrafted bill is a matter of concern while reformulating and passing the bill in the state assembly. This is a pilot experiment of Kerala in ensuring people's participation in the law formulation process under law reforms after much acclaimed experiments with people's planning campaign in Kerala.

7. RELATED SECTOR INFLUENCES ON WATER SECTOR

Field insights from the case states gives the picture that water sector is related with other sectors such as land, agriculture, power, mining, credit, environment etc. Majority of these related sectors have been discussed earlier by different eminent institutions nationally and internationally. In the Indian context, one among the above sector is seen recently emerged is sand mining. Building construction industry is in very high growth stages in the recent years following the growth rate of the Indian economy. All such activities require sand which is becoming a scarce resource. The impact of sand mining from the rivers and rivulets is the depletion of groundwater level in the nearby inhabited areas of the rivers. State like Kerala has 44 rivers out of which 41 of them are west flowing to sea, cross through thickly populated areas before reaching the sea. Indiscriminate and illegal sand mining is still prevalent even with stringent rules of The Kerala Protection of River Banks and Regulation of Removal Sand Act, 2001. A common and easily available alternative for sand has still not been invented by scientific community. Issuing coupons for rationing to extract sand from rivers has been adopted recently in Kerala. But how the sand mining has adversely affected the state is more interesting to study. Income Tax rebates for newly constructed houses (on loans) for an income tax payer is an attraction to reduce the tax burden. Informal interviews with income tax payers who have constructed new houses in Kerala reveals that a new house or construction modifications helps to reduce the income tax burden though the new construction activity may not be essential. More construction activities require more sand and this has affected the river systems of Kerala and hydrological seepage adversely from their water resources i.e., homestead open dug wells.

This field observation was tested to the Karnataka and Tamil Nadu counterparts and reaches the conclusion that income tax rebate can lead to unnecessary or unwanted construction in availing tax benefit. Both these states suffer from indiscriminate sand mining resulting in damages to the river system including for infrastructures like railway bridges (Hemalatha and Chandrakanth 2003). True that the income tax rebate is indeed is a major relief for those who build a house but when this tax benefit opportunity is misused it calls for serious concern from the policy makers[8]. Under this circumstance, Housing policies of the country have to be seriously reviewed in the event of growing water scarcity and groundwater overdraft.

8. RECOMMENDATIONS FOR POLICY MAKING

The discussion shows that water policy and water laws are made without consultation with the stakeholders which results in poor results, particularly in the groundwater laws. This leads to appropriation of available water by individuals or societies by whatever means they can causing unsustainable water resources development and managements. Following recommendations are suggested for water policy and law making and planning institutions by state governments with local people's participation. The policy and law making process has to be standardised with necessary consultations, norms of appointing experts and commons, multi disciplinary teams, formation of select committees, duration of the process and other technical intricacies.

Existence of gram sabha/ward sabha in the rural and urban local government scenario provides ample scope for debating water policy and law formulations at the grassroots level. Articulation of these laws indirectly helps teach the masses about the drafted law under debate. District and lower level consultations with people and coordination of concerns and valid arguments from the people have to be sought and properly addressed while vetting water laws. The draft policy and laws should be available, adequate in number, printed in local languages and in English. Hoisting them in websites will not help the poor farmers or the common people.

While promoting water sector reforms and PIM on one side, donor aid agencies also promote decentralisation and rural and urban local governments without any coordination, which raises concerns. Both these people's bodies work like parallel bodies and can work synergistically. The potentials of NGOs can be effectively tapped to coordinate for better water governance at grassroots level. Training for WUAs has to be institutionalised as in the case of PRIs. State level water training institutions have to be fully equipped. Currently this part is not given required attention and remains a major vacuum in the capacity building process.

Once a water law is implemented enough awareness on the law has to be disseminated through all effective means to reach the micro levels. This can lead the masses including the women and underprivileged for hydrological awareness or water education which has not been mentioned in the former water policies.

Consistent interest and political willingness is crucial to establish and monitor the total water resources development, which are often found missing once a political party changes from state legislative assembly.

Water institutions and administration have to be coordinated from bottom to top to facilitate accountability of government officials. It should ensure water resources management and development involving local people.

States like Kerala where irrigation projects based on reservoirs and recurrent expenditures to maintain the system might incur more cost than the return for farmers produce in terms of crop prices. The canon of economy works negatively with irrigation investments and total crop return from a project. There is a serious need to make irrigation institutions and administration more cost effective.

Water sector is very much related with other developments sectors. The field realisation of income tax rules and housing policies and their nexus with water sector raises concern. Fiscal policies and building construction and industrial activities have to be reviewed to avoid indiscriminate sand mining. Scientific research for alternative building material other than sand also has to be considered.

Several government institutions, NGOs and many agencies are involved with water research. And who takes care of their research outputs for policy adoption requires urgent attention. Scientific research has to be result oriented rather than purely academic. State and national planning agencies like State Planning Boards and National Planning Commission should review and call for research output suited to the needs of the state and the country as a whole. If water research and national & state policy planning in India work in parallel without meeting any end, water problems of the country may remain unresolved.

[8] This fiscal policy reforms has roots from the western developed countries particularly from USA when a loan for acquiring a house is taken, its interest will be deducted from the taxable income as per the USA income tax laws.

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EQUITY IN DISTRIBUTION OF BENEFITS FROM WATER HARVESTING AND GROUNDWATER RECHARGE – AN ECONOMIC STUDY IN SUJALA WATERSHED PROJECT IN KARNATAKA

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Abstract

*The paper looks at the impact of water harvesting programs in ground water recharge through the case of the Sujala watershed in Karnataka. On comparison with areas of non sujala watershed and non watershed cases in one normal rainfall and one drought year, it was revealed that Sujala has been successful in recharging groundwater, improving farmers' incomes and increasing crop production. Further the program is inclusive and the benefits were accrued even to the small and marginal farmers. In fact the net return for small and marginal farmers was higher that that for large and medium farmers. The study concluded that there is potential for expansion of Sujala pattern of watershed development program in other parts of Karnataka and Indi*a.

1. INTRODUCTION

Water harvesting for groundwater recharge has been a major objective of Sujala initiated by Government of Karnataka with the assistance of the World Bank. This is a community driven program implemented by Watershed Development Department with tripartite cost-sharing arrangements. The Sujala project is being implemented in 5 districts of Karnataka covering 5.11 lac hectares of land spread over 77 sub-watersheds, 741 micro watersheds and 1270 villages benefiting about four lac beneficiary households including landless spread over three phases during 2002-07. The overall Sujala watershed project cost is Rs. 677.73 crore, of which Rs. 540.83 crore is financed by the World Bank, Rs 72.51 crore is borne by the government of Karnataka and Rs 64.38 crore contributed by the beneficiaries from the watershed communities. This study aims to assess the economic impact of Sujala watershed programme and Non-Sujala watershed in Karnataka on groundwater recharge, agricultural productivity, and equity in distribution of benefits among different classes of farmers.

2. REVIEW OF LITERATURE

Study on appraisal of watershed development program in three agroclimatic regions of Maharashtra conducted by Deshpande and Narayanamoorthy (1999) indicated that there was a definite improvement in fodder, fuel and food availability. Watershed areas with degraded and fragile natural resources would take a long gestation period to recover the natural losses and then the incremental returns follow. Watersheds in assured and moderate rainfall zones perform better than that in low rainfall zones. Farmers had adequate understanding of ongoing watershed activities and all farmers expressed their satisfaction for extension support received (Deshpande and Narayanamoorthy, 1999).

Another study by John Kerr (2001) on watershed project performance in India indicated that participatory watershed projects are successful in protecting upper catchments to promote water harvesting, but this has come at the expense of landless farmers whose livelihoods are dependent on such areas.

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3. METHODOLOGY

In this study the contribution or impact of Sujala watershed is quantified explicitly by comparing economic performance with (i) non – sujala watershed program and (ii) non-watershed areas. A sample of 30 farmers each was drawn from Sujala watershed, non-Sujala watershed and non-watershed area, totaling 90 (Table A). The data were collected for two cropping years 2004 and 2005, of which 2004 was a drought year and 2005 was a normal year.

The purpose was to analyze the economic performance of Sujala watershed in normal as well as in drought year. While the economic performance of watershed project in normal year is expected, performance in drought year is crucial and hence the comparison over time. The prices of input and output have almost been uniform for both these cropping years in the study area. Recharge of groundwater is a crucial component of watershed impacts. Therefore the impact on farmers who possess irrigation wells and farmers who don't possess irrigation wells is also discerned along with the overall impact of the watershed program.

Table A: Distribution of sample farmers in Sujala watershed, Non-Sujala watershed and Non-watershed Chitradurga district, 2004-05

Sujala watershed Area		Non-Sujala (DPAP) watershed area		Non-Watershed	
Sample village	No. of sample farmers	Sample village	No. of sample farmers	Sample village	No. of sample farmers
Shivanekatte	7	Srirangapura	12	Nagenahalli	15
Sankainahatti	10	Kalkere	18	Honnekere	15
Yalakappanahatti	11				
Chinnapura	2				
Total	30		30		30

In this study the results for drought year are compared with that of normal year across Sujala, non-Sujala and non-watershed areas (using analysis of variance). In the *Veda* river sub-watershed of Sujala watershed in Hosadurga taluk, one micro watershed Sivanekatte -1 with villages Shivanekatte, Sankainahatti, Yalakappanahatti and Chinnapura were selected for detailed study. For the non-Sujala (DPAP) watershed in Hosdurga taluk, Srirangapura and Kalkere were selected for comparison with Sujala watershed to estimate the differential impact. Another sample of 30 farmers from non watershed area in villages Nagenahalli and Honnekere were selected for comparison all totaling 90 farmers for this study.

In order to measure the impact of water harvesting and groundwater recharge with equity implications, primary data were collected with structured pre-tested schedules both for the drought year 2004-05 and normal rainfall year 2005-06. Secondary data from the NGO as well as from Sujala authorities have been collected regarding expenditure on different activities in the watershed (Table B) and thematic maps. Data were analyzed using weighted averages, ratio measures, percentages and proportions. In order to estimate the impact of watershed program on irrigated and rainfed farms, farmers are classified based on those possessing irrigation wells and those not possessing irrigation wells (classified as rainfed).

4. BASIC OUTPUTS

4.1 Per Acre Expenditure of Watershed Program

An investment of Rs.216.84 lac was incurred on the Sujala (veda river bank) sub-watershed during 2002-05 *(*Table B*)*. Major portion was spent on soil and water conservation (Rs. 156.94 lac or 72.37%) followed by drainage line treatment (Rs.35.33 lac or 16.29%), forestry (Rs.9.8 lakh or 4.51%), livestock (Rs.7.11 lac or

3.28%) and horticulture (Rs. 7.09 lac or 3.27%) and demonstration (Rs. 0.57 lac). The total expenditure was Rs. 45.74 lac in Shivanekatte micro watershed treating the total area of 1028 acres. The amortized cost per acre of treated area per year was Rs. 597 considering the differential life of different structures and a social discount rate of 2%, and this is included while calculating the net contribution of the watershed program. Thus all expenditures crop, non-crop and others on watershed program including the amortized cost of watershed program are considered in costing (Table B).

Table B: Amortized cost of watershed treatment in micro watershed Shivanekatte in Veda river bank sub-watershed, Chitradurga district, 2004-05

Sl.No	Particulars	Expenditure (Rs.)
1	Entry point activity	171806.0
2	Soil and water conservation	2564663.0
3	Drainage line treatment	529234.2
4	Forestry	31089.4
5	Horticulture	148761.0
6	Livestock	283850.0
7	Demonstration	52800.0
8	Common land treatment	167484.9
9	Income generating activity	625000.0
10	Total expenditure (Rs.)	4574689.0
11	Area treated (ha)	415.7
12	Compound cost	5576520.0
13	Total amortized cost	620814.6
14	Amortized cost per treatable area in hectares (Rs.)	1493.4
15	Amortized cost per acre of treated area per acre (Rs.)	597.4

Small and marginal farmers formed 66% of the sample in Sujala watershed, 53% in the non-Sujala watershed (DPAP) and 67% of the sample non-watershed area. Medium farmers formed 33% in the non-Sujala watershed (DPAP) 26% in Sujala watershed, 27% in the non-watershed area. Large farmers formed 13% of the sample in Non-Sujala watershed (DPAP), 6% in both Sujala watershed and non-watershed area. The number of farm equipments was higher in the Sujala watershed compared to Non-watershed area. In the Sujala watershed, the total number of bullock carts, tractors and irrigation pump sets in the sample were 11, 4 and 18, while in the non-Sujala watershed (DPAP) they were 10, 3 and 16 respectively. In the non-watershed area, the total number of bullock carts, tractors and irrigation pumpsets were 17, 0 and 8, respectively.

Regarding the livestock of the sample farmers, the total number of local cows, crossbred cows and she-buffaloes were 15, 13 and 22 in the Sujala watershed and 11, 7 and 32 in non-Sujala watershed (DPAP), while it was 9, 7 and 24 in non-watershed area respectively. In the Sujala watershed the total number of oxen, sheep, poultry and goat were 16, 225, 60 and 30 and in non-Sujala watershed (DPAP) they were 20, 150, 37 and 40 while it was 24, 300, 28 and 45 in non-watershed area

4.2 Cropping Pattern

In drought year 2004, Ragi was grown in an area of 49.55 acres in Sujala watershed, 52 acres in non-Sujala and 49.75 acres in non-watershed area, an formed 22.89% of gross cropped area in Sujala watershed and 27.45% in non-watershed area. Sunflower formed 13.16% of gross cropped area in Sujala watershed while it formed 7.61% and 10.34% in non–Sujala watershed (DPAP) and non-watershed area respectively. Sesamum formed 9.79% of gross cropped area in non-watershed area while it was 3.70 and 5.99 per cent in Sujala watershed and non–Sujala watershed (DPAP) respectively. Groundnut formed 6% of gross cropped area and it was 2.84% and 0.55% in non-Sujala watershed (DPAP) and non-watershed area respectively. Green gram contributed to 4.57% of gross cropped area in non–Sujala (DPAP) watershed and 3.17% in non-watershed area, while it was not grown in Sujala watershed.

In *Rabi*, Jowar formed 1.39% of gross cropped area in Sujala watershed while it was 2.48% in non-watershed area. Total *Rabi* crops formed 2.77% of gross cropped area in Sujala watershed which is lower as compared to 4.87% and 6.34% in non-Sujala (DPAP) and non-watershed area.

Arecanut and coconut were major plantation crops in Sujala watershed and formed 8.41% and 30.72% of gross cropped area and coconut formed 41.02% to GCA in non-Sujala (DPAP) and 25.93% in non-watershed area.

4.3 Cropping Pattern fully dependent on Rainfed Agriculture

The major rainfed crops in the area were ragi, groundnut, sesamum, sunflower and jowar in *Kharif*. The proportion of gross cropped area under ragi was comparable in Sujala watershed (36.49%), non-Sujala watershed (34.72%) and non-watershed area (35.22%). Sunflower was the second major crop after Ragi and formed 21% in Sujala watershed which is higher compared to Non-Sujala watershed (DPAP) (12.52%) and non-watershed area (13.27%). Groundnut formed 9.57% of gross cropped area in Sujala watershed and was higher compared to non-Sujala watershed (DPAP) (4.67%) and non-watershed area (0.71%). The proportion of area under Jowar was uniform across different groups i.e. Sujala (9.02%) and non-Sujala watershed (10.18%) and non-watershed area (9.91%). Green gram formed 7.5% of gross cropped area in non-Sujala watershed and 4.07% in non-watershed area while it was not grown in Sujala watershed.

4.4 Watershed Contribution to Groundwater Irrigation

Considering the crop pattern of sample farmers, with groundwater irrigation, in drought year, 2004 the major share of gross irrigated area was by Coconut with 71.87% in Sujala watershed, 78.57% in non- Sujala and 92.5% in non-watershed area. Arecanut formed 22.55%, while it was not grown in non-Sujala watershed (DPAP) and non-watershed area. Other crops which were grown under groundwater irrigation were sunflower, onion, groundnut and chilli in non-Sujala watershed (DPAP) and were not grown in Sujala and non-watershed area in *Rabi*. In summer, crops like brinjal (0.31%) groundnut (2.48%) tomato (0.31%) leafy vegetables (1.24%) and sunflower (1.24%) were cultivated in Sujala watershed. In non-Sujala watershed (DPAP) Groundnut formed 3.06% of gross irrigated area, followed by cotton at 6.12%, and in non-watershed area, onion (7.5% of gross irrigated area). Cropping pattern on those farms with groundwater irrigation and rainfall in normal year 2005 was almost the same as compared to the previous cropping year drought year 2004.

5. RESULTS AND DISCUSSION

5.1 Economics of Crops

In drought year 2004, among rainfed crops, Sujala farmers realized the highest net returns per acre; 129% higher net reruns in Ragi, 110% higher in groundnut, 207% higher in sesamum, 21% in sunflower, 44% higher in green gram and 26% in coconut as compared to non-Sujala watershed (DPAP) farmers while Sujala watershed farmers realized 147% higher net returns in ragi, 288% in groundnut, 327% higher in sesamum, 16% higher in jowar, 211% higher in green gram and 8% higher in coconut compared to non-watershed area farmers. However farmers of non-watershed area realized 30% higher net returns in sunflower from farmers in Sujala watershed area in the cropping year 2004.

Among the irrigated crops in drought year 2004 farmers of Sujala watershed realized higher net returns of 95% in coconut which was almost similar to non-Sujala watershed (DPAP). However, Sujala watershed

Table 1: Economics of crops in watershed programs in Chitradurga district, drought year 2004

(Rs. per Acre)

Crops	Sujala watershed (1)			Non-Sujala watershed (DPAP) (2)			Non-watershed area (3)			Percentage change in Net returns (1 to 2)	Percentage change in Net returns (1 to 3)
	TC	GR	NR	TC	GR	NR	TC	GR	NR		
Rainfed crops											
Ragi	1682	3232	1550	1674	2351	676	2405	3032	628	129.12	147.01
Groundnut	4128	12138	8010	3570	7371	3801	3736	5800	2064	110.72	288.13
Sesamum	1154	7250	6096	2758	4746	1988	2484	3913	1429	206.61	326.72
Sunflower	3216	7472	4256	3045	6571	3525	2682	8729	6047	20.72	-29.62
Jowar	2147	2677	530	1588	2014	426	2049	2505	456	24.29	16.23
Green gram	1820	5000	3180	1821	4022	2201	1535	2558	1024	44.46	210.70
Coconut	3648	6871	3223	3003	5558	2555	3208	6200	2992	26.13	7.69
Irrigated crops											
Groundnut	6725	12083	5359	5593	11392	5799	-	-	-	-7.59	
Cotton	-	-	-	3854	8208	4354					
Coconut	6149	13931	7783	6063	13792	7729	6430	10854	4425	0.69	75.89

Note: TC- Total cost; GR-Gross returns; NR- Net returns

Table 2: Economics of crops in watershed programs in Chitradurga district, normal year 2005

(Rs. per Acre)

Crops	Sujala watershed (1)			Non-Sujala watershed (DPAP) (2)			Non-watershed area (3)			Percentage change in Net returns (1 to 2)	Percentage change in Net returns (1 to 3)
	TC	**GR**	**NR**	**TC**	**GR**	**NR**	**TC**	**GR**	**NR**		
Rainfed crops											
Ragi	1627	4956	3329	1711	3196	1486	2774	3928	1154	124.08	188.48
Groundnut	3299	11323	8025	3591	11329	7738	3858	13800	9942	3.70	-19.28
Sesamum	1391	5474	4082	2654	6347	3692	2554	5513	2959	10.56	37.99
Sunflower	3005	10162	7157	3026	8845	5820	2682	9842	7160	22.98	-0.03
Jowar	2057	3131	1074	2068	2497	429	2217	3071	854	150.27	25.81
Navane	1983	4417	2433	-	-	-	1604	3043	1439		69.06
Horse gram	1865	3077	1212	1383	2308	925	1856	2731	875	31.00	38.53
Green gram	-	-	-	1879	5376	3498	1694	4830	3136		
Coconut	3648	8282	4634	2961	7725	4764	3208	7640	4432	-2.72	4.56
Irrigated crops											
Groundnut	6725	11517	4792	5593	14392	8799	-	-	-	-45.54	
Cotton	-	-	-	3854	10458	6604	-	-	-		
Coconut	6406	16724	10319	6063	13792	7729	6732	12151	5420	33.51	90.39

Note: TC- Total cost; GR-Gross returns; NR- Net returns farmers realized lower net return per acre by 8% in groundnut. They realized 76% higher net returns in coconut as compared to non-watershed farmers (Table 1).

In normal year 2005, among rainfed crops Sujala watershed farmers realized 124% higher net return per acre in Ragi, 4% higher in groundnut, 11% in sesamum, 23% higher in sunflower, 150% higher in jowar and 31% higher in horse gram. However they realized 3% lower net returns in coconut as compared to non-Sujala watershed (DPAP). They realized 189% higher in ragi, 38% higher in Sesamum, 26% higher in jowar, 69% higher in navane, 39% in horse gram and 4.56% in coconut. However they realized 19% lower in Groundnut as compared to non-watershed area (Table 2).

Among irrigated crops in normal year 2005, Sujala watershed farmers realized higher net return of 90% in coconut as compared to non- watershed; and 33% in coconut as compared to non-Sujala watershed (DPAP) farmers. However they realized lower net return per acre by 45% in groundnut. Non-Sujala watershed (DPAP) farmers realized net return per acre of Rs. 6,604 from cotton, which was not cultivated in Sujala watershed and non-watershed area (Table 2).

5.2 Well Irrigation Benefits

It was observed that 11 farmers (37%) owned irrigation wells in Sujala watershed, 10 farmers (33%) in non-Sujala watershed (DPAP) and eight farmers (27%) in non-watershed area.

The net irrigated area of sample farmers was higher in non-Sujala watershed (DPAP) (57.5 acres) by 21% as compared to Sujala watershed (45.35 acres) and the same was higher by 111% compared to non-watershed area. Gross irrigated area among sample farmers was higher in non-watershed area (96 acres, 13%) as compared to Sujala watershed (83.45 acres, 109%) and non-watershed area (40 acres). However the gross irrigated area per farm was lower in Sujala watershed (4.64 acres), lower by 23% as compared to non-Sujala watershed (DPAP) (6.0 acres) and 7% as compared to non-watershed area (5.0 acres).

Groundwater pumping per well in Sujala watershed was 50.08 acre-inch, lower by 21% compared to Non-Sujala watershed (DPAP) (69.94 acre inch) and higher by 4% when compared to non-watershed area (53 acre-inch). Net return per rupee of irrigation cost was Rs. 3.9 in Sujala watershed lower by 2% as compared to Non-Sujala watershed (DPAP) (Rs. 3.98). It was higher by 1.2% as compared to non-watershed area (Table 3). Amortized cost per well was lower by 6.5% in Sujala watershed (Rs. 6,818) and is almost the same in non-watershed area (Rs. 6,856). However amortized cost per functioning well in Sujala watershed (Rs. 9,470) was lower by 5.5% as compared to non-Sujala watershed (DPAP) (Rs. 10,027) and lower by 15% as compared to non-watershed area (Rs. 11,140). The annual externality cost was lower by 38% in Sujala watershed (Rs. 2,654) compared to Non-watershed area (Rs. 4,285) and lower by 3% as compared to non-Sujala (DPAP) watershed (Rs. 2,735) (Table 3).

5.2.1 Irrigation benefit for farmers not possessing irrigation wells but having water harvesting structures

Out of 19 sample farmers, small and marginal farmers (< 5 acres) formed 89.5%; medium farmers (5 to 10 acres) formed 10.5% of the total sample in Sujala watershed. Total expenditure per farm was higher for medium farmers (Rs. 14,948) compared to small and marginal farmers (Rs. 8,149). However, the total expenditure per acre of gross cropped area was higher for small and marginal farmers (Rs. 2,796) compared to medium farmers (Rs. 1,708). Considering the net return from rainfed crops, medium farmers realized higher net returns per farm (Rs. 41,386) compared to small and marginal farmers (Rs. 7,948). The net return per acre of gross cropped area was higher for medium farmers (Rs. 4,730) compared to small and marginal farmers (Rs. 2,727). However, incremental net return per rupee of public investment is higher for small and marginal farmers (Rs. 2.52) compared to medium farmers (Rs. 0.47). The overall net return per rupee of public investment worked to be Rs. 1.95 (Table 4).

5.2.2 Distribution of benefits among land holding classes

In Sujala watershed, small and marginal farmers formed 27.3%, medium farmers formed 54.5% and large farmers formed 18.2% of the farmers possessing irrigation wells and watershed structures. Total

Table 3: Particulars of groundwater resources in watershed programs in Chitradurga district, normal year 2005

Sl. No	Particulars	Sujala watershed	Non-Sujala watershed (DPAP)	Non-watershed area	Percentage change (Sujala to Non-Sujala watershed (DPAP))	Percentage change (Sujala to Non- water-shed area)
1	Groundwater extracted per farm (acre-inch)	90.12	111.43	52.99	-19.12	70.06
2	Groundwater extracted per well (acre-inch)	55.08	69.64	52.99	-20.92	3.93
3	Number of sample farmers owned functioning wells	11	10	8	10	37.50
4	Per cent of farmers owning wells	36.67	33.33	26.67	10	37.50
5	Number of functioning wells	18	16	8	12.5	125.00
6	Net irrigated area (acre)	45.35	57.50	21.50	-21.13	110.93
7	Net irrigated area per functioning well (acre)	2.52	3.59	2.69	-29.89	-6.25
8	Gross irrigated area (acre)	83.45	96.00	40.00	-13.07	108.63
9	Gross irrigated area per functioning well (acre)	4.64	6.00	5.00	-22.73	-7.28
10	Gross irrigated area per farm (acre)	7.59	9.60	5.00	-20.98	51.73
11	Irrigation intensity (per cent)	184	167	186	10.22	-1.09
12	Groundwater used per acre of gross irrigated area (acre inch)	11.88	11.61	10.60	2.35	12.08
13	Irrigation cost per acre inch of groundwater used (Rs.)	125	117	138	7.48	-8.98
14	Net returns per farm (Rs.)	44265	51992	28246	-14.86	56.71
15	Net returns per acre inch of groundwater used (Rs.)	491	466	533	5.27	-7.85
16	Net returns per acre of gross irrigated area (Rs.)	5834	5415	5649	7.74	3.28
17	Net returns per acre of net irrigated area (Rs.)	10737	9042	10510	18.74	2.16
18	Net returns per rupee of irrigation cost (ratio)	3.90	3.98	3.85	-2.06	1.24
19	Amortized cost per well (Rs.)	6818	7292	6856	-6.50	-0.54
20	Amortized cost per functioning well (Rs.)	9470	10027	11140	-5.55	-14.99
21	Annual externality cost (Rs.)	2652	2735	4285	-3.04	-38.11
22	Amortized cost per well (Rs.)	6818	7292	6856	-6.50	-0.54

Note: Net returns per rupee of irrigation cost was derived to compare the net return per acre-inch of groundwater used with irrigation cost per acre-inch of groundwater (net return per acre-inch of groundwater used/ irrigation cost per acre-inch of groundwater) expenditure on Sujala watershed structures per farm is higher for large farms (Rs. 3, 02,221) compared to small and marginal farms (Rs. 9,596) and medium farms (Rs. 19,650). However, expenditure per gross cropped area is higher for small farms (Rs. 1,745) compared to medium farms (Rs. 1,456) and large farms (Rs. 836).

Table 4: Benefits accrued to sample Sujala farmers not possessing irrigation wells but having water harvesting structures in Chitradurga district, normal year 2005

Sl. No	Particulars	Small and marginal farmers	Medium Farmers	Overall
1.	No. of farmers in each category	17	2	19
2.	Size of holding per farm (acre)	2.7	8.5	3.3
3.	No. of water harvest structures per farm	1.6	2.0	1.7
4.	Water harvest structures constructed on the farm	Earthen bund, boulder outlet, boulder bund, farm pond, strengthening of existing bund, boulder bund repair	Earthen bund, boulder outlet, boulder bund, farm pond,	Earthen Bund, boulder outlet, boulder bund, farm pond, strengthening of existing bund, boulder bund repair
5.	Total expenditure on water harvest structure on sample farms (Rs)	138532	29895	168427
6.	Sujala Expenditure per farm (Rs)	8149	14948	8865
7.	Sujala expenditure per water harvest structure (Rs)	4948	7474	5263
8.	Sujala Expenditure per acre of gross cropped area (Rs)	2796	1708	2512
9.	Gross cropped area per farm (acre)	2.91	8.75	3.53
10.	Net return from rainfed crops per farm (Rs)	7948	41386	11468
11.	Net return from rainfed crops per acre of Sujala Gross cropped area (Rs)	2727	4730	3250
12.	Incremental net return per acre of gross cropped area in Sujala over non-watershed area (Rs)	7048	796	4907
13.	Net return per rupee of Sujala expenditure(12/8) (Rs)	2.52	0.47	1.95

Medium farms realized higher net return from irrigation per farm (Rs. 84,777) compared to large farms (Rs. 65,156) and small and marginal farms (Rs. 12,153). Net returns per acre of gross irrigated area was higher for medium farms (Rs. 6,280) compared to small and marginal farmers (Rs. 2,210) and medium farmers (Rs. 1,802). Considering the net return per rupee of amortized cost of irrigation, medium farmers realized higher net returns (Rs. 8.8) and were same for small and large farms (Rs 2.5). The net return from irrigation per rupee of Sujala expenditure on watershed structure was higher in medium farms (Rs.4.3) than small farms (Rs.1.3) and large farms (Rs.2.2). Considering the incremental net return per rupee of expenditure on watershed structures, medium farmers (Rs. 3.7) realized higher net return compared to large farms (Rs. 2.6) and small and marginal farms (Rs. 1.5) (Table 5).

Table 5: Benefits accrued to Sujala sample farmers possessing irrigation wells and water harvesting structures in Chitradurga district, normal year 2005

Sl. No	Particulars	Small and marginal farmers	Medium farmers	Large farmers	overall
1.	Number of farmers in each category	3	6	2	11
2.	Total number of wells	6	10	9	25
3.	Number of functioning wells	3	8	8	19
4.	Number of non functioning wells	3	2	1	6
5.	Size of holding per farm (acre)	4.7	8.5	23.0	10.1
6.	Number water harvesting structures per farm	1.7	2.2	3.0	2.2
7.	Total expenditure on water harvest structure (Rs.)	28789	117898	60442	207129
8.	Expenditure per farm (Rs.)	9596	19650	30221	18830
9.	Expenditure per water harvest structure (Rs.)	5758	9069	10074	8630
10.	Expenditure per acre of gross cropped area (Rs.)	1745	1456	836	1220
11.	Gross cropped area per farm (acre)	5.5	13.5	36.2	15.4
12.	Net returns from irrigated crops per farm (Rs.)	12153	84777	65156	61403
13.	Net returns from irrigated per acre of Gross irrigated area (Rs.)	2210	6280	1802	3978
14.	Net return per acre inch of groundwater (Rs.)	783	1504	215	681
15.	Net return per rupee of amortized groundwater irrig-ationcost (Rs.)(= NRs per Rupee of private investment)	2.5	8.8	2.5	5.4
16.	Net returns from irrigation per rupee of expenditure on water harvesting structures (Rs.) (=NRs per rupee of public or Sujala investment)	1.3	4.3	2.2	3.3
17.	Net returns from rainfed crops per farm (Rs.)	7201	34930	83582	36213
18.	Net returns from rainfed crops per acre of Gross cropped area (Rs.)	1309	2587	2312	2346
19.	Incremental net returns per acre of gross cropped in Sujala over non-watershed area (Rs.)	2640	5407	2159	3808
20.	Synergistic role of Sujala WDP (=19-18)	1331	2820	-153	1462
21.	Net returns per rupee of expenditure on all watershed structure (Rs.) = (19 /10)	1.5	3.7	2.6	3.1

Note: Synergistic role of Sujala WDP = Incremental net returns per acre of gross cropped area over non-watershed area (Rs.) - Net returns from rainfed crops per acre of gross cropped area (Rs.)
Net returns per rupee of expenditure on all watershed structures= Incremental net returns per acre of gross cropped area in Sujala over non-watershed area (Rs.) - Expenditure per acre of gross cropped area in Sujala (Rs.); *NR: Net returns*

5.3 Incremental Net Return due to Sujala Watershed in Drought Year, 2004

This analysis on incremental net return due to Sujala watershed pertains to a drought year. With this backdrop, the incremental return in Sujala watershed has been positive for the sample farmers who do not possess irrigation wells. However, barring the medium farmers, for all sample farmers possessing irrigation wells, the incremental net return per acre is negative. This is because, in Sujala watershed, arecanut is still in establishment stage. Once arecanut crop begins bearing, this difference would be positive. When the incremental net return is computed between Sujala watershed and non watershed area, it turns out to be positive for sample farmers possessing irrigation wells as well as for those who are totally dependent on rainfall. Here too, the incremental returns are relatively higher for farmers not possessing irrigation wells than for farmers not possessing irrigation wells. This reiterates that Sujala watershed program has contributed substantially for farmers who are totally dependent on rainfall compared with those farmers who are dependent on irrigation wells (Table 6).

Table 6: Incremental net returns due to Sujala watershed over Non- Sujala watershed area and Non-watershed area in Chitradurga District, drought year 2004

Type of farm	Sujala WDP over Non -Sujala (DPAP) WDP = Rs. 8375 -Rs. 5689 = Rs. 2686		Sujala WDP over Non-watershed area = Rs. 8375 – Rs. 5309 = Rs. 3066	
	For sample farmers possessing irrigation wells	For sample farmers not possessing irrigation wells	For sample farmers possessing not possessing	For sample farmers irrigation wells irrigation wells
Small and marginal farmers	-3782	5863	3618	7714
Medium farmers	2184	7765	3461	6739
Large farmers	-1672	NA	1195	NA
Overall	-65	7798	614	7354

Note: NA: There were no large farmers in the sample not possessing irrigation wells
Incremental net return in Sujala over Non-Sujala watershed = net return per acre from all sources in Sujala minus that in Non-Sujala watershed Incremental net return in Sujala over Non- watershed = net return per acre from all sources in Sujala minus that in non-watershed area

5.4 Net Return per Farm from Different Sources in Normal Year, 2005

Considering net returns per acre of net cropped area realized from all the sources in normal year 2005, in Sujala watershed, small and marginal farmers and medium farmers with irrigation wells realized higher return of Rs. 8,693and Rs. 13,081 respectively as compared to large farmers (Rs. 7,536). Small and marginal farmers without irrigation wells realized a net return (Rs. 12,922) higher than medium farmers (Rs. 9,848). The overall net return per acre of net cropped area for sample farmers without irrigation wells (Rs. 12,203) was higher than that of sample farmers with irrigation wells (Rs. 7,199) (Table 9)**,** since Sujala program amply supported these farmers through wage employment to a large extent and through income generating activity to some extent. The wage employment was the single largest contributor forming 38% of the net return per farm here (Table 7).

Those farmers not possessing irrigation wells in Non-watershed area in normal year 2005 are realizing a net return of Rs. 6,094 per acre while those possessing irrigation wells are realizing a net return of Rs. 5,370. Farmers not possessing irrigation wells realized 52% of their income from wage employment and livestock while those possessing irrigation wells realized only 13% of their income from livestock and wage employment. They realized the remaining 87% from agriculture and horticulture (Table 9).

5.5 Incremental Net Return due to Sujala Watershed in Normal Year, 2005

The incremental net return due to Sujala watershed in good rainfall year (normal year 2005) was positive for the sample farmers who should not possess irrigation wells in comparison to non-Sujala watershed (DPAP).

In the Non-Sujala (DPAP) watershed in good rainfall year (normal year 2005), the overall net return per acre for sample farmers possessing irrigation wells was Rs. 10,787 per acre it is higher than that obtained by sample farmers not possessing irrigation wells being Rs. 5,245 per acre. The contribution of wage employment in DPAP is substantial being 31% for sample farmers without irrigation wells. For the farmers with irrigation, 93% of their net return was from agriculture and horticulture. Medium farmers realized lower net return per acre (Rs. 8,018) as compared to small and marginal farmers (Rs. 13,438) and large farmers (Rs. 10,998). Similar results were observed for farmers without irrigation wells, wherein small and marginal farmers realized Rs. 8,629 which is higher that obtained by medium farmers (Rs. 3,179) (Table8).

Table 7: Net returns per farm from different sources in Sujala Watershed in Chitradurga district, normal year 2005 *(Rupees)*

Sources of net returns	Sample total							NR per NCA	per farm
	Agriculture	Horticulture	Livestock	Income Generating Activities	Wage employment	Sum of net returns	NCA		
For sample farmers possessing irrigation wells									
Small and marginal farmers (3)	58062 (46)	0 (0)	23180 (18)	4800 (4)	40000 (32)	126042	14.5	8693	42014
Medium farmers (6)	547125 (67)	171117 (21)	64800 (8)	0 (0)	28000 (3)	811042	62	13081	135174
Large farmers (2)	169352 (41)	108123 (26)	13490 (3)	125000 (30)	0 (0)	415965	55.2	7536	217983
Overall (11)	774540 (56)	299240 (22)	101470 (7)	129800 (9)	68000 (5)	1373050	131.7	10426	124823
For sample farmers not possessing irrigation wells									
Small and marginal farmers (17)	119799 (20)	15317 (3)	166270 (28)	55200 (9)	241680 (40)	598266	46.3	12922	35192
Medium farmers (2)	78392 (66)	4379 (4)	6020 (5)	0 (0)	30000 (25)	118791	16.5	7199	59396
Overall (19)	198192 (28)	19696 (3)	172290 (24)	55200 (8)	271680 (38)	717057	62.8	11418	37740
Overall Net returns per acre from all sources considering irrigated and rainfed condition from agriculture, horticulture, livestock and wage employment and income generating activities in Sujala watershed= (1373050+717057)/(131.7+62.8)=10746									

Note: NCA: Gross cropped area, NR: Net returns, Figures in the parentheses indicate percentage to the respective total

Table 8: Net returns per farm from different sources in Non- Sujala Watershed in Chitradurga district, normal year 2005 (Rupees)

Sources of net returns	Sample total							NR per NCA	per farm
	Agriculture	Horticul-ture	Livestock	Income Generating Activities	Wage employment	Sum of net returns	NCA		
For sample farmers possessing irrigation wells									
Small and marginal farmers (3)	137368 (68)	42999 (21)	21200 (11)	0 (0)	0 (0)	201567	15	13438	67189
Medium farmers (3)	62922 (38)	77351 (47)	24100 (15)	0 (0)	0 (0)	164373	20.5	8018	54791
Large farmers (4)	662079 (75)	177214 (20)	46030 (5)	0 (0)	0 (0)	885323	80.5	10998	221331
Overall (10)	862369 (69)	297564 (24)	91330 (7)	0 (0)	0 (0)	1251263	116	10787	124975
For sample farmers not possessing irrigation wells									
Small and marginal farmers (13)	83478 (26)	20721 (6)	58540 (18)	0 (0)	158700 (49)	321439	37.25	8629	24726
Medium farmers (7)	124376 (64)	36447 (19)	25900 (13)	7200 (4)	0 (0)	193922	61	3179	29132
Overall (20)	207853 (40)	57168 (11)	84440 (16)	7200 (1)	158700 (31)	515361	98.25	5245	26268
Overall net returns per acre from all sources considering Irrigated and Rainfed condition from agriculture, horticulture, livestock wage employment and income generating activities in Non-Sujala watershed (DPAP)= (1251263+515361)/116+98.25)=8246									

Note: NCA: Gross cropped area, NR: Net returns, Figures in the parentheses indicate percentage to the respective total

Table 9: Net returns per farm from different sources in Non- Watershed area in Chitradurga district, normal year, 2005 *(Rupees)*

Sources of net returns	Sample total							NR per NCA	per farm
	Agriculture	Horticulture	Livestock	Income Generating Activities	Wage employment	Sum of net returns	NCA		
For sample farmers possessing irrigation wells									
Small and marginal farmers (1)	20860 (64)	5483 (17)	6150 (19)	0 (0)	0 (0)	32493	5.5	5908	32493
Medium farmers (5)	147244 (61)	60241 (25)	34330 (14)	0 (0)	0 (0)	241815	41	5898	48363
Large farmers (2)	70158 (61)	34538 (30)	10330 (9)	0 (0)	0 (0)	115026	26	4424	57513
Overall (8)	238261 (61)	100262 (26)	50810 (13)	0 (0)	0 (0)	389334	72.5	5370	48667
For sample farmers not possessing irrigation wells									
Small and marginal farmers (19)	176257 (44)	15610 (4)	104470 (26)	0 (0)	104470 (26)	400807	75.75	5291	24081
Medium farmers (3)	77126 (66)	6552 (6)	23170 (20)	0 (0)	10000 (9)	116847	18.5	6316	38949
Overall (22)	253382 (44)	22162 (4)	127640 (22)	0 (0)	171200 (30)	574384	94.25	6094	26108
Overall Net returns per acre from all sources considering Irrigated and Rainfed condition from agriculture, horticulture, livestock wage employment and income generating activities in Non watershed= (389334+574384)/(72.5+94.25)=5779									

Note: NCA: Gross cropped area, NR: Net returns, Figures in the parentheses indicate percentage to the respective total

When the incremental net return was computed between Sujala watershed and non-watershed area, it turns to be positive for sample farmers possessing irrigation wells as well as for those who are totally dependent on rainfall. Here too, the incremental returns were relatively higher for farmers possessing irrigation wells (Rs.5, 326) than for farmers not possessing irrigation wells (Rs. 5,056). This reiterates that Sujala watershed program has contributed substantially for farmers who are totally dependent on rainfall as compared to those farmers who are dependent on irrigation wells (Table10).

Table 10: Incremental net returns in Sujala watershed over Non- Sujala (DPAP) watershed area and Non-watershed area in Chitradurga District, normal year, 2005

Type of farm	Sujala WDP over Non -Sujala (DPAP) WDP = Rs. 10746 –Rs. 8246 = Rs. 2500		Sujala WDP over Non-watershed area = Rs. 10746 –Rs. 5779 = Rs. 4967	
	sample farmers possessing irrigation wells	sample farmers not possessing irrigation wells	sample farmers possessing not possessing	sample farmers irrigation wells irrigation wells
Small and marginal farmers	-4745	4292	2785	7630
Medium farmers	5063	4020	7183	883
Large farmers	-3462	NA	3112	NA
Overall	-361	6173	5056	5326

NA: There were no large farmers in the sample not possessing irrigation wells

5.6 Contribution of Watershed Program for Farmers not Possessing Irrigation Wells

Farmers who are totally dependent on rainfall and not possessing irrigation wells form an important class of beneficiaries in a watershed program. They are far more exposed to the vagaries of weather and market uncertainties. The contribution of Sujala watershed program for these farmers totally dependent on rainfall is thus a serious equity issue, since these farmers with relatively low endowment, will have been benefited the most, compared with farmers who have irrigation wells. The contribution of Sujala and non-Sujala (DPAP) watershed in a drought year (2004) as well as in a normal rainfall year (2005) for these farmers was therefore estimated using the net returns (as enunciated in Table11).

The estimated contribution of watershed institutions and community participation in the drought year (2004) as well as in normal rainfall year (2005) for farmers totally dependent on rainfed agriculture was Rs. 7,798 and Rs. 6,173 respectively. The overall contribution of Sujala watershed program to farmers totally dependent was Rs. 7,354 in the drought year (2004) and Rs. 5,324 in the normal rainfall year (2005). Thus, Sujala watershed program has greatly benefited the farmers dependent on rainfall.

In corroboration of these findings, the ANOVA performed by comparing the net returns per acre for farmers dependent on rainfall in a drought year (2004) as well as in normal rainfall year (2005) in Sujala watershed, non-Sujala watershed and non-watershed were, indicated that the net returns per acre from all sources for farmers totally dependent on rainfall in Sujala watershed were significantly higher than those in non-Sujala (DPAP) watershed and in non-watershed area. Thus, the contribution of Sujala watershed to farmers totally dependent on rainfall is both statistically and economically significant.

Table 11: Estimated contribution of Sujala watershed development program exclusively for farmers who totally depend on rainfed agriculture (and not possessing irrigation wells) in Veda river bank in Chitradurga district, 2004-05 (Rs per acre)

Sl.No	Particulars	Drought year (2004)	Normal rainfall year (2005)
1	Contribution of (Non-Sujala) DPAP Watershed program (= net returns in Non-Sujala WDP minus net returns in Non-watershed area)	(= 4405 - 4849) = - 444	(= 5245- 6094) = - 849
2	Contribution of Watershed institutions and community participation (= net returns in Sujala minus Net returns in Non-Sujala WDP)	(=12203- 4405) = 7798	(=11418- 5245) = 6173
3	Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area)= (1) + (2)	(= 12203- 4849) = 7354	(=11418-6094) = 5324

5.7 Contribution of Watershed Program for Farmers Possessing Irrigation Wells

Considering the contribution of watershed program for farmers possessing irrigation wells, the results indicated that the contribution of Non-Sujala (DPAP) watershed on the farmers possessing irrigation wells is Rs. 680 in a drought year (2004) while it rose to Rs. 5,417 in a normal rainfall year (2005). However, the role of Sujala watershed institutions and community participation in watershed program is negative in 2004 and 2005 indicating that the institutions have to have different and better strategies exclusively for farmers possessing irrigation wells. This does not mean that watershed institutions and community participation haven't performed well. The watershed institutions and community participation in watershed program have done their best in augmenting incomes of those depending totally on rainfed farming. Their role in augmenting incomes of those having wells has to improve. Discerning the contribution of Sujala watershed program, it is apparent that the overall contribution of Sujala watershed program to farmers possessing irrigation wells is Rs. 614 per acre in a drought year (2004) and Rs. 5,056 per acre in normal rainfall year. Thus, the contribution of Sujala watershed as well as non-Sujala (DPAP) watershed is uniform for the farmers possessing irrigation wells (Table12).

While considering whether the net returns per acre for farmers possessing irrigation wells in Sujala and non-Sujala watershed are different from that of the control area through ANOVA, it was found that these net returns per acre are not statistically significantly different. However, this result is not true for the farmers totally dependent on rainfall as already discussed. Thus, while the contribution of Sujala watershed program is statistically significant for farmers not possessing irrigation wells, it is not statistically significant for farmers possessing irrigation wells.

Table 12: Estimated contribution of Sujala watershed development program exclusively for farmers who are possessing irrigation wells in Veda river bank in Chitradurga district, 2004-05 (Rs per acre)

Sl.No	Particulars	Drought year (2004)	Normal rainfall year (2005)
1	Contribution of (Non-Sujala) DPAP Watershed program (= net returns in Non-Sujala WDP minus net returns in Non-watershed area)	(= 6615- 5935) = 680	(= 10787- 5370) = 5417
2	Contribution of Watershed institutions and community participation (= net returns in Sujala minus Net returns in Non-Sujala WDP)	(=6549- 6615) = -66	(=10426 - 10787) = -361
3	Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area)= (1) + (2)	(= 6549- 5935) = 614	(=10426 -5370) = 5056

5.8 Overall Contribution of Watershed Program for Farmers Dependent on Rainfall as well as for Farmers Possessing Irrigation Wells

Considering the overall contribution of non-Sujala (DPAP) watershed on farmers possessing irrigation wells and those not possessing irrigation wells was Rs. 380 per acre in a drought year (2004) and Rs. 2,467 per acre in a normal rainfall year (2005). The contributions of the Sujala watershed institutions and the community in a drought year was Rs. 2686 per acre and in a good year was Rs. 2500 per acre. For farmers, the contribution of watershed institutions and the community was not only uniform irrespective of the agro-climatic conditions, but also higher than the contributions of non-Sujala (DPAP) watershed program (Table 13).

Table 13: Estimated contribution of Sujala watershed development program in Veda riverbank in Chitradurga district, 2004-05 (Rs per acre)

Sl.No	Particulars	Drought year (2004)	Normal rainfall year (2005)
1	Contribution of (Non-Sujala) DPAP Watershed program (= net returns in Non-Sujala WDP minus net returns in Non-watershed area)	(= 5689- 5309) = 380	(= 8246-5779) = 2467
2	Contribution of Watershed institutions and community participation (= net returns in Sujala minus Net returns in Non-Sujala WDP)	(=8375-5689) = 2686	(=10746-8246) = 2500
3	Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area)= (1) + (2)	(=8375-5309) = 3066	(=10746-5779) = 4967

The contribution of Sujala watershed program in a normal rainfall year (2005) was Rs. 4967/acre. This is higher than the contribution of Sujala watershed program in a drought year (2004) (Rs. 3066/acre). Thus, the contributions of Sujala watershed program in both good and drought years are higher than the contributions of Non-Sujala (DPAP) watershed as well as the contributions of Sujala watershed institutions and community participation. Upon performing ANOVA, it was found that the net returns per acre from all sources in Sujala watershed is significantly different from that in non-watershed area in a drought year (2004) as well as in a good year (2005). Thus, the overall contribution of Sujala watershed program to farmers not possessing irrigation wells as well as farmers possessing irrigation wells is statistically significant.

5.9 Contribution of Watershed Program for Farmers Possessing Irrigation Wells

The economic contribution in terms of incremental net returns per acre, which is exclusive of income from wage employment and which considers watershed expenditure in (i) Sujala over non-watershed area (in drought year, normal year) to be as contribution of Sujala watershed is Rs. 1726, Rs. 3650; (ii) Sujala over non-Sujala (DPAP) watershed to be equal to the contribution of Sujala watershed institutions and community participation is Rs. 1067, Rs. 898; (iii) Non Sujala (DPAP) over non-watershed area, as contribution of Non-Sujala or DPAP watershed was Rs. 133 and Rs. 2226. This indicates the economic supremacy of Sujala watershed program (Table 14).

The economic contribution in terms of incremental net returns per acre without deducting watershed expenditure, including wage income in (i) Sujala over non-watershed area in drought year, normal year was Rs. 3066 and Rs. 4967 respectively; (ii) Sujala over non-Sujala (DPAP) watershed is Rs. 2686 and Rs.2500; (iii) Non Sujala (DPAP) over non-watershed area was Rs. 380 and Rs. 2467) (Table 15).

The economic contribution in terms of incremental net returns per acre after adding watershed expenditure, adding wage income in (i) Sujala over non-watershed area (in drought year, normal year) is Rs. 2469 and Rs. 4370; (ii) Sujala over non-Sujala (DPAP) watershed is Rs. 2089 and Rs. 1903; (iii) Non Sujala (DPAP) over non-watershed area was Rs. 146 and Rs. 1941 (Table 16).

The economic contribution in terms of incremental net returns per acre excluding income from wage employment, exclusive of watershed expenditure in (i) Sujala over non-watershed area (in drought year, normal year) was Rs. 2323 and Rs. 4247; (ii) Sujala over non-Sujala (DPAP) watershed was Rs. 1664 and Rs. 1495; (iii) Non Sujala (DPAP) over non-watershed area was Rs. 659, Rs. 2752 (Table 17).

Table 14: Estimated contribution of watershed development program in Chitradurga district, 2004-05 (Excluding income from wage employment and adding watershed expenditure) (Rs per acre)

Sl. No	Particulars	Drought year 2004	Normal year 2005
1	Contribution of (Non-Sujala) DPAP Watershed program(= net returns in Non-Sujala WDP minus net returns in Non-watershed area)	(= 4877 - 526- 4218) = 133	(= 7505 – 526 - 4753) = 2226
2	Contribution of Watershed institution and community participation (=net returns in Sujala minus NRs in Non-Sujala WDP)	(=6541 – 597 - 4877) = 1067	(=9000 - 597-7505) = 898
3	Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non-watershed area)= (1) + (2)	(=6541 - 597 -4218) = 1726	(=9000 - 597 -4753) = 3650
4	Effect of rainfall on (Non-Sujala) Watershed program =(contribution of NS watershed in normal year 2005 minus contribution of NS watershed in drought year 2004)	(=2226 - 133) = 2093	
5	Effect of rainfall on Watershed institution and community participation (=contribution of watershed institution and community participation in normal year 2005 minus contribution of watershed institution and community participation in drought year 2004)	(=898 - 1067) = -169	
6	Effect of rainfall on Sujala Watershed (= contribution of Sujala watershed in normal year 2005 minus contribution of Sujala watershed in drought year 2004 is also equal to (4) + (5)	(=3650 - 1726) = 1924	
7	Net contribution of non Sujala (DPAP) watershed	= 2226 - 2093= Rs. 133	
8	Net contribution of Sujala watershed	Rs. 3650 – Rs. 1924 = Rs. 1726	

Table 15: Contribution of Sujala watershed development program, in Veda river bank in Chitradurga district, 2004-05 (Without deducting watershed expenditure, adding wage income) (Rs per acre)

Sl. No	Particulars	Drought year 2004	Normal year 2005
1	Contribution of (Non-Sujala) DPAP Watershed program(= net returns in Non-Sujala or DPAP WDP minus net returns in Non-watershed area)	(= 5689- 5309) = 380	(= 8246-5779) = 2467
2	Contribution of Watershed institution and community participation (=net returns in Sujala minus NRs in Non-Sujala WDP)	(=8375-5689) = 2686	(=10746-8246) = 2500
3	Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area) = (1) + (2)	(=8375-5309) = 3066	(=10746-5779) = 4967
4	Effect of rainfall on (Non-Sujala or DPAP) Watershed program = (contribution of NS watershed in normal year minus contribution of NS watershed in drought year)	(=2467 - 380) = 2087	
5	Effect of rainfall on Watershed institution and community participation (=contribution of watershed institution and community participation in normal year minus contribution of watershed institution and community participation in drought year)	(=2500- 2686) = -186	
6	Effective of rainfall on Sujala Watershed (= contribution of Sujala watershed in normal year minus contribution of Sujala watershed in drought year, is also equal to (4) + (5)	(=4967- 3066) = 1901	
7	Net contribution of non Sujala (DPAP) watershed	= 2467-2087 = Rs.380	
8	Net contribution of Sujala watershed	(4967 – 1901) = 3066	

Table 16: Estimated contribution of watershed, institutions and rainfall in Veda river bank in Chitradurga district, 2004-05 (after adding watershed expenditure, adding wage income) (Rs per acre).

Sl. No	Particulars	Drought year 2004	Normal year 2005
1	Contribution of (non-Sujala) or DPAP Watershed program (= net returns in Non-Sujala WDP minus net returns in Non-watershed area)	(5689 - 526-5309) = -146	(=8246 -526 -5779) = 1941
2	Contribution of Watershed institution and community participation (=net returns in Sujala minus NRs in Non -Sujala or DPAP WDP)	(=8375-597-5689) = 2089	(=10746–597-8246) = 1903
3	Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area)= (1) + (2)	(=8375-597-5309) = 2469	(=10746-597-5779) = 4370
4	Effect of rainfall on (Non-Sujala) Watershed program = (contribution of NS watershed in 2005 minus contribution of NS watershed in 2004)	= [1941-(- 146)] = 2087	
5	Effect of rainfall on Watershed institution and community participation (=contribution of watershed institution and community participation in 2005 minus contribution of watershed institution and community participation in 2004)	(= 1903 - 2089) = - 186	
6	Effect of rainfall on Sujala Watershed (= contribution of sujala watershed in 2005 minus contribution of sujala watershed in 2004 is also equal to (4) + (5)	(= 4370 - 2467) = 1901	

Note: 2004 - drought year. 2005 - good rainfall year; Expenditure in Sujala watershed programme = Rs 597 per acre; *Expenditure in Non-Sujala (DPAP) watershed programme = Rs 526 per acre, ;*

Table 17: Estimated contribution of watershed development program in Chitradurga district, 2004-05 (Excluding income from wage employment and without deducting watershed expenditure) (Rs. per acre)

Sl. No	Particulars	Drought year 2004	Normal year 2005
1	Contribution of Non-Sujala (DPAP)Watershed program(= net returns in Non-Sujala (DPAP) WDP minus net returns in Non-watershed area)	(= 4877- 4218) = 659	(= 7505-4753) = 2752
2	Contribution of Watershed institution and community participation (=net returns in Sujala minus NRs in Non-Sujala (DPAP) WDP)	(=6541-4877) = 1664	(=9000-7505) = 1495
3	Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area) = (1) + (2)	(=6541-4218) = 2323	(=9000-4753) = 4247
4	Effect of rainfall on (Non-Sujala) Watershed program = (contribution of NS watershed in normal year 2005 minus contribution of NS watershed in drought year 2004)	(=2752 - 659) = 2093	
5	Effect of rainfall on Watershed institution and community participation (=contribution of watershed institution and community participation in normal year 2005 minus contribution of watershed institution and community participation in drought year 2004)	(=1495- 1664)= -169	
6	Effect of rainfall on Sujala Watershed (= contribution of Sujala watershed in normal year 2005 minus contribution of Sujala watershed in drought year 2004 is also equal to (4) + (5)	(=4247- 2323) = 1924	
7	Net contribution of non Sujala (DPAP) watershed	= 2752-2093 = 659	
8	Net contribution of Sujala watershed	(4247–1924) = 2323	

The net return per acre is hypothesized to reflect the quintessence of farm efficiency in using the resources and opportunities optimally. Considering small and marginal, medium and large farmers together, the net return in Sujala is Rs. 10,426 per acre. For small and marginal farmers, net return is Rs. 8,693 and for medium farmers, net return is Rs.13, 081. For Large farmers, net return is Rs 7,536 per acre. These are the direct impacts of Sujala on farmers possessing irrigation wells. For these farmers, 56% of the net return was obtained from the cultivation of crops or agriculture, 22% from horticulture, and 9% from income generating activities, 7% from livestock and 5% from wage employment.

5.10 Economic Impact on Rainfed Farmers

For farmers who are totally dependent on rainfall, small, marginal and medium farmers together in Sujala, the net return per acre was estimated to be Rs. 11418. For small and marginal farmers, the net return was Rs. 12922 and medium farmers Rs.7199. Considering both rainfed and irrigated condition the overall net return per acre from all the sources was Rs. 10746. For rainfed farmers, 28% of the net returns were from cultivation of field crops, 3% from horticulture, 24% from livestock, 8% from income generating activities and 38% from wage income.

Considering small and marginal, medium and large farmers with irrigation in non watershed area, the net return per acre was Rs.5370 per acre, for small and marginal farmers net return was Rs. 5908 and medium farmers Rs.5898 and for large farmers it was Rs 4424. Here farmers realized 61% net returns from agriculture, 26% from horticulture and 13% from livestock.

Considering small, marginal and medium farmers under rainfed conditions in non watershed area, the net was Rs. 6094. For small and marginal farmers net return was Rs. 5291 and medium farmers Rs.6316. Here farmers realized 44% of the net returns from agriculture, 4% from horticulture, 22% from livestock and 33% from wage employment. Considering both rainfed and irrigated condition the overall net return per acre from all the sources was Rs. 5779.

5.11 Economics of Groundwater Recharge

Economics of groundwater recharge for small and marginal farmers is measured as the difference in the net returns between farmers with irrigation wells in Sujala and farmers with wells outside Sujala. Accordingly, farmers with irrigation wells in Sujala realized a net return of Rs. 10,426 while those outside the watershed realized Rs. 5,370 per acre as net return. Thus, the overall contribution of groundwater recharge because of Sujala is Rs. 5,056 per acre, which is 94% higher than net returns outside the watershed. Thus, the recharge contribution of Sujala watershed through groundwater recharge was Rs. 5056 per acre to which agriculture, horticulture and livestock contribute substantially.

5.12 Assessment of Equity in Benefits

There is equity in distribution of benefits in Sujala for farmers possessing irrigation wells. Here large farmers realized net returns of Rs. 7,536 per acre while small and marginal farmers realized net return of Rs. 8,693 and Rs. 13,081. Small and marginal farmers constitute around 80% in the Sujala watershed and as they realized 15% higher net return than large farmers it points towards equity in the distribution of benefits.

Under rained category, the net returns obtained by small and marginal farmers (Rs. 12,922) are 80% higher than the return obtained by medium farmers (Rs. 7, 199). Here, rainfed small and marginal farmers enjoy two types of equity. First, the net return of small and marginal farmers under rainfed condition (Rs. 12,922) is almost 50% higher than the net return of small and marginal farmers with irrigation (Rs. 8,693). Second, the net return of small and marginal farmers (Rs. 12,922) under rainfed is 80% higher than medium farmers (Rs. 7,199).

5.13 Sustainability

The equity impacts of watershed program on rainfed farmers are largely owing to incremental wage employment offered by Sujala which is contributing to 40% of net returns. Thus, after the Sujala project rainfed farmers are deprived of wage employment, they will loose this net return. Hence, incomes for farmers possessing irrigation wells in Sujala will be more sustainable than farmers without irrigation wells. The rainfed farmers in Sujala received Rs. 7019 per acre while the irrigated farmers in Sujala received Rs. 10,426, this is 48% higher than the net returns realized by Sujala rainfed farmers. Thus, the overall contribution of Sujala to groundwater recharge is 48% on sustainable basis (Tables 11 and 12).

5.14 Estimation of Synergies

The economic benefit owing to synergistic roles of technical support by Sujala authorities, watershed structures, NGOs, SHGs, watershed *sanghas*, area group, executive committee and the participating farmers was estimated by deducting net return obtained in non-Sujala watershed (DPAP) from the net return obtained in

Sujala watershed. This works out to Rs. 2500 per acre, which forms 50% of the total contribution of Sujala watershed. Thus, the synergistic benefits contribute around 50%. The synergistic effect here was computed to reflect the interaction effects of technical support (Table 18).

5.15 Policy Implications for Sustainability of Sujala

Considering the synergistic contribution of 50% in the success of Sujala watershed program, the role NGO improvement, peoples' participation and the private property rights for watershed structures, would continue to contribute towards the sustainability of the Sujala watershed program. Hence, the transaction cost of eracting watershed institution and evolving community participation needs to be either borne by farmers themselves or subsidized in part or full by the government. Thus, Sujala pattern of watershed development program holds promise for future Watershed Development program in the country and has potential for emulation in other parts of Karnataka and India. While this paper was being written, already the World Bank approved extension of Sujala program to other five districts of Karnataka.

Table 18: Economic benefits due to synergistic role of surface water bodies, in situ conservation efforts and institutional innovations *(Rs per Acre)*

Sl.No	Particulars	Contribution / Effects in 2005
1.	Contribution of (Non-Sujala) DPAP Watershed program (= net returns in Non-Sujala WDP minus net returns in Non-watershed area)	(= 8246-5779) = 2467
2	Synergistic effect (=net returns in Sujala minus NRs in Non-Sujala WDP)	(=10746-8246) = 2500
3	Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area)= (1) + (2)	(=.2467 + 2500) = 4967

The results and findings along with objectives and methodology are summarized in Table 19.

Table 19: Conclusions

Sl No	Objective	Hypothesis	Methodology	Results and Findings
1	To evaluate the impact of watershed development on cropping pattern, income, and employment.	Net returns from watershed induced cropping pattern have resulted in economic drought proofing.	Net returns per acre in Sujala minus net returns per acre in non watershed area in drought year	1. For farmers possessing wells: Rs. 614 2. For farmers not possessing wells: Rs. 7354 3. For pooled sample: Rs. 3066 Findings: 1. Sujala watershed program has not induced major change in crop pattern in this micro-watershed 2. The positive net returns above indicate the extent of drought proofing offered by Sujala watershed program
		Watershed Development Program has improved household level income.	Net returns per acre from livestock, wage employment and income generating activities in Sujala minus Non watershed area	1. In drought year, household income per acre in Sujala minus that in non watershed area is Rs. 3997 – Rs. 2231 = Rs. 1766 2. In normal year, household income in sujala minus that in non watershed area is Rs. 4105 – Rs. 2097 = Rs. 2008 Findings: Due to Sujala, the household income per acre has increased by Rs. 1766 in drought year, and by Rs. 2008 in normal year.
		Watershed Development Program has resulted in additional employment generation	Employment generation in Sujala minus employment generation outside Sujala	1. In drought year, in Sujala employment generation is 2244 man days per household, while outside watershed, employment generation is 112 man days per household 2. In normal year, in Sujala, employment generation is 2264 mandays per household, while outside watershed, employment generation is 114 man days per household. Findings: Watershed development program has resulted in additional employment generation to the tune of around 2244 man days in drought year and 2264 man days in normal year

Sl No	Objective	Hypothesis	Methodology	Results and Findings
2	To assess the distribution of economic benefits across different categories of farmers	Watershed Development Program has brought fair distribution of income across different classes of farmers.	Incremental net returns due to Sujala over non-watershed area in drought year and in normal year for the three classes of farmers	1. In drought year, for class of farmers with irrigation wells, small and marginal farmers realized Rs. 3618 per acre; medium farmers realized Rs. 3461 per acre and large farmers realized Rs. 1195 per acre. 2. In drought year, for class of farmers without irrigation wells, small and marginal farmers realized Rs. 7,714 per acre, medium farmers realized Rs. 6,739 per acre, (and there were no large farmers in this class) 3. In normal year, for class of farmers with irrigation wells, small and marginal farmers realized Rs. 2,785 per acre; medium farmers realized Rs. 7,183 per acre and large farmers realized Rs. 5,056 per acre. 4. In normal year, for class of farmers without irrigation wells, small and marginal farmers realized Rs. 7,630 per acre, medium farmers realized Rs. 883 per acre, (and there were no large farmers in this class) 5. In normal year, among farmers possessing wells, the small and marginal farmers realized incremental net returns of Rs. 2,640, while medium farmers realized incremental net returns of Rs. 5,407per acre and large farmers realized Rs. 2,159 even though the Sujala expenditure per acre was Rs. 1,745 on small and marginal farmers and Rs. 1,456 per acre in medium farmers and for large farmers Rs.836

Sl No	Objective	Hypothesis	Methodology	Results and Findings
				6. In normal year, among farmers without wells, the small and marginal farmers realized incremental net returns of Rs. 7048, while medium farmers realized incremental net returns of Rs. 796 per acre, even though the Sujala expenditure per acre was Rs. 2796 on small and marginal farmers and Rs. 1708 per acre in medium farmers Findings: In drought and normal year, small and marginal farmers have performed economically better than medium / large farmers. Hence Sujala watershed program has favored small and marginal farmers more than large farmers, despite the fact that small and marginal farmers received lower Sujala expenditure per acre. Hence small and marginal farmers have exhibited higher economic efficiency in utilizing both public and private resources than medium and large farmers.

6. SUMMARY AND CONCLUSION

In this study, economic impact of water harvesting and groundwater recharging was analyzed in the context of Sujala watershed equity and efficiency in the distribution of benefits in Chitradurga district, Karnataka. Field data for 2004-05 (drought year) and 2005-06 (normal year) from 30 sample farmers in Sujala watershed form the data base for the study. Another sample of 30 farmers from Non-Sujala (or DPAP) watershed, and 30 from outside watershed area form the control. Farmers were further classified as: (i) those who had bore well irrigation; and (ii) those who had no borewell irrigation in order to assess the impact of watershed.

It was found that the amortized cost per functioning well and cost per acre inch of groundwater in Sujala watershed is lower than that in non-Sujala watershed and non-watershed area. The economic contribution in terms of incremental net returns per acre in (i) Sujala over non-watershed area (in drought year, normal year) as the contribution of Sujala watershed are Rs. 1726 and Rs. 3650; (ii) Sujala over Non-Sujala (DPAP) watershed (as the contribution of Sujala watershed institutions) is Rs. 1067 and Rs. 898); (iii) Non Sujala (DPAP) over non-watershed area (equal to contribution to Non-Sujala or DPAP watershed) is Rs. 133 and Rs. 2226. These indicate economic supremacy of Sujala watershed program.

The incremental net returns of Sujala over non-watershed area in drought year and in normal year for farmers possessing irrigation wells were Rs. 614 and Rs. 5056 respectively; for farmers not possessing irrigation wells is Rs. 7354 and Rs. 5326; for all classes of farmers is Rs. 3066 and Rs. 4967 are the prima facie indicators of economic contributions of Sujala watershed program. The negative externality per well per year in Sujala was Rs 2652, in Non-Sujala watershed was Rs. 2735, and in non-watershed area was Rs. 4285. It shows that the negative externality in groundwater irrigation has reduced by 38% in Sujala over non-watershed area.

Sujala watershed program had a higher expenditure as compared to non-sujala watershed. Still the B-C ratios were higher in Sujala watershed during both drought and normal year.

ACKNOWLEDGEMENT

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CHASING A MIRAGE: WATER HARVESTING AND ARTIFICIAL RECHARGE TO SOLVE WATER PROBLEMS IN NATURALLY WATER-SCARCE REGIONS[1]

M. Dinesh Kumar[2], Ankit Patel, R. Ravindranath and O. P. Singh

Abstract

Often as a frantic response to problems of water scarcity and consequent hardships faced by communities in urban areas as well as country-side, India had invested many billions in rainwater harvesting. The analysis presented in this paper shows that in water-scarce regions of India, runoff harvesting does not offer any potential for groundwater recharge or improving water supplies at the basin level. The issues can be summarized as follows. 1. Water harvesting in "closed" basins have negative hydrological impacts on the downstream areas. 2. Due to high inter-annual variability in rainfall and subsequent runoff WHSs become highly unreliable during drought years, whereas attempt to capture runoff would remarkably increase the unit cost of harvesting water. 3. In closed basins, intensive water harvesting will lead to negative welfare outcomes due to high negative externalities at higher degrees of basin development. 4. Even at the local level, physical efficiency of WH is likely to be poor, mainly due to groundwater-surface water interactions; and poor storage capacity of hard rock aquifers underlying most of the water-scarce regions. Artificial recharge systems in natural water-scarce areas in India are economically unviable.

1. INTRODUCTION

India has a long tradition of water harvesting (Agarwal and Narain, 1997). But, the past two decades in the country's water sector history are characterized by a boom in water harvesting. They are markedly different from the traditional ones in 2 ways; first from the context; and second from the purpose. As regards the context, they are able to use recent advancements in soil, geosciences and hydro-sciences; and modern day techniques and technologies in survey and investigation, earth moving and construction; and management tools such as hydrological and hydraulic modeling (Kumar et al., 2006). While the traditional ones represented the best engineering feat of those times, in terms of water technology used for water harnessing and distribution (Agarwal and Narain, 1997); and the volume of water handled, the modern water harvesting systems are at best miniatures of the large water resource systems that use advances in civil engineering and hydrology. As regards purpose, they are employed as resource management solution, and not as resource development solutions (Kumar et al., 2006).

The limited Indian research on runoff harvesting (RWH)/artificial recharge so far had focused on engineering performance of individual structures (see Muralidharan and Athawale, 1998; Patel, 2002). While a lot of anecdotal evidences on the social and economic gains exist, there is little understanding based on empirical work to study: 1] the impacts of water harvesting activities on local hydrological regime in terms of net water gain; 2] basin level impacts on the water balance of the overall basin; and 3] economic imperatives from a long term perspective (Kumar et al., 2006). Analysis of performance of runoff harvesting systems also misses the influence of "scale factor", with the exception of the work by Ray and Bijarnia (2006). Of late, researchers have raised questions about the reliability of water supplies from these systems in water-scarce regions, its

[1] This paper draws partly on the ideas and data presented in Kumar *et al*. (2006) in addition to fresh analyses and insights.

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possible unintended impacts (see Bachelor et al., 2002; Kumar et al., 2006; Ray and Bijarnia, 2006), its economics (see Kumar, 2004; Kumar et al., 2006), and its role in improving the overall basin water economy (Kumar et al., 2006).

2. PURPOSE AND SCOPE OF THE PAPER

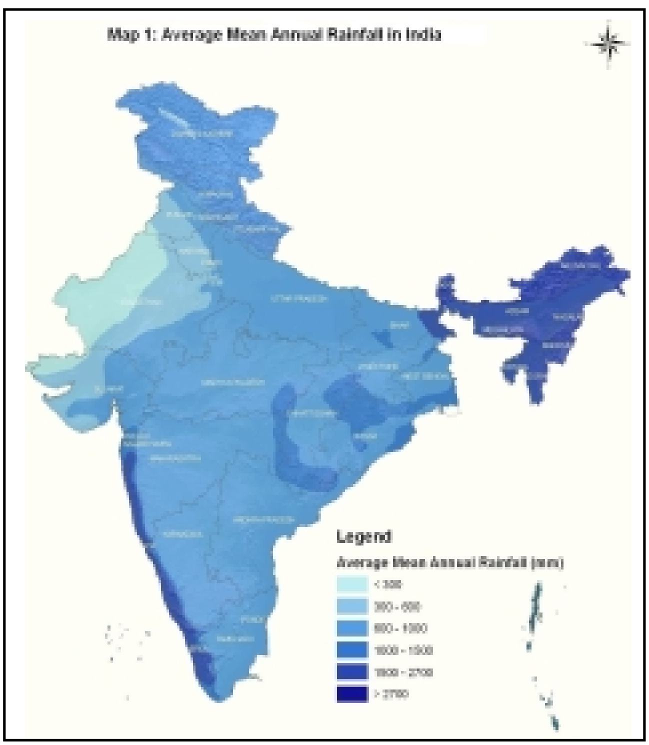
The purpose of this paper is to: 1] assess the effectiveness of runoff harvesting in improving both local hydrological regimes, and basin water balance in water-scarce regions of India; 2] discuss the various considerations needed to analyze economics of runoff harvesting; 3] discuss the imperatives of runoff harvesting for determining the optimum level of water harvesting in water-scarce basins. In order to do this, we analyze and synthesize macro level hydrological and geo-hydrological data for the country, including data on annual rainfalls, rainfall variability, no. of rainy days, soil infiltration, potential evaporation (PE); data on rainfall, runoff and reference evapo-transpiration (ET_0) for selected basins viz., Narmada, Cauvery, Pennar, Krishna and Sabarmati; and data on effects of water harvesting on stream flows and groundwater levels for Ghelo river basin in Saurashtra, Gujarat.

3. RUNOFF HARVESTING IN WATER SCARCE REGIONS: PETER TAKING PAUL'S WATER?

In order to understand the issue of negative downstream impacts of intensive water harvesting, we must first define "natural water-scarce regions", and "closed and open basins".

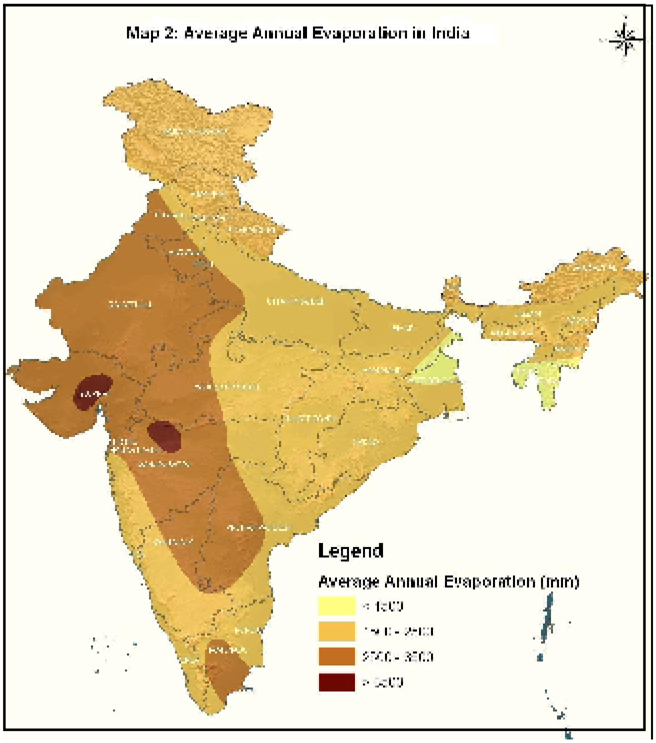
3.1 Which are the naturally water-scarce regions in India?

From an anthropogenic perspective, water-scarce regions are those where the demand for water for various human uses far exceeds the total water available from the natural system, or the technology to access it is economically unviable. This includes the surface water, water stored in the aquifers, and that held in the soil profile. Water scarcity can also be felt when the resources are available in plenty in the natural system in a particular region, but adequate financial resources to access it are not available with the populations living there. The former is called physical scarcity, and the latter economic scarcity. north Gujarat in India and Israel are ideal examples of physical scarcity, whereas Ethiopia in eastern Africa and Bihar in eastern India are ideal examples of economic scarcity of water. In this article we are concerned with regions facing physical scarcity of water.



Physical scarcity of water occurs in regions which experiences low to medium rainfalls and high evaporation rates. Most parts of western, north-western, central and peninsular India fall under this category. They have low to medium rainfalls (see Map 1[3]), and high potential evaporation rates (see Map 2). The mean annual rainfall ranges from less than 300mm to 1000mm, where as the PE ranges from less than 1500 in some pockets in the north east to more than 3500 in some pockets in Gujarat and Maharashtra.

[3] Data used for generation of GIS Maps 1, 3, 4 and 5 were derived from Pisharoty (1990).



In the subsequent section, we will explain the processes that determine supply and demand for water, which in turn induces water scarcity in those regions. The natural water supply and runoff[4] available from precipitation and groundwater recharge per unit area of land is low. This is because of high evaporation rates, which depletes the soil moisture which infiltrates rain water. This leaves little chance for water to runoff (see Kumar et al., 2006 for detailed discussion).

Crop evapo-transpiration mainly determines the demand of water for agriculture. Agriculture is the largest source of water demand for human uses in all major river basins in India.

Table 1 gives the reference evapo-transpiration against the effective renewable water resources from surface runoff and replenishable groundwater[5]. It shows that for all the 5 basins, annual reference evapo-transpiration is many times more than effective renewable water resources. But, what is available for crop production includes the soil moisture storage as well. But since the soil moisture storage is a small fraction of the rainfall even in very high rainfall regimes, the potential evapo-transpiration (PET) for the entire year would be much higher than the sum of soil moisture storage, (which is a fraction of the rainfall) and effective renewable water resources.

The imbalance between effective water availability and water demand for agricultural uses is very high for all the five basins. In addition to agricultural water, there are demands for water from domestic and industrial sectors as well. However, for the time being, we can ignore the other sectors. This gap between demand and renewable supplies can be reduced if we have very little arable land, and very large amount of land serving as natural catchments for supplying runoff water. Unfortunately, the remaining virgin catchment in water-scarce regions of India is very small. It varies from 58.6% in case of the Pennar basin to 28% in case of the Sabarmati basin.

The increasing intensity of crop production in the rich upper catchments of river basins and watersheds has two major negative impacts on available renewable water resources. First: it captures a share of the runoff generated from the area, and therefore reduces the available surface water supplies. Second: increase in cultivated land increases the water requirement for irrigation. This way, large regions in India are facing shortage of water to meet the existing demands. The recent report on groundwater resource assessment and irrigation potential in India shows that the regions facing problems of groundwater over-exploitation are mostly in Gujarat, Rajasthan, Maharashtra, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and parts of Karnataka, which are the naturally water-scarce regions (GoI, 2005).

3.2 "Closed" vs "Open Basins"

"Closed" basins are those where no extra renewable water resources are available for diversions to meet consumptive water demands, or "closed" basins are those where new diversions would reduce the availability of water for uses at some other points within the basin. This means in such basins, it is not possible to increase the beneficial evapo-transpiration, as wastage of water through non-beneficial evaporation or flows into the natural sink such as saline aquifers or seawater do not take place. "Open basins" are those where wastage of

[4] Runoff is the amount in excess of the soil moisture storage and storage.

[5] For a basin, if only a small fraction of the drainage area is under cultivation, then effective renewable water availability per unit of cultivated land would be more, and vice versa.

Table 1: Average Reference Evapo-transpiration Against Mean Annual Rainfall in Selected River Basins in Water-Scarce Regions

Sr. No	Name of the basin	Mean annual rainfall (mm)		Average annual water resources[1] (mm)	Effective annual water resource[2] (mm)	Reference Evapo-transpiration[3] (mm)	
		Upper	Lower			Upper	Lower
1	Narmada basin	1352.00	792.00	444.70	937.60	1639.00	2127.00
2	Sabarmati basin	643.00	821.00	222.84	309.61	1263.00	1788.80
3	Cauvery basin	3283.00	1337.00	316.15	682.80	1586.90	1852.90
4	Pennar basin	900.00	567.00	193.90	467.80	1783.00	1888.00
5	Krishna basin	2100.00	1029.00	249.16	489.15	1637.00	1785.90

Sources: [1] The average annual water resources was estimated by taking the sum of annual utilizable runoff (GoI, 1999: Table 3.6) and the dynamic groundwater resources from natural recharge in these basins (GoI, 1999: Table 3.9) and dividing by the geographical area of the basin.

[2] The effective renewable water resources were estimated by dividing the average renewable water resources for the basin by the fraction of total cultivated land to the total basin drainage area. The basin-wise total cultivated land considered was for the year 1993-94 (GoI, 1999).

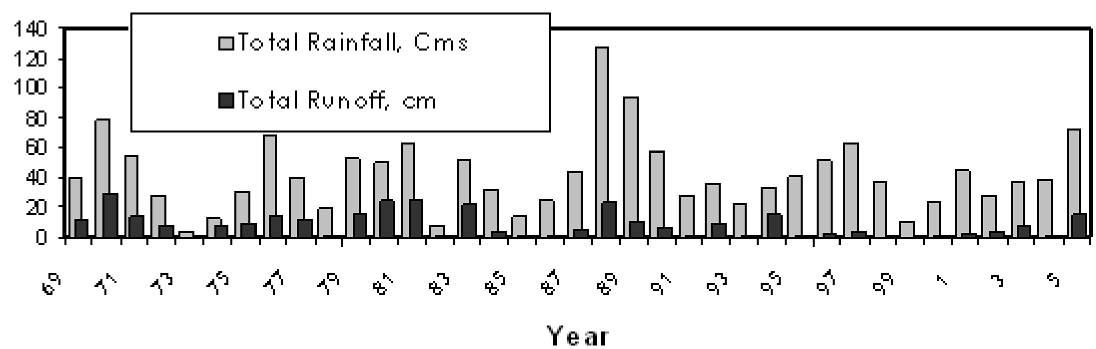
[3] Reference evapo-transpiration values were estimated using meteorological data from FAO CROPWAT model, except for Pennar basin and upper Krishna. For Pennar and upper Krishna, the data were obtained from IWMI climate atlas.

water through non-beneficial evaporation or flow into natural sinks take place, and where it is possible to increase utilizable water resources and increase beneficial evapo-transpiration. In the subsequent section, we will show which basins in India are considered "closed".

3.3 Downstream Impacts of Upstream Water Harvesting

The states of Gujarat, Rajasthan, Madhya Pradesh and Maharashtra took up intensive water harvesting during the past 20 years. The first decentralized modern water harvesting intervention in India was dug well recharging, and started in Saurashtra region after 3 years of consecutive droughts during 1985-87. This involved diverting field runoff and runoff in the local streams and nallas into open wells, which have the characteristics

Figure 1: Ghelo-Somanath Rainfall and Reservior Inflows



of hard rock region (Kumar, 2000). Grass root level NGOs, spiritual and religious institutions, private agencies and social activists participated in this programme, which later on came to be known as Saurashtra dug-well recharge movement (Kumar, 2000).

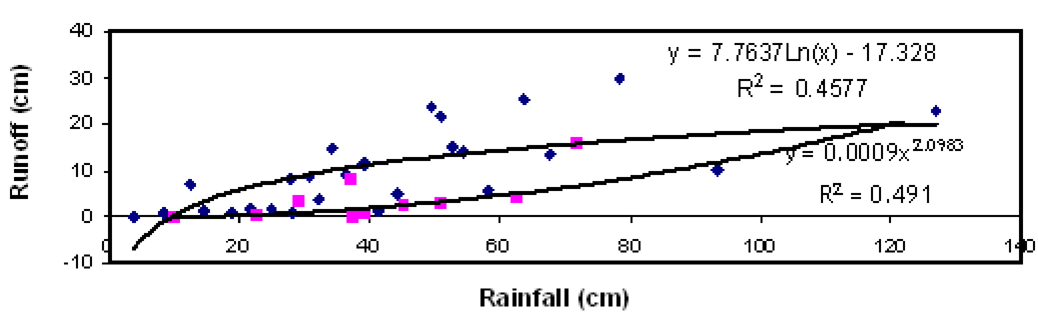
The argument was that the 7 lac open wells in the region could be recharged using monsoon runoff, which was flowing waste into the sea. The people behind this movement, did not consider that approximately 110 medium and a few large reservoirs located downstream were not getting sufficient flows for irrigation and drinking even in normal rainfall years. The dependable runoff of the entire Saurashtra peninsula, generated from 91 small river basins, is 3613 MCM. Whereas all the major and medium reservoirs in the region have sufficient storage capacity to capture up to 5458 MCM water annually. This clearly shows that dug well recharging if carried out in the upper catchments of these basins, would only help reduce inflows into these reservoirs (Kumar, 2000).

The government of Gujarat launched the Sardar Patel Participatory Water Conservation programme in Saurashtra and north Gujarat in 1999 and built nearly 54,000 check dams in local streams, and nallas with the involvement of local communities (GoI, 2007). As Prof. Saul Arlosoroff, an Israeli water expert opined, this indiscriminate water harvesting activity has the potential to spell doom for the ecology of Saurashtra region.

But, the general belief is that because these structures are too small they are benign (Batchelor et al., 2002) though present in large numbers in most cases. The primary reason for such an outlook is that the agencies concerned with small water harvesting (in the upper catchment) and those concerned with major head- works are different and they do not act in coordination at the basin level. Building small water harvesting systems such as tanks and check dams is often the responsibility of the minor irrigation department or district arms of the rural development departments of the states concerned. This ad hoc approach to planning often leads to over-appropriation of the basin water, with negative consequences for large reservoir schemes downstream (Kumar et al., 2000). The quality of implementation of the programme came under severe attack from Public Accounts Committee, which found that the quality of construction was poor and funds were mis-appropriated. While the Panchayats were supposed to carry out the work, all construction work was awarded to a few big contractors.

Data collected from Ghelo river basin shows that the inflows into Ghelo-Somnath reservoir reduced significantly after intensive water harvesting work was undertaken in the upper catchment. The total number of structures in the upper catchment area of 59.57 km^2 is around 100. Figure 1 shows the catchment rainfall and runoff in Ghelo-Somnath. After 1995, the year which saw intensive water harvesting work, the reservoir overflowed only in 2005 when the rainfall recorded was 789 mm. Regressions of rainfall and runoff, carried out for 2 time periods i.e., 1969-95 and 1995-05, clearly show that the relationship between rainfall and runoff had changed after water harvesting interventions (see Figure 2). The amount of rainfall required for filling the reservoir had now increased from 320 mm to 800 mm. Though the curves intersect at higher rainfall magnitudes, this does not occur frequently as such high rainfall does not occur in the basin.

Figure 2: Impact of Water Harvesting on Inflows in Reservior: Ghelo-Somnath



Many large and important river basins in India, which are also facing water scarcity, are now "closed" or do not have uncommitted flows that are utilizable through conventional engineering interventions. Some of them are Pennar, Cauvery and Vaigai in the South (based on GoI, 1999), and Sabarmati, Banas in the west. In addition to these, all the west-flowing rivers in Saurashtra and Kachchh in Gujarat are also "closed" (Kumar, 2002). While Krishna basin is on the verge of closure, one basin which is still "open" is Godhavari in the east (based on GoI, 1999).

In nutshell, water harvesting interventions in the "closed basins" located in the naturally water-scarce regions would have adverse impacts on stream-flow availability for downstream uses. One could always argue that in wet years, the runoff would be sufficient to completely fill up downstream reservoirs, it would mean huge investments for the structures. The aquifers in hard rock areas lack the storage capacity to absorb the runoff diverted into the system. This is dealt with separately in Section 3.2. On the other hand, in low rainfall years, the downstream impact of intensive water harvesting systems in the upper catchments would be severe. This is also evident from Figure 2 where the difference in runoffs between pre and post water harvesting scenarios is quite high for low rainfall regimes.

4. WHERE DOES RECHARGING OF GROUNDWATER REALLY WORK?

The effectiveness of groundwater recharging in any area depends on three factors: i] technical efficiency of recharging; ii] storage potential of aquifers, which are being recharged; and, iii] dynamics of interaction between groundwater and surface water. We also discuss hydrological variability and its implications for reliability of supplies and cost of water harvesting.

4.1 Poor Technical Efficiency in Artificial Recharge Activities

From a technical perspective, there are 3 major problems facing artificial recharge efforts in water-scarce regions of India. First: most water-scarce regions are underlain by hard rock formations (see Map 3). These hard rock formations consist of Deccan basalt, crystalline rocks and sedimentary sandstone and limestone aquifers.

Most of South Indian peninsula has crystalline rocks and basalts, whereas Central India has basalt formations, crystalline rocks and sedimentary aquifers. The soils in the hard rock regions, mostly loamy clay, have very poor infiltration capacity (Muralidharan and Athavale, 1998**)**. After the first few minutes, the rate of infiltration comes down to zero. The performance of water harvesting structures such as tanks, ponds and check dams, which depend on infiltration, is poor. Second: in water-scarce regions, the evaporation rates are very high. Tanks and ponds are the common water harvesting systems found in south Indian peninsula. These structures have very high surface area in relation to the total amount of water they impound. Therefore, evaporation losses from these structures are bound to be high. Third: hard rock geology induces significant constraints in recharge efforts through percolation tanks. The high depth to water table below and around the recharge structure due to occurrence of recharge mount and shallow bed rocks and low infiltration capacity of the thin soils overlaying the hard rock formations prevent percolation of water (Muralidharan, 1990 as cited in Muralidharan and Athawale, 1998).

Over the past couple of decades, "dug well recharging" had attracted a lot of attention from government agencies in other states facing water shortages. This is also known as Aquifer Storage and Recovery (ASR) method of recharging. This was considered as a simple method for conservation of rain water, involving a meager expense of Rs.150 (US $ 4 approximately). According to the proponents, 300,000 wells were recharged in Saurashtra alone using this method. The proponents argued that a single well could recharge as much as 4,000m^3 of water, based on the assumption that each well will have a storage capacity of 800m^3 on an average, and could receive 5 fillings.

These success stories from Saurashtra motivated the government planning new artificial recharge schemes in hard rock district of south India. But, planning such a project did not consider the availability of uncommitted flows in the particular river basins/regions, for which such schemes are proposed. The government of India report on groundwater management and ownership (GoI, 2007) cited a figure of 214 BCM as the uncommitted runoff in India for recharging, and 35 BCM as the total annual recharge technically feasible. However, the calculation does not consider that in regions where ground water is over-exploited, there are no uncommitted flows. Instead, it only looks at the aggregate figures at the country level and the storage space in the aquifers. Further, from the point of view of technical efficiency, no thought has gone into working out the amount of catchment needed to harvest runoff as high as 4000m^3 per well, nor the storage efficiency of the dug wells in hard rock areas.

The catchment area required in four different basins in South India, estimated on the basis of the average runoff in these basins, are given in Table 2 below. In all these basins, the hilly and forested upper catchments are rich in terms of runoff generation potential. The runoff generation potential of the moderately plain agricultural lands in the basin would be much lower due to the lower rainfall, higher aridity (as Table 1 indicates), milder slopes, and presence of field bunds and standing crops. Hence, the actual catchment required would be much higher. Again, we have ignored flows that are committed for downstream tanks, ponds and reservoirs.

Even if we assume that such a large volume of water can be recharged effectively into the aquifers through dug wells at the farmer level, the availability of sufficient amount of private land to be used as catchments is open to question. In the most optimistic situation, only some of the large farmers would be able to manage such a large amount of field runoff.

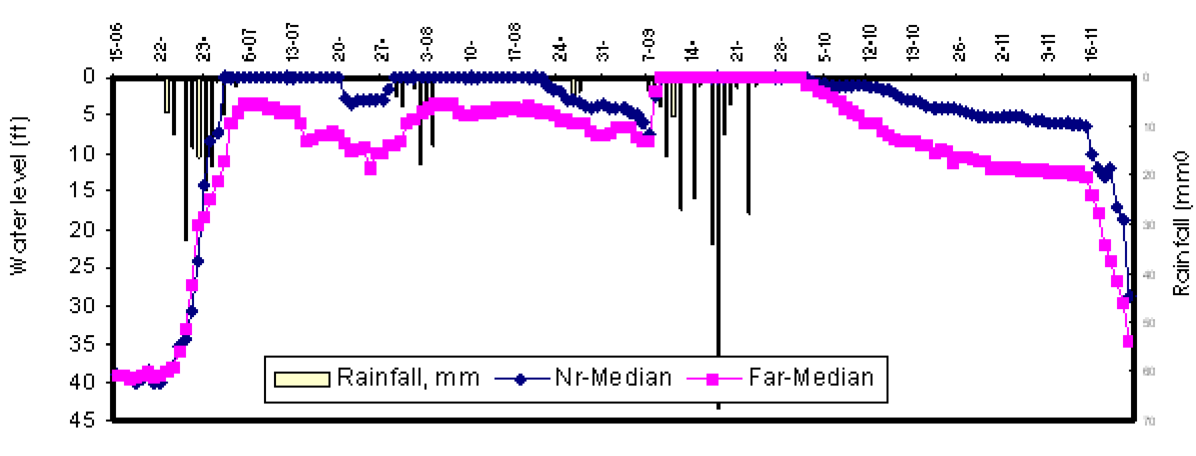
Table 2: Catchment Area Required to Harness Field Runoff for Well Recharging

Sr. No	Name of the Basin	Average Utilizable Annual Runoff (m)*	Catchment area (acre) required for a runoff of 5000 m^3
1	Cauvery River Basin	0.216	5.76
2	Pennar River Basin	0.120	10.24
3	Krishna River Basin	0.220	5.58
4	East Flowing Rivers in the South**	0.168	7.45

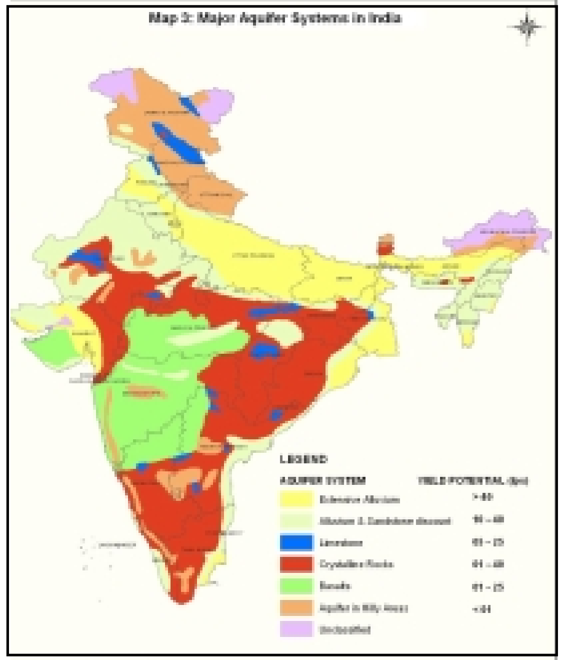
* Estimated on the basis of the utilizable runoff in the basin and the total drainage area provided in GoI (1999).

** Between Pennar & Cauvery, and East Flowing Rivers South of Cauvery

Figure 3: Water Level Fluctuation in Wells in Fulzar, Ghelo River Basin



As regards the storage efficiency, for each well to harness 4000-5000 m^3 of water, the well would have to receive 15-20 fillings during the monsoon. The hydraulic diffusivity is very poor in hard rock areas. Hence, the recharge mount created from a filling is unlikely to disappear before the wells starts getting the next inflow. An empirical study carried out back in 1997 in Saurashtra region of Gujarat showed very limited impact of this method of recharging groundwater with a total recharge to the tune of 320 m^3.

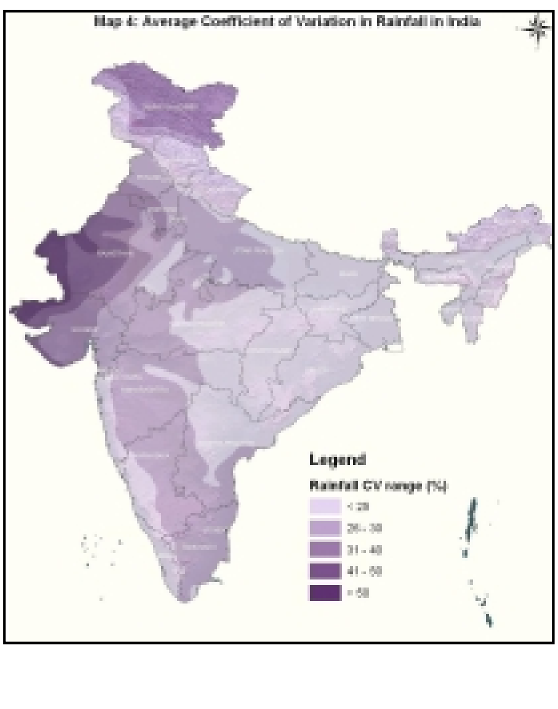


Map 3: Major Aquifer Systems in India

4.2 Poor Aquifer Storage in Hard Rock Areas

With two third of the country's geographical area underlain by hard rock formations, storage capacity of aquifers poses a major challenge for artificial recharge from local runoff. Most parts of water-scarce states like Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Orissa, Chhattisgarh and Tamil Nadu are underlain by hard rocks ranging from basalt, crystalline granite, hill aquifers and sandstone. A small areas in of the Narmada valley ad Cambay Basin in Gujarat has extensive alluvium (see Map 3). Hard rock aquifers have no primary porosity and have only secondary porosity. Due to low specific yield (0.01-0.03), sharp rise in water levels is observed in aquifers during monsoon, leaving little space for infiltration from structures. Harnessing water for recharge is extremely important during normal and wet years when the natural recharge in hard rock formation is high (based on regression equations shown in Figure 7 in Athawale, 2003), further reducing the scope for artificial recharge.

Significant recharge efforts were made in Saurashtra. But, the biggest constraint in storing water underground during high rainfall years is the poor storage capacity or specific yield of the basalt formations. During good rainfall years, the aquifers get saturated with natural recharge immediately after the rains, leaving no space for entry of water from the recharge systems (Kumar, 2000).



Map 4: Average Coefficient of Variation in Rainfall in India

The groundwater level fluctuation data obtained from Ghelo river basin in Saurashtra illustrate this. The basin had experienced intensive water-harvesting since 1995. The data were collected periodically from open wells located inside the basin during and after the monsoon rains. The wells located close to the water harvesting structures and those away from the structures were demarcated. The water level fluctuation in the wells in relation to the rainfall events were analyzed and are presented in Figure 3. The time series data shows that the wells close to water harvesting structures get replenished faster than those located away from the structures. But, these wells start overflowing after the first major wet spell, while the second category of wells showed similar trends after the second wet spell. There is a steep rise in water levels in the order of 35 – 40 ft in wells located both close to and away from the water harvesting structures soon after the first wet spell. The steep rise in water levels shows the poor specific yield of the aquifer in the area, as the magnitude of cumulative rainfall that had caused this fluctuation is only 200 mm.

This leads to the conclusion that in hard rock areas, the aquifers get fully replenished during good rainfall years even without water harvesting systems. Therefore, the only way to store the runoff would be through surface storage. This would have serious negative implications for the cost of the system. This issue is dealt with in detail in section 3.4.

4.3 Hydro-schizophrenia: Ignoring Groundwater-surface Water Interactions

In many river basins, the surface water systems and groundwater systems are often inter-connected. Any alterations made in one of them could change the availability of water in the other (Sohiquilo, 1985; Llamas, 2000). In many river basins, which do not get snow melt but have perennial flows, part of the monsoon recharge in the upper catchment areas outflows into the surface streams as base flow. This is the water which is available as non-monsoon flows in these river basins. Examples are basins in central India such as Narmada, Mahi and Tapi, and those in Peninsular India such as Krishna, Pennar and Cauvery. Such outflows occur due to negative hydraulic gradients between groundwater levels and stream water levels. A recent analysis showed that increased groundwater withdrawals in the upper catchments led to a reduction in stream-flows in the Narmada basin (Kumar et al., 2006).

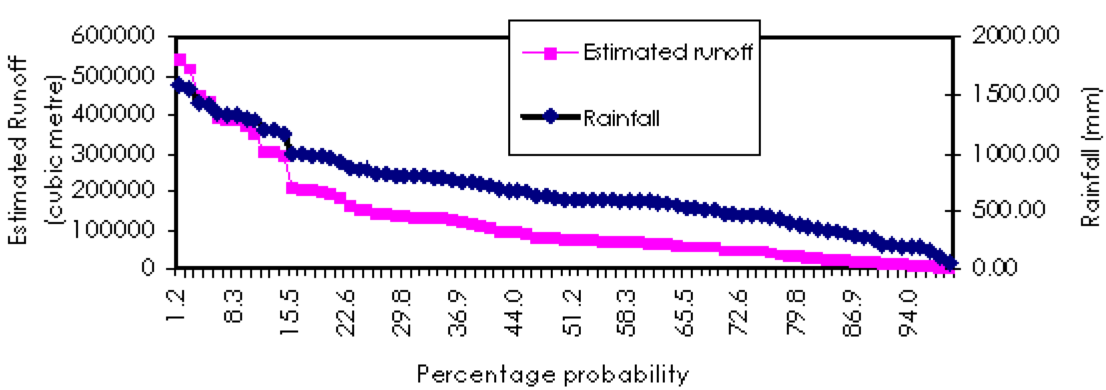
In such cases, water harvesting interventions to store water underground may not make much sense as it would get rejected and appear as surface flows (Mayya, 2005). On the other hand, in regions with deep water table conditions like in north Gujarat, the runoff directly moves into the groundwater systems of the plains through the sandy river bed as dewatering of the upper aquifers increases the rate and cumulative percolation (Kumar, 2002b).

4.4 High Inter-annual Variability in Rainfall and its Implications for Reliability of Water Supplies and Economic Viability

Regions with semi arid and arid climate experience extreme hydrological events (Hurd et al., 1999). As seen from Map 1, 2 and 4, regions with high variability in rainfall in India coincide with low magnitudes of rainfall and high PE, which also has high dryness ratio. In such areas, a slight variation in precipitation or PE can substantially magnify the water stress on biological systems as compared to humid regions (Hurd *et al*., 1999). Rainfall variability induces higher degree of variability in runoff. We take the example of the catchments of Banas basin in North Gujarat to illustrate this.

In Palanpur area of Banaskantha district in north Gujarat, which has semi arid to arid climatic conditions, the rainfall records show a variation from a lowest of 56mm in 1987 to 1584mm in 1907. The runoff estimated on the basis of regression equation developed for a sub-basin, named, Hathmati of Sabarmati basin in north

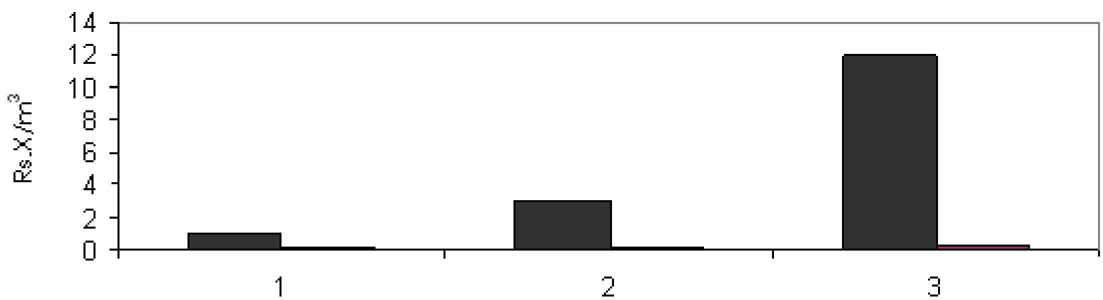
Figure 4: Probability of Occurance of Ranilfall and Runoff in Banas Basin



Gujarat, which is physiographically quite similar to Palanpur area of Banaskantha, shows that the runoff can vary from a lowest of 0.6mm to 541mm (Figure 4). The lowest runoff is close to 1/1000th of the highest runoff. This means, in drought years, when the actual water demand for irrigation increases, the amount of runoff that can be captured is almost negligible. Hence, the water harvesting systems become unreliable. What can occurs at the sub-basin level may not be representative of that in small upper catchments, the difference will not be drastic.

When there is a high inter-annual variability in the runoff a catchment generates, a major planning question which arises is "for what capacity the water harvesting system should be designed". When scarcity is acute, highest consideration is given to capturing all the water that is available. If all the runoff which occurs in a high rainfall year is to be captured, then the cost of building the storage system would be many hundred times more than what is required to capture the one which occurs during the lowest rainfall. But, the system would receive water to fill only a small fraction of its storage capacity in the rest of the years. This will make it cost-ineffective. The issue of variability is applicable to the design of large head works as well. But, in large systems, the water in excess of the storage capacity could be diverted for irrigation and other uses to areas which face water shortages during the same season, thereby increasing effective storage.

Figure 5: Cost of Rainwater Harvesting with Increasing Collection Efficiently



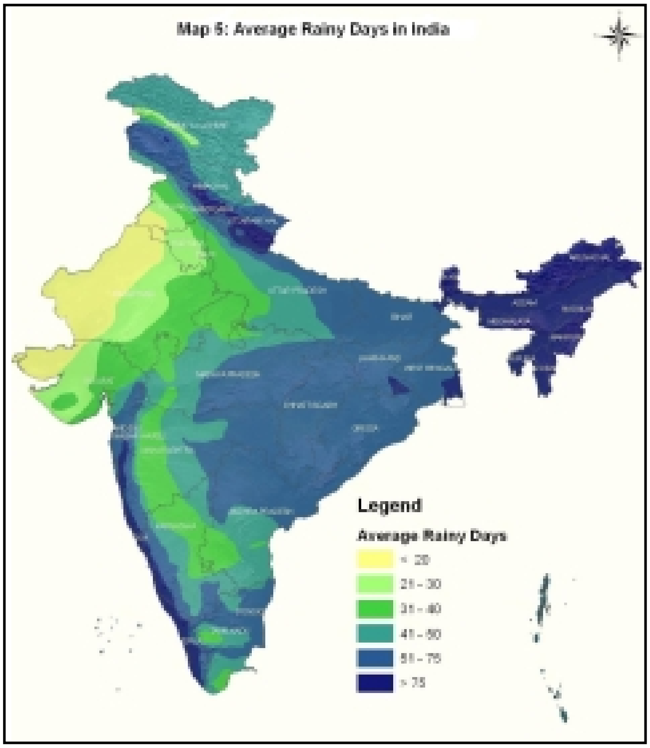
In order to illustrate this point, we use data generated from Ghelo river basin in Saurashtra. The basin has a total catchment area of 59. 20 km^2. It had a medium irrigation reservoir with a storage capacity of 5.68 MCM, which has been functional since 1966. Inflow data of the reservoir for the period 1969-95 showed that the total runoff generated in the basin varied from zero in the year corresponding to a rainfall of 39 mm to a maximum of 17.78 MCM in the year corresponding to a rainfall of 1270 mm. Today, the total capacity of water harvesting systems built in the upstream of Ghelo reservoir is 0.15 MCM. During the period from 1969 to 2005, the reservoir showed overflow for 13 years with a total quantum of 60.936 MCM. If one million cubic metres of runoff had to be captured in addition to the 5.89 MCM that would be captured by the medium irrigation reservoir, it would cost around 0.09 X/m^3 of water, while capturing 3 MCM would cost 0.11 X/m^3 of water. If the maximum runoff observed in the basin, i.e., 17.785 MCM has to be captured, the total volume of water captured would be only 60.91 MCM, in which case the unit cost of water harvesting would be around 0.21 X/m^3 of water (Figure 5). Here, "X" is the cost of storage structures for creating an effective storage space of one MCM. Here, again, we are not considering the incremental financial cost of the special structures for capturing high magnitudes of runoff, which cause flash flood.

6. IN WATER HARVESTING, SHOULDN'T WE WORRY ABOUT THE ECONOMICS?

6.1 Economics of Water Harvesting for Groundwater Recharge

In the planning of large water resource systems, cost and economics are important considerations in evaluating different options. But unfortunately, the same does not seem to be applicable in the case of small systems, though concerns about economics of recharge systems in certain situations were raised by authors such as Phadtare (1988) and Kumar (2004).

Part of the reason for lack of emphasis on “cost” is the lack of scientific understanding of the hydrological aspects of small scale interventions, such as the amount of stream flows that are available at the point of impoundment, its pattern, the amount that could be impounded or recharged and the influence area of the recharge system. Even though simulation models are available for analyzing catchment hydrology, there are great difficulties in generating micro lavel data on daily rainfall, soil infiltration rates, catchment slopes, land cover and PET which determine the potential inflows; and evaporation rates that determine potential outflows. Further for small water harvesting projects, implemented by local agencies and NGOs with small budgets, cost of hydrological investigations and planning is hard to justify. Often, provision for such items is not made in small water harvesting projects.



Map 5: Average Rainy Days in India

The amount of runoff a water harvesting structure can capture depends on not only the total quantum of runoff, but also how it occurs. A total annual runoff of 20 cm occurring over a catchment of one sq. km. can generate a surface flow of 0.20 MCM. The amount that can be captured depends on the pattern. The low rainfall, semi arid and arid regions of India, which experience extreme hydrological events, have annual rains occurring in a fewer number of days as compared to sub-humid and humid regions with high rainfalls regions (Map 5). As a result, as Garg (1987) points out, in these regions, high intensity rainfalls of short duration are quite common (source: Garg, 1987 as cited in Athawale, 2003: Figure 24). This runoff generates flash floods[1]. If the entire runoff occurs in a major rainfall event, the effective runoff collection would reduce with reducing capacity of the structures built. If large structures are built to capture high intensity runoff thereby increasing the runoff collection efficiency, that would mean inflating cost per unit volume of water captured. In fact, authors such as Oweis, Hachum and Kijne (1999) have argued that runoff harvesting should be encouraged in arid area only if the harvested water is directly diverted for crop use.

Given the data on inflows and runoff collection efficiencies, predicting the impacts on local hydrological regime is also extremely complex, requiring accurate data on geological and geo-hydrological profiles, and variables. In lieu of the above described difficulties in assessing the effective storage, unit costs are worked out on the basis of the design storage capacity of the structures and thumb rules on number of fillings (see for instance Raju, 1995). The recent book by Dr. R. N. Athawale on rainwater harvesting in India had covered a gamut of technical aspects of water harvesting in different regions of India, does not deal with economics issues (see for instance Athawale, 2003). However, proponents project them as low cost technology and under-estimate the costs and inflate the recharge benefits. The best example is the government of India report on groundwater management and ownership (GoI, 2007), and recently-sanctioned government of India scheme for recharging aquifers in hard rock districts of south India, with an investment of 1,800 crore rupees.

[6] Many parts of Kachchh, which records one of the lowest mean annual rainfalls (350 mm) experienced floods during 1992 and 2003 with many WH structures overflowing. Flash flood occurs even in some of the semi arid and water scarce basins such as Sabarmati and Banas (Kumar, 2002b).

Table 3: Estimated Unit Cost of Artificial Recharge Structures Built under Pilot Scheme of CGWB

Sr. No	Type of Recharge Structure (Life in years)	Expected Active Life of the System	Estimated Recharge Benefit (TCM)	Capital Cost of the Structure (in Lac Rs.)	Cost of the Structure per m^3 of water (Rs/m^3)	Annualized Cost* (Rs/m^3)
1.	Percolation Tank	10	2.0-225.0	1.55-71.00	20.0-193.0	2.00-19.30
2.	Check Dam	5	1.0-2100.0	1.50-1050.0	73.0-290.0	14.60-58.0
3.	Recharge Trench/Shaft	3	1.0-1550.0	1.00-15.00	2.50-80.0	0.83-26.33
4.	Sub-surface Dyke	5	2.0-11.5	7.30-17.70	158-455.0	31.60-91.00

Source: GoI, 2007, Table 7: pp14

*Estimated by dividing the capital cost by the life of the system

The government of India report (GoI, 2007) bases its arguments for rainwater harvesting on the pilot experiments conducted by CGWB in different parts of India using five different types of structures (see GoI, 2007:). While the estimated costs per cubic metre of water were one-time costs (see Column 6 of Table 3), the report assumes that the structures would have a uniform life of 25 years. Two things in these figures are very striking. First: the costs widely vary from location to location and from system to system, and the range is wide, which the report duly acknowledges. Second: even for a life of 25 years, the upper values would be extremely high, touching Rs.7.7/m^3 of water for percolation tank and Rs. 18.2/m^3 for sub-surface dyke. But, such a long life for recharge system is highly unrealistic[7]. Considering an active life of 10 years for a percolation tank, 5 years for check dam and sub-surface dyke, and 3 years for recharge shaft, we have worked out the unit cost of recharging using these systems.

The results are provided in Column 7 of Table 3. It shows that the costs are prohibitively high for sub-surface dyke and check dam, and very high for percolation tanks. Added to the cost of recharging, would be the cost of pumping out the water from wells. The size of returns from crop production should justify such high investments. A recent study in nine agro-climatic locations in Narmada river basin showed that the gross return ranged from Rs. 2.94/m^3 to Rs.13.49/m^3 for various crops in Hoshangabad; Rs. 1.9/m^3 to Rs. 10.93/m^3 for various crops in Jabalpur; Rs. 2.59/m^3 to Rs. 12.58/m^3 for crops in Narsingpur; Rs. 1.33/m^3 to Rs. 17/m^3 for crops in Dhar; and Rs. 3.01/m^3 to Rs. 17.91/m^3 for crops in Raisen (Kumar and Singh, 2006). The lower values of gross return per cubic metre of water were found for cereals, and high values were for low water consuming pulses, and cotton. This means that the net returns would be negative if recharged water is used for irrigating such crops. Contrary to this, the report argues that the costs are comparable with that of surface irrigation schemes (GoI, 2007: pp 13). Such an inference has essentially come from over-estimation of productive life of the structures.

A close look at the dug well recharging method reveals that this method of in situ water conservation suffers from many problems. First: the open wells used for irrigation are always located at the highest elevation in the farms, which makes it easy for farmers to take the pumped water to the fields by gravity. This means that farmers have to cut deep channels to convey the runoff water from the farthest points in the field to the wells for recharging, which may run into hundreds of metres. This can cost significant amount of money. The filter box alone could cost around Rs. 5000 per farmer. As seen in Section 3.1, the benefits, which are likely to accrue against these investments, are quite low.

[7] The life of the system depends on the type, and also a variety of complex hydrological and hydraulic parameters. In regions receiving flash floods, and where the silt load in flood water is high, the technical efficiency of recharge structures drastically reduces after every major rainfall event. Percolation tanks would require de-silting continuously year after year, cost of which is quite significant when compared to the capital cost of the system. Filters attached to recharge shaft become dysfunctional very fast, after one or two years of rains. So is the case with the recharge tube wells fitted with sub-surface dykes.

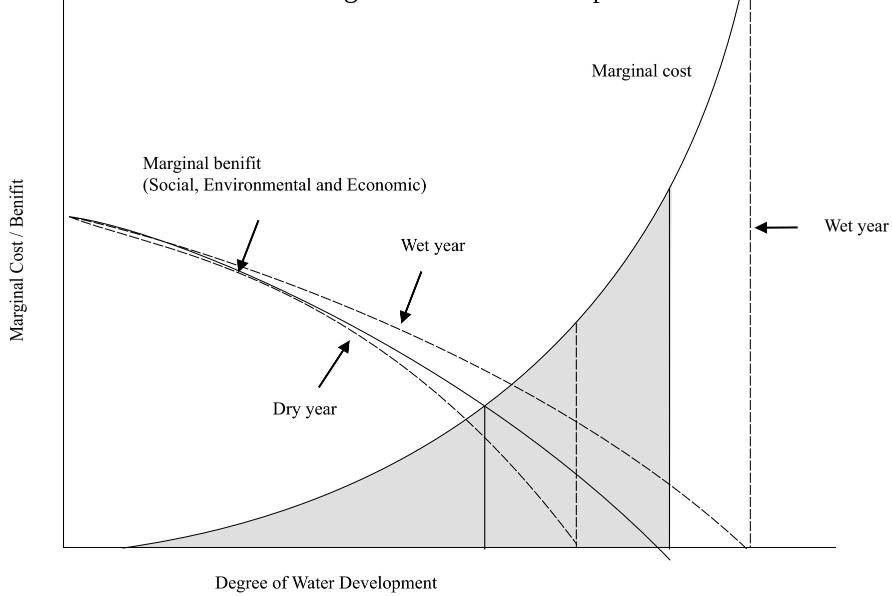
Scale considerations are extremely important in evaluating the cost and economics of water harvesting/ groundwater recharge structures because of the hydrological integration of catchments at the watershed and river basin level. The economics of water harvesting systems for individual systems in isolation do not make sense when the amount of surplus water available in a basin is limited (Kumar, 2000a) and interventions in the upper catchments reduce the potential hydrological benefits from systems in the lower catchment (Kumar *et al*., 2006; Ray and Bijarnia, 2006). In case of the Arwari basin, while the irrigated area in the upper catchment villages increased (where structures were built), it reduces significantly in the lower catchment villages (Ray and Bijarnia, 2006). It is therefore important to look at the incremental hydrological benefit due to the introduction of a new structure.

In any basin, the marginal benefit from a new water harvesting structure would be smaller for basins with higher degrees of development, while the marginal cost would be higher (see Figure 6). The reason being: 1] higher the degree of basin development, lower would be the chances for getting socially and economically viable sites for building water impounding structures, increasing the economic and financial cost of harvesting every unit of water; and 2] with higher degree of development, the social and environmental costs of harvesting every unit of water increases (Frederick, 1993), reducing the net economic value of benefits. Therefore, the cost and economic evaluation should move from watershed to basin level. As Figure 6 indicates, the level at which basin development can be carried out depends on whether we consider the flows in a wet year or dry year or a normal year. There is a stage of development (marked by O in the chart) beyond which, the social, economic and environmental benefits start becoming negative. Here, O is the optimum level of water resource development.

But, it is important to keep in mind that the negative social and environmental effects of over-appropriation of basin's water resources may be borne by a community living in one part of the basin, while the benefits are accrued to a community living in another part. Ideally, water development projects in a basin should meet the needs and interests of all stakeholders. Therefore, optimum level of water development should not aim at maximizing the net basin level benefits, but rather optimizing the net hydrological and socio-economic benefits for different stakeholders and communities across the basin.

The potential impacts of the artificial recharge projects of the government have to be seen from this perspective. Even if recharging of millions of wells and tanks and ponds in the region is achieved successfully, it is unlikely to create equivalent additional economic benefits from agriculture production. As per official

Figure 6: Marginal Cost & Benefit of Water Harvesting with Different Degress of Basin Development



estimates, the total storage capacity created in the river basins of South and Central India, viz., Cauvery, Pennar, Krishna, Narmada, east flowing rivers between Pennar and Cauvery, and east flowing rivers south of Cauvery is 57.11 BCM, against utilizable water resources of 100.32 BCM (GoI, 1999, Table 3.5 and 3.6). Now, the actual volume of water being effectively diverted by the reservoirs/diversion systems in these basins would be much higher due to diversion during the monsoon, and additional water stored in the dead storage. This apart, the traditional minor irrigation schemes such as tanks are also likely to receive inflows during monsoon. It is estimated that the south Indian Peninsula had nearly 135000 tanks, which cater to various human needs including irrigation. Thus, the existing storage and diversion capacities in the region would be close to the utilizable flows. Hence, the livelihoods of farmers, who do not have access to groundwater, will be at stake at least in normal rainfall years and drought year.

To improve the economics of RWH, it is critical to divert the new water to high-valued uses. Phadtare (1988) pointed out that recharge projects would be economically viable in alluvial north Gujarat if the water is diverted for irrigation, as structures are expensive. Yield losses due to moisture stress are extremely high in arid and semi-arid regions and providing a few protective irrigations could enhance yield and water productivity of rain-fed crops remarkably, especially during drought years (Rockström et al., 2003). The available extra water harvested from monsoon rains should therefore be diverted to supplement irrigation in drought years. There are regions where drinking water for human and cattle become high priority demands. North western Rajasthan, which is arid and dominated by pastoral communities, named Gujjars, is one such example. The social and economic value realized from the use of water for human drinking and livestock use, respectively, would be much more than the economic value realized from its use in irrigating crops.

6. SUMMARY AND CONCLUSIONS

In most instances, the regions facing problems of water shortage in India do so due to natural water scarcity. In these regions, demands for water exceeds the utilizable water resources. This is one reason why these regions are facing over-draft of groundwater. These regions are characterized by low and erratic annual rainfalls, high inter-annual variability in rainfall, high aridity due to excessively high evaporation rates including that during monsoon and low and highly variable runoffs. These regions are mostly underlain by hard rock formations, which have poor water holding capacity. These regions have also experienced high degree of water resources development in the past many decades. The basins here are either “closed” or on the verge of “closure”. Modern water harvesting initiatives are concentrated in these regions.

Analysis of data available from pilot projects of CGWB shows that artificial recharging using methods such as percolation tank, check dam, sub-surface dyke and recharge shaft is prohibitively expensive. Also, the cost of using a cubic metre of recharge water for irrigation is much higher than the expected gross returns per cubic metre of the water, making irrigated crop production with it unviable.

As evidences suggest, in these regions, it is impossible to carry out local water harvesting and groundwater recharge activities in an economically efficient way and without causing negative downstream impacts. The reasons are many: highly variability in runoff means high unit cost of capturing water; low infiltration rates for soils overlaying hard rock areas reduce technical efficiency of recharging through percolation tanks and check dams; hard rock aquifers offer very little storage space to absorb the high runoff in good rainfall years; due to high aridity, evaporation from surface storage is very high during monsoon; and the degree of water development is already very high in most water-scarce basins with small traditional water harvesting systems and large reservoirs/diversion systems. This is leading to colossal waste of scarce resources, apart from causing several negative social and environmental consequences. In spite of all this, the recent government of India plans to undertake artificial recharge of groundwater in over-exploited areas of India. This raises fundamental questions about the method used for analyzing the hydrological and economic impacts of these interventions.

Further intensive runoff harvesting in basins with high degree of water development can lead to several negative externalities on the ecosystem health, and the socio-economic production functions, and an overall negative welfare impacts, and therefore has to be discouraged even at private costs.

In sum, there are no “quick fix solutions” to the complex water problems facing India. There has to be a better application of natural and social sciences, the socio-economic and institutional and policy context while designing water management programmes and policies. In this particular case, it is important to generate better understanding of the catchment and basin hydrology, the groundwater storage potential, the stage of water development in the basin, and climatic and socio-economic factors that determine water demands. The experiences from different parts of India show that piecemeal solutions, which do not take cognizance of these, would do more harm than mitigating the problems.

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IMPACT OF WATER HARVESTING ON GROUNDWATER RECHARGE, PRODUCTIVITY AND NET RETURNS WITH INTEGRATED FARMING SYSTEMS APPROACH IN EASTERN DRY ZONE OF KARNATAKA[1]

N. Nagaraj, M. G. Chandrakanth[2] and R. Prathima

Abstract

The paper evaluates the performance of water harvesting structures by looking at the case of the Sujala watershed in Karnataka. The water harvesting structures have facilitated the rejuvenation of failed wells and enhanced the water yield. About 75% of the failed bore wells were rejuvenated as against 66% in the non-watershed. The yield of bore wells were increased by 21% in the watershed where as in non-watershed area the water yield has reduced by 11%. Investment analysis of water harvesting structures indicated that for every rupee of present investment on water harvesting structure there is a return of Rs. 2.79 in farm pond and Rs. 2.19 in recharge pits. Further, productivity of crops has enhanced through protective irrigation given at critical stages of crop growth and moisture conservation, which in turn increased the net returns of the farmer.

1. INTRODUCTION

In India, semi arid areas are characterized by low and variable rainfall, low productivity, degraded natural resources and extensive poverty. In these areas, green revolution had created little impact, where 50% of the rural population depends on agriculture for their livelihood (Kerr, 2001). Recurrent droughts coupled with reduction in number of rainy days, uncertainty of rainfall and its ill distribution are affecting surface and ground water resource availability for irrigation and potable purposes. Further, rural people are facing the predicament of acute water scarcity not only for agriculture but also for livestock and domestic needs. In response, there has been alarming increase in private and public investment on wells for irrigation and drinking water needs leading to overexploitation of groundwater. Hence, it is imperative to conserve rainwater in order to sustain not only rainfed agriculture but also groundwater-irrigated agriculture. The creation of water harvesting structures in a watershed for artificial groundwater recharge entails lumpy investments, which need to be evaluated for their cost effectiveness and social benefits. These structures for surface storage and groundwater recharge offer scarcity value for water and improve access to surface water and groundwater for rural people. Restoration of groundwater through these structures facilitates conservation and management of groundwater ensuring drinking water and sustaining agricultural production. Thus, it is imperative to evaluate the relative economics of different water harvesting structures on improving groundwater recharge and associated benefits of improved agricultural productivity, resource sustainability and livelihood security of the farming community in the watersheds.

The specific objectives of the study are: i) estimation of benefits from water harvesting structures in improving groundwater recharge, agricultural productivity, and profitability; and, ii) analysis of cost effectiveness and feasibility of investment on water harvesting structures

2. METHODOLOGY

Sujala Watershed Project is a World Bank sponsored project being implemented in 5 districts of Karnataka. Its activities are implemented in Kolar, Tumkur, Chitradurga, Haveri and Dharwad covering 1270 villages over

[1] This paper forms part of the research project entitled Institutional and Economic analysis of Water harvesting in different micro-watershed in the EDZ of Karnataka, submitted to Sujala Watershed Project, GOK, Bangalore-9

5.11 lac ha. The project outlay is Rs. 676.96 crore, which includes a loan from World Bank and contribution from government of Karnataka. The objective of the project is sustainable alleviation of poverty in rain fed areas by improving production potential and natural resource base through strengthening institutional arrangements. The project lays emphasis on strengthening capacity of communities in the project area.

2.1 Selection of the Study Area

In consonance with the objectives of the study and consultation with Sujala officials, Kurudi micro watershed of Kumudavathi sub watershed in Gauribidnur taluk of Kolar district was selected for this study, and here most of the watershed activities are completed. The Kadalaveni village outside the watershed, seven kilometers away from the watershed area, was chosen as control area to compare the impact of watershed project. A random sample of 30 respondents from watershed and 30 from control area were selected from each of these villages to constitute a total sample size of 60.

Both secondary and primary data were collected for analysis. Secondary data on investment on water harvesting structures, investment pertaining to watershed activities in private and common land, transaction cost of implementation and sustainable management of watershed assets were collected from Sujala watershed office at Cauvery Bhavan, Bangalore. For evaluating the specific objectives of the study, primary data were elicited from farmers through personal interviews with pre-tested and structured schedule for 2006-07.

3. ANALYTICAL FRAMEWORK

3.1 Amortized Cost of Watershed Programme

The amortized cost represents the annual share of the fixed cost component of watershed development programme. Amortized cost of watershed programme = [(Compounded cost of total public investment on watershed structures)*$((1+i)^{15} * i)] \div [(1+i)^{15} - 1]$.

The working life of watershed structures differed across structures. But the life of the watershed development programme as a whole was considered 15 years considering the average life of different components of watershed development programme.

Compounded cost of groundwater recharge structures = total investment on groundwater recharge structure * $(1+i)^{(2006\text{-year of construction})}$.

Average life of well $= \sum [(f_i X_i) \div \sum (f_i)]$

Where,

f_i = frequency of wells yielding irrigation water in each group

X_i = age group of well (1, 2, 3.….n in years)

i = ranges from 0 to n, where n refers to the longest age of well group

3.2 Yield of Irrigation Wells

The yield of bore well was estimated considering the perception of the bore well owners. In order to revalidate the data from farmers regarding yield of groundwater from their wells, a few cases of actual measurement of groundwater yield from the selected borewells of the sample farmers were made during collection of primary data. The measurements recorded were converted into gallons per hour using appropriate conversion[2].

3.3 Costing of Irrigation Well

Groundwater is commonly extracted from bore - wells in Kurudi micro-watershed. In order to obtain the annul share of irrigation cost, investment on well irrigation is amortized. The amortized cost of irrigation bore

[2] The time required to fill a container of known volume was recorded and converted to gallons per hour. If a bucket of 15 litres, took 5 seconds to fill when borewell was put on, then for 60 seconds or 1 minute, it would fill 180 litres, or 10,800 litres per hour equal to 2379 gallons per hour.

well = [Amortized cost of borewell + Amortized cost of pumpset and accessories + Amortized cost of conveyance + annual repair and maintenance cost of pumpset and accessories]

Amortized cost of bore well = [(Compounded cost of borewell)*$(1+i)^{AL}$ *I]   [$(1+i)^{AL}$ -1]

Where:

AL = Average life of bore wells

Compounded cost of bore well = [(Bore well cost)*$(1+i)^{(2005\text{-Year of construction})}$

Amortized cost of pump set and accessories = {[(Sum of compounded cost of pump set + pump set house + electricity at current price)* $(1+i)^{15}$ * i] [$(1+i)^{15}$ - 1]}

The working life of pump set and pump house is assumed to be 15 years

Amortized cost of conveyance = {[(Compounded cost of conveyance pipe used) * $(1+i)^{10}$ * i]+ [$(1+i)^{10}$ - 1]}

The working life of conveyance pipe (PVC) is assumed to be 10 years.

3.4 Economics of Irrigation

The amortized cost per acre-inch of water is computed by dividing the amortized cost of bore-well by the total water used on the farm. The cost of cultivation is obtained by including expenditure on human labour, bullock labour, machine hours, seeds, fertilizers, plant protection chemicals, manure, transportation and bagging, amortized cost of irrigation and the opportunity cost of working capital. The opportunity cost of working capital is considered at 12%. Cost of production is cost of cultivation + amortized cost of irrigation + interest on variable cost.

The gross cropped area (GCA) is the sum of area under crops in all the three seasons (Kharif, Rabi and Summer) + Area under perennials. The net cropped area (NCA) is calculated as, the sum of area under crops for a season (Kharif) + Area under perennials.

Gross returns for each crop are the value of the output at the prices realized by the farmers. Net returns from well irrigation are the gross returns from crops in irrigated area minus cost of production of these crops. While computing the cost of production, establishment cost of crops like tamarind, which are newly established, could not be considered, as they were still giving returns. Crop wise cost of cultivation is calculated by including water used on the farm in acre inches valued at the cost of water per acre inch for each farm. In the case of rain fed crops, the net returns are derived from subtracting the total costs from the gross revenue.

3.5 Discounted Cash Flow Techniques

The investment appraisal measures such as NPV, BCR and IRR are used to evaluate the economic feasibility of investment on different water harvesting structures. The benefit cost analysis and economic value analysis are carried out based on the investment on water harvesting structures and incremental returns accruing due to water harvesting structures in the upstream and downstream area of the watershed.

Investments on watershed projects are public investment. Hence, choice of discount rate is debatable in benefit-cost analysis. The choice of discount rate is indicative of social time preference, which is a proxy for inflation, risk and opportunity cost and it usually ranges between 3-5%. This represents the difference between the institutional lending rate and the inflation rate. The impact of watershed projects is long term in nature and for the project to be viable; the discount rate should be low. The discount rate considered for this study was 5%.

Many assumptions are made while computing the investment evaluation measures such as NPV, BCR and IRR. The difference in the incremental net returns between watershed and non-watershed was considered as the incremental net returns due to the impact of watershed development programme. This incremental net return due to the impact of watershed development programme was extrapolated for the total cultivated area. The benefits from water harvesting structures like net returns realized from fish rearing were also considered. The incremental net returns after the project implementations were considered for all the farms. Returns from second year onwards are assumed to be same over the entire period, assuming that farmers will fallow the same technology, package of practice and crop cultivation.

3.6 Land Use Pattern in the Micro Watershed

Land use pattern in Kurudi micro watershed is presented in the Table 1. Total cultivable area of the micro watershed is 600.02 ha. Bulk of the cultivable area is under rainfed farming (92%) and only 8% of the area is under irrigated farming with bore wells being the major source of irrigation. Dry land agriculture is dominated and the proportion of irrigated area was relatively low reflecting their reliance on rainfall for even moderate cropping. Thus, watershed development in this area is a gain to farmers, as it richly contributes to soil and moisture conservation and in improving natural resource base. Among the total bore wells in the micro watershed failed wells (52%) proportion was more than the functional wells (48%) emphasizing the importance of watershed on ground water recharge.

Table 1: Land use pattern in Kurudi micro watershed

Particulars	Area (ha)
Rainfed land	554.32 (92)
Irrigated land	45.7 (8)
Fallow land	41.15
Forest area	365
Total cultivable area	600.02
Total number of bore wells	117
Functional wells	56 (48)
Failed wells	61 (52)

Note: Figures in parentheses indicate percentage to total cultivable area

3.7 Investment Pattern on Watershed Treatment in Kurudi Micro Watershed

Investment pattern on watershed treatment in Kurudi micro watershed (Table 2,) indicated that soil and water conservation activities involved major investment on private land (75.11%) followed by the forestry (15.01%). Horticulture component received about 6% of the total investment. In the forestry component, silver oak, pongamia, neem and in horticulture component tamarind, sapota, and mango seedlings were given to the beneficiary farmers. These plants were mainly planted on private lands around water harvesting structures like farm ponds because of access to protective irrigation from farm ponds.

Table 2: Particulars of Investment made by Sujala on Private land

Activity	Value (Lac Rs.)	Percentage
Soil and Water conservation	33.43	75.11
Drainage line treatment	0.59	1.33
Horticulture	2.73	6.13
Forestry	6.68	15.01
Others	1.08	2.43
Total	44.51	100.00

Source: Compiled from the Sujala Watershed Project reports, Cauvery Bhavan, Bangalore

In the common land, only two components were considered viz., soil and water conservation and drainage line treatment. In both, Gokattes were constructed for impounding rainwater for domestic and livestock use (Table 3).

Table 3: Particulars of Investment made by Sujala on Common land

Activity	Value (lac Rs.)	Percentage
Soil and Water conservation	0.57	47.11
Drainage line treatment	0.64	52.89
Total	1.21	100.00

Note: Figures in the parentheses are the percentage of total investment

Major water harvesting structures constructed in the Kurudi micro watershed are farm ponds, recharge pits, earthen bunds in private land and Gokattes in the common land. Farm ponds have gained prime importance in the private land accounting for 58% of the total investment followed by recharge pits (37%). Earthen bunds, Gokatte and Nala revetment altogether accounted for less than 5% of the total investment (Table 4).

Table 4: Major Water Harvesting Structures in the Private land.

SL.No.	Structure	Total cost (Lac Rs.)	Percentage
1	Earthen Bund	1.01	3.00
2	Farm Pond	19.55	58.12
3	Recharge Pits	12.48	37.10
4	Gokatte	0.54	1.61
5	Nala Revetment	0.06	0.18
	Total	33.64	100.00

Investment on water harvesting structures was amortized to get the annual share of the fixed cost on water harvesting structures. About 104 farm ponds were constructed in the entire micro watershed and amortized cost per unit is Rs.2092. There are 28 recharge pits and the amortized cost per unit worked out to be Rs.1674. Earthen bunds were constructed in about 63 ha and amortized cost per ha is about Rs.554.81 (Table 5).

Table 5: Amortized cost of investment on Water Harvesting Structures

Structure	Unit	Qty	Cost per unit	Total cost	Average life (years)	Amortized cost (Rs.)
Common land						
Gokatte	No	9	13444.44	1.21	10	1496.72
Individual land						
Earthen Bund	Rmt	63	1600	1.01 (3)	5	554.81
Farm Pond	No	104	18798.08	19.55 (58)	10	2092.72
Recharge Pits	No	58	21517.24	12.48 (37)	15	1674.59
Gokatte	No.	4	13444.44	0.54 (1.61)	10	1496.72
Nala Revetment	No	24	250	0.06 (0.18)	5	53.04

Note: Figures in the parentheses are the percentage of total investment.

The purpose of amortization of investment on irrigation well(s) is to offer weightage to the repetitive investment on irrigation wells which is made necessary due to reducing life/age of irrigation wells, their initial or premature failure, as well as reduction in groundwater yield of wells, with different probabilities. Else, investment on irrigation wells would be considered as fixed cost which would not enter into the decision making process as the marginal cost is unaffected. However, due to increasing incidences of premature and initial failures of irrigation wells, the investments can no longer be considered as fixed costs, since they become recurring variable costs varying with well failures.

3.8 Impacts of Water Harvesting Structures on well Irrigation in the Study Area

Groundwater is an important resource in watershed development for enhancing productivity and sustainability of farming. Water harvesting structures in watershed development programme facilitates ground water recharge leading to improvement in the availability of water for irrigation. The groundwater recharge in the eastern dry zone of Karnataka with sandy loam soils is largely a function of rainfall intensity and the associated efforts to recharge irrigation wells through surface water bodies such as irrigation tanks, farm ponds and other watershed structures. There have been instances where the ground water in the wells is recharged on the very next day of a heavy rainfall, to several months for recharge. Nevertheless, the impounding the runoff rain water in surface water bodies is crucial for recharge of groundwater. Thus, even though recharge is relatively faster, it is the absence of surface water bodies with adequate water which is responsible for low or poor recharge of irrigation wells in the eastren dry zone. And hence the importance of watershed development, integrated farming systems, drip irrigation and the associated wise use of scarce groundwater. The impact of water harvesting

Table 6: Particulars of Irrigation wells in Kurudi micro watershed

Particulars		Watershed	Non watershed
Number of farmers owning irrigation wells		14	14
Total number of bore wells		20	14
Number of functioning wells	Before watershed	9	4
	After watershed	16	8
Number of Failed wells	Before watershed	11	10
	After watershed	4 (175)	6 (66)
Total number of dug wells		2	2
Average age of the irrigation wells (years)		10.8	10.7
Average life of the irrigation wells (years)		11.4	12
Average depth of the irrigation wells (feet)		323 (80-600)	380(250-700)
Water used per farm (acre inch)		62.20	42.62
Water used per acre of GIA (acre inch)		17.63	21
Irrigation cost per acre inch of water (Rs.)		159.75	246
Amortized cost per all well (Rs.)		9937	10499
Amortized cost per functioning well (Rs.)		10542	11925
Net returns per acre of GIA (Rs.)		29233	19680
Net returns per acre inch of groundwater (Rs.)		1658	1209
Average yield of the bore well (gallons per hr)	Before watershed (2001)	1979	2000
	After watershed (2005)	2396	1800
		(21)	(-11)

Note: Figures in Parenthesis indicate percentage change structures is assessed based on the number of failed irrigation wells rejuvenated, increase in the water yield in the bore wells and reduction in water cost. About 46% of the farmers have irrigation wells in both watershed and non-watershed area. Watershed farmers owned 20 bore wells. Before watershed there were about 9 functional wells and 11 failed wells. After the watershed there are about 16 functional wells and 4 failed wells. About 75% of the bore wells were rejuvenated due to the recharge effects of the recharge pit facilitated by good rain in the previous year. Studies also indicated that watershed development activities have significant impact on groundwater recharge and hence policy focus must be for the development of water harvesting structures (Palinisami and Kumar, 2005, Chandrakanth and Nagaraj, 2005).

In non-watershed areas also about 66% of the borewells were rejuvenated due to good rain but the rejuvenation of bore wells is higher in watershed compared to the non watershed. The yield of bore wells increased from 1979 gallons per hour to 2396 gallons per hour with a 21% change in the watershed. In contrast, in non-watershed area, the water yield reduced by 11% (Table 6).

Average depth of the bore wells was 323 feet in watershed area and 383 feet in non-watershed area. The average age of well was found to be 10.8 and 10.7 years in watershed and non-watershed areas respectively. The average life of bore wells in the watershed area was 11.4 years and 12 in non-watershed area. Amortized cost per bore well was lower in watershed areas (Rs. 9937) than that of non-watershed area (Rs. 10499).

Water used per acre of gross irrigated area is another indicator to assess the impact of watershed development programme on groundwater recharge. The estimated groundwater use was 62 acre-inch per farm in the watershed and 42 acre-inches for non-watershed farmers. Irrigation cost per acre-inch of water is lower in watershed (Rs.159) compared to non watershed (Rs.246). Thus analysis of cost of groundwater irrigation reveals that groundwater recharge has contributed in reducing irrigation cost. Net returns per acre of gross irrigated area is found to be much more in watershed area (Rs. 29233) compared to non-watershed area (Rs.19680). This clearly indicates positive impact of water harvesting structures on ground water recharge.

3.9 Case studies on Farm Pond based Integrated Farming Systems

Farm pond is an in situ water conservation and storage structure. Few case studies of a farm pond where the beneficiary farmer has put the water into multiple uses are given below. There are 48 farm ponds in the sample area with a dimension of 15m X 15m X 3m costing Rs. 18798 per farm pond. About two percent of farm ponds are used for multiple uses, Six percent are or growing fodder crops, six percent of ponds for crops as supplementary irrigation, 17% of farm pond were used for rearing fish and 54% used for trees which are planted and surrounded by farm pond. Hence, we have chosen some of the case studies for economic analysis.

Case Study 1

The beneficiary farmer possessed 3 acres of dry land, of which 2 acres had been devoted towards maize cultivation and 0.75 acre for finger millet. Protective irrigation was provided for maize from the farm pond water resulting in a net return of about Rs.3330. In finger millet, the incremental net returns realized were about Rs. 250, which is the result of the improved field bunds for moisture conservation.

The farmer allotted two guntas of land for napier and haemata grass and the associated net returns realized was about Rs.1700. Returns from fishery component at explicit cost in the farm pond was Rs.867. From livestock component, there was an improvement in the milk yield to the tune of two lt per day due to increased availability of fodder. The cumulative incremental return from all these activities was Rs.9406 (Table 7).

Further costing of farm pond water has been carried out to know the productivity of water. The actual dimension of the farm pond is 15 x 15 x 3 m. Considering the slope (1:1.2), the dimension of the farm pond comes to 11.5 x 11.5 x 3m. Depth of water impounded was about 10 feet and it was filled three times in year. So the total water impounded was about 1190 cubic meter in a year. The amortized cost of farm pond per year was Rs.2092. The cost per cubic meter of water was Rs.1.76 and net return per cubic meter of water is worked

Table 7: Costs and returns of Farm pond based farming system

Crop	Before				After			
	Area	Yield	TC	NR	Area	Yield	TC	NR
Maize	2	15	5130	6320	2	20	4850	9650
Ragi	0.75	3	1125	2325	0.75	4	1125	2575
Napier and Haemata (kg)	-	-	-	-	2 gunta	1900	200	1700
Fishery (number)	-	-	-	-	250	32	107.73	867.27
Livestock	1	12	14762	6805	1	14	15112	10064
Total	-	-	21017	15450	-	-	21394	24856

out to be Rs.7.90 with multiple use of water from the farm pond. This situation is again compared with the farm pond where the water is not used for multiple purposes. The cost per cubic meter of water remains same. Farm pond water is used for only haemata, which was planted on the bunds. So the increase in milk yield due to availability of fodder is considered in the net incremental returns, which comes to Rs.2.70 per cubic meter of water (Table 8). Farmers with integrated farming system have realized more benefits compared to those who have not.

Table 8: Comparison of cost and returns with and without multiple use of water

Particulars	With multiple use of water (Crop+Fodder+ Fishery +Livestock)	Without multiple use of water (Crop+Livestock)
Dimension (m)	15 x 15 x 3	15 x 15 x 3
Dimension with slope (1.2:1)	11.5 x 11.5 x 3	11.5 x 11.5 x 3
Depth of water filled (ft)	10	10
No. of times water filled in year	3	3
Water impounded in one filling (Cubic meter)	396.75	396.75
Total water impounded (m^3)	1190.25	1190.25
Amortized cost (Rs.)	2092	2092
Cost per cubic meter of water (Rs.)	1.76	1.76
Net returns per cubic meter of water	7.90	2.70

Case Study 2

In another case study, the farmer had three acres of dry land, of which 0.75 acre was devoted towards cultivation of chilly using the farm pond water. Around 4 irrigations were provided from farm pond water using kerosene oil pump. The net return realized from chilly was about Rs. 3720. On the periphery of the farm ponds, vegetables were grown resulting a net return of Rs. 1160. Similarly, the net returns due to fishery component in the farm pond was Rs. 867, while the incremental net return from increased milk yield was about Rs. 1804. The sum of incremental net return realized was about Rs. 7551 (Table 9).

Case Study 3

In this particular case, a number of components are included such as vegetables, flowers and fodder crops. In the adjacent land, different layers of trees have been grown (silver oak, drumstick, bamboo, lemon, papaya, mango, sapota, jack, jamoon, tamarind and ficus). Fish rearing was undertaken in the farm pond water

Table 9: Case Study

Particulars	Area	Yield	TC	NR	Area	Yield	TC	NR
Maize (Qtls)	2	16	3780	7420	2	16	3780	7420
Chilly (Qtls)	-	-	-	-	0.75	6	8280	3720
Vegetables grown								
inside the farm pond	-	-	-	-			445	1160
Fisheries	-	-	-	-	250	32	107.73	867
Livestock (Buffalo) (ltrs/day)	1	4.5	5040	5112	1	5	5040	6916
Total	0	0	8820	12532	0	0	17652.73	20083

Note: Vegetables grown are ridge gourd, Bottle gourd, Pumpkin, Ladies finger, castor and red gram

and haemata was grown on the farm pond for fodder as well as it serves as a good soil binder. The total present net benefits from the farm pond were about Rs.4543 per year (from vegetables, fishery and livestock). For the tree crops, the expected benefits over the lifespan are considered for working out the net present value. There are about 100 trees planted around the farm pond and NPW from these constituted around Rs.6, 92,293 and per tree, it worked out to be Rs.6923. The BC ratio was 14 and the IRR was 38%. In addition to the economic benefits, the bio diversity of the field has improved (Table 10).

Table 10: Case study

Particulars	Net returns
Present benefits	
Vegetables grown in small scale	708
Returns from fishery (Explicit cost)	460
Returns from live stock (incremental net returns)	3375
Total present benefits	4543
Expected benefits from the trees grown around the farm pond	
NPW (Rs.)	6,92,293
BC ratio	14
IRR (%)	38

3.10 Additional Costs and Returns Due to Introduction of WHS

Partial budgeting analysis was carried out to analyze the profitability of water harvesting structures. In this regard, the additional cost and additional returns realized due to the investment on water harvesting structures is considered. Analysis was carried out separately for each water harvesting structure.

In the case of farm pond, partial budgeting analysis was carried out with integrated farming system and without integrated farming system. Integrated farming system approach includes fishery, vegetables on a small scale and livestock. In this case additional returns (Rs. 6144) obtained exceeded the additional cost (Rs. 2994) resulting in a net gain of Rs. 3154 (Table 11).

Table 11: Additional costs and returns due to farm pond with Integrated farming system.

Cost		Benefits	
Added costs		Increase in benefits	
1. Amortized cost of farm pond	2092	1. Additional returns from fishery	975
2. Additional cost on fishery	107	2. Additional returns from the vegetables grown	1605
3. Additional cost incurred on growing vegetables	445	3. Additional returns from cow (increase in milk yield by 1.5 ltr per day due to haemata grown on farm pond)	3564
4. Additional cost on Haemata	350		
Total	2994	Total	6144

Net gain: Rs. 6144 - Rs.2994 = Rs.3150

Table 12: Partial budgeting for the Farm pond without Integrated farming system.

Cost		Benefits	
Added costs		Increase in benefits	
1. Amortized cost of farm pond	2092	Additional net returns from increased productivity of tamarind	1000
2. Additional cost on Haemata	350	Additional returns from cow (increase in milk yield by 1.5 ltr per day due to haemata grown on farm pond)	3564
Total	2442	Total	4564

Net gain: 4564-2442 = 2122

Without integrated farming system, the additional returns realized were Rs.4564 and the additional cost was Rs.2442 with a net gain of Rs.2122. In this case, farmers had sown only haemata seeds as fodder on the farm pond to feed livestock. There was also an added return due to plantation of the tamarind trees (Table 12). Thus, the integrated farming system approach generated more benefits than without integration of enterprises.

In the watershed, recharge pits were exclusively constructed for the recharge of borewells. As a result, the added cost (amortized cost) was about Rs.1674, and the added gains in terms of net returns realized from additional area bought under irrigation was Rs. 14160. The recharge pits enabled to increased area under irrigation to the tune of 0.54 acre (Table 12).

3.11 Benefit Cost Analysis

The results of Benefit-Cost analysis of water harvesting structures are presented in the table. Sensitivity analysis was also carried out to determine the feasibility of the investment on water harvesting structures with a fall in expected net returns by 10-20%. Farm pond yielded a net present worth of Rs.132 lac upon realization of expected returns. If there is 10% reduction in expected returns, it would give a net present worth of Rs. 118 lac and with 20% reduction in expected returns it was 105 lac. Discounted benefit cost ratio was Rs. 2.79, Rs. 2.51 and Rs. 2.23 upon realization, 10% reduction and 20% reduction in expected net returns. The IRR worked out to be 14% and 13% upon a reduction of 10 and 20 percent expected net returns. In the case of recharge pits, the net present worth per acre was Rs. 62 lac, 54 lac and 45 lac respectively under three conditions. With respect to

BCR Rs. 2.10 is obtained per rupee of investment on recharge pit on realization of expected returns. All these measures indicated that the investment on farm pond and recharge pits (which forms around 95% of total investment on water harvesting structures) is economically feasible (Table 13).

Table 13 : Benefit cost analysis of water harvesting structures

Particulars	Investment on WHS (Lac Rs.)	Total cost including maintenance cost (Lac Rs.)	NPV @5% (Lac Rs.)	Discounted BCR	IRR (%)
Farm ponds					
Upon realization of expected returns	19.55	47.36	132.18	2.79	14
Upon reduction of 10 percent of expected returns	19.55	47.36	118.97	2.51	14
Upon reduction of 20 percent of expected returns	19.55	47.36	105.75	2.23	13
Recharge pits					
Upon realization of expected returns	12.48	29.95	62.93	2.10	56
Upon reduction of 10 percent of expected returns	12.48	29.95	54.27	1.81	49
Upon reduction of 20 percent of expected returns	12.48	29.95	45.61	1.52	42

4. SUMMERY AND CONCLUSIONS

The productivity of crops has enhanced through protective irrigation given at critical stages of crop growth and moisture conservation, which in turn increased the net returns of the farmer. About 75% of the failed borewells were rejuvenated as against 66% in the non-watershed. The yield of bore wells were increased by 21 percent in the watershed where as in non-watershed area the water yield has reduced by 11 percent. Few case studies of a farm pond where the beneficiary farmer has put the water into multiple uses have been compared with the case where water has not been put into multiple uses. Cost per cubic meter of farm pond water is Rs. 1.76 while net return is Rs. 7.90 with multiple uses of water (integrated farming system) and Rs.2.70 for without the multiple use of water. Partial budgeting analysis indicated the highest net gain (Rs. 3154) in the case of multiple use of water (IFS) compared to without multiple use of water (Rs. 2122). In the case of recharge pits additional returns (Rs. 15834) exceeded the additional cost (Rs.1674) with a net gain of Rs.14160. In earthen bunds, there was a net gain of Rs.696/ha. Investment analysis of water harvesting structures indicated that for every rupee of present investment on water harvesting structure there is a return of Rs. 2.79 in farm pond and Rs. 2.19 in recharge pits. IRR is around 14% in farm pond and 56% in recharge pits.

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WATERSHED DEVELOPMENT IN NORTH-EAST: PROBLEMS AND OPPORTUNITIES*

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Abstract

The paper looks at some of the watershed development programs in the north eastern states of India. Given the unique topography, fertile land, abundant water resources, evergreen dense forests, high and dependable rainfall, mega biodiversity and agriculture friendly climate. It has various constraints such as uneven topography, soil erosion, small landholdings and jhuming practice of agriculture or shifting irrigation, which has lead to a number of environmental problems. To address the problems of the region government of India had initiated several watershed development programs to improve people's livelihoods and abolish the practice of jhum cultivation. Watershed programs have helped in raising income, generating employment and conserving the natural resource base as well as motivating people to abandon jhum practice. Watershed program can greatly help to alleviate poverty by raising farm productivity and generating employment opportunities in marginal and fragile environments. The scope for watershed development is even greater in given the region's problems and opportunities.

1. INTRODUCTION

North-Eastern Region (NER) comprising of eight states has remained far behind in the growth and development of the country. Agriculture being an important economic sector in the NE region contributes about 30% to gross domestic product and is the main source of livelihood for a majority of rural population. However, agriculture in the region is mainly subsistence, low input and technology laggard (Birthal *et al*, 2006). The geophysical conditions limit horizontal expansion of cultivable land. The percentage of cultivated area to total geographical area ranges from 2.2% in Arunachal Pradesh to 35.4% in Assam as compared to 43.3% at national level. High growth of population (varying from 2.01-5.22% per annum, except in Assam and Tripura) with a large proportion of small and marginal farm households, traditional and low input agricultural practices coupled with the problem of insurgency have affected the agricultural economies adversely in the region. The region has several unique features such as fertile land, abundant water resources, evergreen dense forests, high and dependable rainfall, mega biodiversity and agriculture friendly climate. Yet it has failed to convert its strengths optimally into growth opportunities for the well-being of the people (Barah, 2006).

Sustained supply of irrigation water is crucial to improving production and productivity of agricultural crops, but only about 10% of the total cropped area in the region is irrigated (FAI, 2003). The region has considerable surface and groundwater resources because of its location in the high rainfall zone varying from 1400 mm to 6000 mm across NE states, but remain untapped due to uneven topography and difficulty in construction of reservoirs.

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1.1 Jhum Cultivation

Jhum practice or shifting cultivation is regarded as the primitive step in transition from food gathering to hunting and food production. When this system emerged, it worked well and there was a balance of 20-30 years between fallow cycles. However, with increasing population pressure, the jhum cycle slowly reduced to 3-6 years, causing serious land degradation and ecological problems. Jhuming is practiced by tribals on the hill slopes ranging from steep to very steep. The jhumias do not own the lands and it belongs to the forest or revenue department. Generally, areas having good forest growth or dense bamboo forest are selected for jhuming as they give good burn; consequently, better crop yields. There is progressive degradation of the production base due to large-scale deforestation by shifting cultivation. Since the hill tops, particularly the catchment areas are the source of water, deforestation in the hills has led to elimination of sources of water while increasing run-off water. The system is labor intensive with low technology. The system leads to severe soil erosion; low crop production; and elimination of important tree species as well as genetic resources of the region; thereby causing a total degradation on the natural resources resulting in the ecological imbalance in the area.

2. ROLE OF WATERSHEDS

The role of watershed programs in the development of rainfed agriculture in India has been documented by a number of researchers (World Bank, 1990; Fernandez, 1994; Farrington and Lobo, 1997; Hinchcliffe et al., 1999; Kerr John, 2002; Kerr John et al., 2002; Joshi et al., 2005). These studies bring forth various issues related to watershed development programs, such as management of common property resources, sharing of benefits and costs, multiple and conflicting uses of common property resources within watersheds, multiple and overlapping property rights regimes in watersheds, difficulty of encouraging social groups to organize around a spatial unit defined by hydrology, upstream and downstream issues, equity and gender.

The north east region (NER) has problems of; uneven topography, soil erosion, small landholdings, *jhuming* practice, and opportunities of; fertile land, high and dependable rainfall and agricultural friendly climate. This can be a good bet for the development of watershed programs on large scale. The region is confronted with two major water related problems; (i) heavy and intense rainfall and surface run-off during monsoons leading to soil erosion and siltation or pollution of water bodies downstream; and (ii) drought situation in the months of February to April, leading to acute scarcity of water for spring season crops. These two extreme eventualities need to be managed for enhancing agricultural productivity, augmenting income and preventing degradation of soil and water, which can be best addressed by watershed programs.

Rainfed agriculture in India occupies an important place in the development initiative as 69% of 142 million hectare is rainfed, and productivity is low (> 1 ton per ha) although potential is quite high (Wani *et al.*, 2004). India achieved self-sufficiency for food through the green revolution. Integrated watershed management programs have shown the potential of doubling productivity of rainfed areas (Wani et al., 2003), an opportunity to maintain self-sufficiency for food while sustaining the natural resource base.

3. PROBLEM SPECIFICATION AND METHODOLOGY

A number of impact assessment studies have been done in past by various researchers and organizations on watershed development programs. However, no thorough study has been conducted on the impact of water-

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[4] Meta analysis is a statistical procedure that integrates and upscales numerous spatially and temporally distributed combinable micro-level studies to distil logical macro-level policy inferences. The inferences drawn, based on meta analysis, are often more objective and authentic.

[5] A list of these studies is given at the end of paper. Moreover, four case studies were conducted in 2007 under which, four watershed projects were selected which were implemented by various departments and organizations under various watershed programs. The purpose was to see the performance of these different agencies in implementation of these programs and their effectiveness with respect to targeted objectives.

shed development programs carried out in the north eastern region, which has a peculiar geography and social system from the rest of the country. It is in this endeavor that the study was attempted. The study is based on the review of evaluation reports as well as the case studies carried out under the project. In this regard, various departmental reports were collected and studied to get broader conclusions from these reports. The study assessed the performance of watershed programs by employing meta analysis[4]. Based on an available review of 37 case studies on watershed programs in north east region, the study attempted to document efficiency, equity and sustainability benefits. Similar approach was followed by Joshi et. al. (2005) for Indian watersheds, which however excluded the north east states[5].

4. HISTORY OF WATERSHED PROGRAMS IN NE REGION

The history of watershed management in India dates back to 1880 with the Famine Commission and then with Royal Commission of Agriculture in 1928. Both commissions laid the foundation for organized research in a watershed framework. After Independence, the Government supported programs started in mid-1950s, when the focus on watershed programs was sharpened with the establishment of the Soil Conservation Research, Demonstration and Training Centres at eight different locations of the country. The center started watershed activities in 42 locations mainly at small-scale to understand the technicalities of soil degradation and options that contribute to soil conservation (Samra, 1997).

As per the report of the Task Force on Development of Shifting Cultivation Areas, constituted by Ministry of Agriculture in 1983, the total area affected by *jhum* practice was 43.57 lakh hectares in the states of Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Orissa and Tripura. In the seven states of north east, (As per ICAR Research Complex for NEH Region) a total of 14.66 lac ha was affected with *jhum* problem involving 4.433 lac *jhumia* families. In order to address the problem of shifting cultivation, the Government of India took a major initiative by launching the Watershed Development Program for Shifting Cultivation Areas (WDPSCA). The WDPSCA program was taken up during the fifth five year plan as a pilot project with 100% financial assistance from the central government and was implemented through ministry of agriculture. The scheme was launched during 1976-77 covering all NE states, Andhra Pradesh and Orissa. After operation for 2 years, the scheme was transferred to state sector as per the decision of National Development Council (NDC). A total of 1700 *jhumia* families benefited with an expenditure of Rs.129.71 lac in its initial phase.

A similar scheme was launched during the VII Plan, in persuasion of the recommendation of the Task Force on Shifting Cultivation (1983), again with 100% central assistance to the State Plan Program from 1987-88 to 1990-91 in the same stages and later transferred to the State Sector and discontinued from 1991-92. During the VII Plan also the scheme was implemented through the ministry of agriculture on the basis of family development approach and 26512 *jhumia* families benefited under the program with an expenditure of Rs.60.72 crores. In 1994-95, on pressing demand from NE states, the Planning Commission agreed for revival of the scheme for NE region only as an additional central assistance to State Plan Scheme.

The Government of India (GOI) undertook strategic investments through watershed approach to develop rain-fed areas for sustainable management of natural resources in the region. The National Watershed Development Program for Rainfed Areas (NWDPRA) introduced at national level in 1986-87, was started in NER by 1990-91. The funding pattern was 75% grant in aid and 25% as loan to the states. The NWDPRA program which was launched in the VIII Plan, continued in IX and X five year plans as well. Apart from this, the Integrated Wasteland Development Project Scheme (IWDP) was taken up by the National Wasteland Development Board also aimed at developing wastelands on a watershed basis in the region.

5. BENEFITS OF WATERSHED PROGRAMS

Watershed programs have been specifically launched in the rainfed areas with the primary objective of improving livelihoods of poor rural households that are afflicted by a disproportionate degree of risk with respect to agrarian activities. Their net income levels are low and uncertain and their plight is compounded by acute degradation of soil and water resources (Wani et al., 2003). The Government of India aggressively intensified watershed programs in fragile and high-risk ecosystems, where farm incomes drastically declined due to excessive soil erosion and moisture stress. It was anticipated that the watershed programs would augment farm incomes, raise agricultural production and conserve soil and water resources in rainfed areas through appropriate technical and financial support (Joshi et al., 2005).

Watershed programs were initiated over a wide range of "agro-ecoregions" and were planned, developed and implemented by various government agencies. A review of the available reports (37 in number for NE states) indicate that the past investment in watershed programs yielded positive results like raising incomes, generating employment opportunities and conserving the natural resource base. A summary of the multiple benefits derived from these programs is presented in Table 2.

It is worth mentioning that the watershed programs were launched in the region with four principal objectives, namely, improving production efficiency, equity, sustainability and abandonment of *jhumia* (shifting cultivation) practice in the NE region. To document these benefits proxy indicators were chosen and analyzed. The benefit-cost ratio (BCR) and the internal rate of return (IRR) were used as proxies from efficiency gains from the watershed programs. However, there is criticism of the way BC ratio and IRR are arrived at in the Indian context. All these evaluation reports have been prepared by different organizations and most probably may not have adopted the same procedure in calculating these figures. Moreover, the watershed programs generate substantial non-market benefits and costs, which cannot be quantified easily in monetary terms. Additional employment generation in agriculture as a consequence of watershed activities was assessed as an equity benefit. Four important indicators were identified to demonstrate sustainability benefits. These include (i) increased water storage capacity, which augments irrigation; (ii) increased cropping intensity; (iii) reduced run-off leading to reduced soil loss; and (iv) abandonment of *jhumia* practice, which conserves the natural resource base and makes the people of region settle down to farming. Similar approach was also used by the Joshi et al., (2005) in meta analysis of watersheds and their impacts in India.

The mean benefit cost ratio of watershed program was modest at 1.79 indicating that the investment in watershed programs in the North East region yielded near to double the initial investment. Similarly, the mean internal rate of return on watershed investments was approximately 19.40%, with a maximum of 39.25% (Table 2). These results suggested that the watershed programs performed reasonably well under these fragile and uncertain environments and the investments were justified as it raised income levels within the target domains.

Another important function of watershed programs was to generate employment opportunities. This would have the positive impact of alleviating rural poverty and reducing income disparities among households. The mean additional annual employment generation in the watershed area on various activities and operation was 164 person days/ha/year. In those watershed projects that included multiple activities, employment generation increased to 795 person days/ha/year. The generation of employment opportunities within these rural communities will invariably increase their purchasing power and a corresponding decline in rural poverty. Based on these observations, the watershed investments may be viewed as a poverty alleviation program in the fragile areas.

Rainfed areas are confronted with acute problems of land degradation through soil erosion, and high levels of risk associated with agriculture due to variable rainfall. Technological interventions through soil and water conservation can greatly reduce the risk in rainfed degraded systems. The watershed programs largely aimed to conserve soil and water as a means of raising farm productivity. The available evidences revealed that both these objectives were accomplished in the watershed programs. There is a mean reduction of 63% in soil loss due to watershed interventions (Table 2). This has a direct impact on expanding the irrigated area and increasing cropping intensity. On average the irrigated area increased by 60.25%, while the cropping intensity increased by 24.67% (Table 2).

Watershed programs such as the WDPSCA Scheme were launched in the NE states for abolition of *jhumia* cultivation in a befitting way. Watersheds were taken as units of development in order to lead the *jhumias* to the principles of proper scientific land use technique according to land capability and suitability. Seventh and eighth five year plans focused on conservation, management and development of land and water with village community as a whole on watershed basis instead of settlement and resettlement of *jhumia* families alone. Land and water conservation was carried out in an integrated manner with scientific land use planning in an eco-friendly system, which led to increase in productivity and employment generation. The summary results on this account reveal almost 40% reduction in the area under *jhumia* cultivation under these watershed projects with a maximum of 90% in area reduction. These benefits confirm that the watershed programs are a viable strategy to overcome several externalities arising from the degradation of soil and water resources. The above summary results of the reviewed watersheds clearly suggest that these programs successfully meted the objectives. These benefits have far reaching implications for rural populations in the rainfed environments. However, the benefits often vary depending upon the location, size, type, rainfall, implementing agency, and people's participation, among others (Joshi et al., 2005).

6. CAST STUDIES

The watershed programs in the country were undertaken with multiple objectives ranging from the rehabilitation of degraded areas to conservation of the resource base and improvement of productivity in agriculture (Joshi *et al.*, 2004). In recent years, the watershed programs have become more focused on poverty reduction and livelihood security. In order to get an onsite assessment of the watershed programs and its benefits to the community, case studies were conducted through PRA and discussions were held with the watershed committee members, SHGs, beneficiaries and landless along with the PIAs of the watersheds. In all, four watersheds were selected which were implemented by different agencies/organizations under different watershed development programs in the state of Meghalaya. The detailed case studies of these watersheds are documented in the following sections.

6.1 Umpling-Umrynjah Watershed (WDPSCA)

The Umpling-Umrynjah Watershed program was done under the Watershed Development Program for Shifting Cultivation Areas (WDPSCA) sponsored by Ministry of Agriculture (MoA), government of India and implemented by the Soil and Water Conservation Department, Shillong, East Khasi Hills District, Meghalaya. The watershed development program was started in the year 1999-2000. The watershed is located in the North Eastern direction on the Shillong Umroi Airport road at a distance of about 38 km under Mylliem C&RD Block, East Khasi Hills District. The watershed lies geographically between 25^{o} 39.6" to 25^{o} 41.4" North Latitude and 91^{o} 53.3" to 92^{o} 0" East Longitude. It covers four villages; Umrynjah, Madan Mawkhar, Umphrew and Umjathang with a total number of 183 households. The total geographical area of watershed is 1300 ha with a net treatable area of 875 ha. The project cost is Rs.63.54 lac with a project period of five years.

6.1.1 Objectives of the program

The main objectives of the watershed development project were (i) to protect and develop hill slopes of *jhum* areas through different soil and water conservation measures on watershed basis and reduce further land degradation process, (ii) to encourage and assist *jhummia* families to develop *jhum* land for productive use with improved cultivation and suitable practices, (iii) to improve the socio-economic status of the people through household/land based activities; and (iv) to mitigate the ill effects of shifting cultivation by introducing appropriate land use and water management technologies. With this aim in mind, the project was formulated in the concept of watershed development and carried out in the organizational and committee set up.

6.1.2 Methodology

In order to make the project a people's program addressing their needs based on the priorities and available resources, the PIA did a participatory rural appraisal (PRA) exercise using various techniques viz. participatory mapping, wealth ranking, matrix ranking, transect walk, and venn diagram with the villagers and beneficiaries to understand what the people have to say about the program.

6.1.3 Process

In order to empowerment people by the project, decentralization of decision making process was brought in by identifying existing village institutions namely, *durbar shnong* (village council). Umpling-Umrynjah Watershed Association (WA) was formed and registered as per the Society Registration Act. Members were made aware of their duties and responsibilities. The president and its members head the association. All the works taken up in the project were done in consultation with the WA.

Watershed Committee (WC) were constituted by the WA and comprises representatives of village elders, user groups, SHGs, youth and women's groups. All members have been imparted trainings and are made aware of their roles and responsibilities. The committee is headed by the chairman, and the secretary is drawn from the PIA. When the group matures, the secretary may be withdrawn. All works and day to day activities are supervised by WC and facilitators.

To gain confidence and enthuse the spirit of belongings among the WC, certain activities were identified by the committees and taken up with participation and labor contribution from people. Entry point activities such as drinking well, washing place, community water harvesting structure, repairs of community hall, school building including footpaths were taken up on priority in all the four villages falling under this watershed.

In the watershed villages, SHGs have been promoted and linked with financial institutions. A good number of SHGs have been promoted comprising of agricultural laborers, landless persons, women and youth. Separate groups were organized among women, as they have been found highly successful in management of credit and thrift activities. Each group has 10-15 members. Twelve SHGs have been formed under Umpling-Umrynjah Watershed among which 7 groups have already been graded by Mylliem C&RD Block/Bank and DRDA have granted revolving fund of Rs.25000 each.

The watershed also witnessed the convergence of several R&D schemes through DRDA such as providing drinking water supply. Agriculture Department provided HYV seeds of paddy, maize, soyabean and conducted training programs on taking up specific crop production technologies in the watershed areas. Through horticulture department, Rs.30,000 was granted for taking up vermi composting under Technology Mission (TM) and Rs.40, 000 for green house to SHGs under Umrynjah (WDPSCA). Other departments such as veterinary, PWD, DIPR, State Council for Education and Training and ICAR were also involved in the watershed development program. Various training programs were held for different categories of farmers such as training of watershed association and watershed committee members on their roles and responsibilities in watershed committee development, SHGs formation and watershed volunteering. Field visits to developed watersheds like ICAR, RRTC, Umran, and Vocational Training Centre (VTC) were held to appraise the target groups of the new technologies in farm production and how to replicate those activities in their respective watershed areas.

6.1.4 Work carried out

The development activities carried out on arable land were in form of contour bunding, peripheral bunding, agro-horticulture, crop demonstration, improvement of existing paddy fields etc. Non-arable land treatment mainly included afforestation, dry land horticulture, improvement of existing natural forest and establishment of compost nursery. Furthermore, drainage line treatment in form of spurs or protection walls, small dug out ponds, check dams, diversion dams and water harvesting structures were taken up under the program.

6.1.5 Future Funding for Project

In an effort to make the project sustainable, community participation and contribution to the tune of 5%

was made mandatory and this was achieved through participatory approach. The fund generated through labor contributions, calculated in terms of monetary value was deposited in the fixed deposit with RRB, Mawlai Branch and the same is to be jointly operated by President of WA and Chairman of WC after the end of project for maintenance of assets created during the project period. The four WAs of four villages have a corpus fund of Rs.2, 04,804. Besides this, they have planned to collect a fixed amount from individual beneficiaries to maintain corpus fund for watershed activities. The respective WAs duly adopted a resolution that every household shall contribute 5% each time for every development activity to WDF which will be maintained by the Executive Committee (*Durbar Shnong*). Fund may also be used to provide loans to SHGs at nominal interest besides helping the poor and needy in times of emergencies or natural calamities. Moreover, they have community forests from which they can generate the funds for maintenance of watershed structures after project withdrawal which is scheduled in a short time period. The impact indicators of the Umpling-Umrynjah watershed are shown in Table 3.

6.1.6 Impact

In the watershed area, farmers have diversified their farming practices by switching over to double and mixed cropping systems instead of mono cropping system as practiced earlier. In areas with assured irrigation facility, they grow paddy as main crop followed by subsidiary crops like potato, tomato and french beans. Under rainfed conditions, the farmers take ginger and maize as main crop mixed with other subsidiary crops like yam, bitter gourd, cucumber, soybean, french beans and pumpkin.

During discussion with beneficiaries and members of WC, it was revealed that all farmers were practicing *jhum* cultivation previously, but have given it up (except 6-7 farmers) after watershed implementation. As per farmer's own assessment, with adoption of contour bunding, they were able to arrest about 95% of soil erosion. There has not been much change in the composition of crops, only change is that they improved existing cultivation of crops and have come to settled crop cultivation system. In terms of crop productivity, there has been increase of almost 40% which may mainly be attributed to HYV seeds and better irrigation. There is a 23% increase in household income from farming. About 399 ha area was brought under agro-horticulture system while 296 ha non-arable area was brought under dry land horticulture. Besides this, horticulture was introduced in watershed development program. Varieties of fruit plants such as guava, pear, lagoon pear, Khasi lemon, Assam lemon, mosambi, plum, peach, papaya, jack fruit, chest nut etc were distributed to beneficiaries and planted in their homestead/back yard garden. The survival rate of these fruit plants was about 85%, which is satisfactory. Once these fruit plants come in bearing stage, it will change the household economy of the beneficiaries.

In order to address the equity problem, watershed program also targeted poor and landless farmers in its developmental program through activities such as bee keeping, tailoring, piggery, pisciculture and vermicomposting, by formation of SHGs. Besides these special packages, landless people also benefited through labor work under watershed development program. Beneficiary card is also maintained for rehabilitation program of *jhumia* families containing basic information about the beneficiary, his family, current income, activities taken up, disbursement of funds, progress and benefits, which is being updated from time to time and for which separate funds have been earmarked (17.5% of the project cost).

6.2 Lyngiong Watershed (NWDPRA)

The Lyngiong Watershed was implemented by the State Agriculture Department under NWDPRA (X^{th} Plan). Presently, there are 78 watersheds under NWDPRA in Meghalaya State which are in the last phase of implementation and are expected to be completed by September, 2007. The Lyngiong Watershed was chosen for case study as almost 95% of the interventions were already over. It is located on Shillong-Mawsynram road about 36 km from capital city Shillong. The total geographical area of watershed is 515 hectares with 292 hectares arable area and 207 ha non-arable area. The total project cost is Rs.16.50 lac. It covers six villages.

6.2.1 Process

Before implementation of WS program, the PIAs made a meeting with the *Durbar Shnong* (village council) in which they were made aware of the proposed project. After few meetings, WC was formed which was selected by the general Durbar Committee members. With the formation and registration of WC, actual layout for developmental works was sorted out in consultation with the members. Watershed Associations (WAs) were formed at village levels. Each WAs comprise of 7-10 members. There are three women members in six WAs, however, they have a fair number of six in Watershed Committee (WC) out of total 15 members. Besides this, there are six women SHGs in the watershed area.

6.2.2 Works carried out

Developmental works carried out consisted construction of check dams and stabilization of stream bank in form of brush wood structures and boulders. There was considerable land reclamation in upper watershed area due to the developmental activities carried under watershed program. Besides this, a number of fishery ponds were constructed on private lands as well as community land. In case of private lands, 20% of the cost was shared by the beneficiary for making the fishery ponds and rest came from the watershed program. The other activities include piggery, poultry, goat rearing and vermi-composting.

6.2.3 Impact

There is a shift from traditional crops to high value vegetable crops in the area due to increase in water availability and better facilities provided under watershed program. The watershed villages were predominantly potato growing area with little paddy cultivation also. Under watershed development program, farmers started pea cultivation, which gave good results and better income. Quality seeds were provided by the department. There was a 18-20% increase in the yield levels of various crops. Pig rearing and poultry farming were very successful under the watershed development program[6]. Goat rearing and fisheries were also adopted with susccess. Good number of fish ponds were constructed under the watershed program, which will boost the beneficiary income after two-three harvests. The impact indicators for Lyngiong watershed are given in Table 4. These indicators show improvement in the livelihood opportunities of the beneficiaries.

6.3 Wah Umroi (ICAR Model Watershed)

Development of model watersheds in NE region under NWDPRA scheme was entrusted to Engineering Division of ICAR Research Complex for NEH Region, Barapani, Meghalaya. These model watersheds were taken at Meghalaya (Wah Umroi WS), Nagaland (Peren-Jalukie WS) and Sikkim (Sajung WS). The geographical location of Wah Umroi watershed is 25^{o} 41.5” N and 25^{o} 45” N longitude and 91.5^{o} 5.5” E to 91.5^{o} 9.7” E latitude in Ri-Bhoi district. The total geographical area of watershed is about 1612.5 ha out of which 532.5 ha has been selected at five different locations namely, Umroi, Mawthei, Umeit, Mawpun-I and Mawpun-II. Umroi model watershed project started during 2003-04 for a period of five years. Out of the total selected 532.5 ha, an

[6] Mr. Pranshon Jala was supplied 10 cross-bred piglets by the PIA under watershed program worth Rs.10, 000 on full subsidy in February, 2006. He started with these piglets and after every 7 months, he sells them. These are exclusively reared for pork purpose. Their litter is used as FYM in vegetable cultivation. He has now increased his piggery rearing scale and sells three batches of pigs every year. He has made three pig sheds and is now planning to construct further more. As per his own assessment, he gets a net income of Rs 65,000 per annum from the piggery farming. Looking to his success, other farmers are also now planning to go for pig rearing. Mrs Maygreen Kharbteng started poultry two years back with her own resources. She constructed a low cost poultry shed with Rs.6, 500 initial investments. The PIA under watershed program supplied her 200 broiler chicks with which she started her poultry farming. She sells five poultry batches in a year with 150-160 number of broilers per batch. One broiler on an average fetches Rs.120-130. She buys now chicks at a rate of Rs.14 per chick. She is very happy with her new enterprise and wants to increase her poultry farming scale.

area of 179.69 ha was developed till 2005-06.

6.3.1 Works carried out

The development works were carried out in form of constructing water storage tank tapped from spring water at Umeit village (upper reach). Drainage line treatments were made at upper, middle and lower reaches of watershed area. Activities on natural resource management have been carried out at Mawpun-I where 2 ha of land was taken up under soil and moisture conservation activities and 7 ha of land were developed for horticulture and agro-forestry. Other works included construction of diversion wall, spillway and rectangular weir of drainage line treatment.

To ensure people participation in the planning and development activities of the watershed, self help groups (SHGs) were involved and action plans were decided after regular discussions. A total of eleven SHGs are functioning at present in the watersheds. SHG meetings are generally held once in a month to collect the funds from the members and deposit in their respective bank accounts. The SHG[7] members also discuss common problems and needs which are recorded in minute books and brought for discussion in the Watershed Development Committee meetings. During the work season of watershed development activities, the WC meetings are held monthly and in case of lag season, quarterly.

Initially private landowners were hesitant in allowing watershed development interventions on their lands due to certain apprehensions. This issue was addressed by the implementing agency through involving the secretary of the *Durbar Raj*. After realizing the true motive of the implementing agency, every farmer wants to have watershed interventions on his field. Thus it can be said that formation of institutions or involving the village/local institutions is a pre-requisite for successful implementation of watershed development programs, which can also maintain the system after the project withdrawal.

6.3.2 Impact

Only 34% of the proposed area has been treated by the implementing agency till now. The watershed development program will last until 2008. The changes in cropping pattern, crop yield and production are coming up and it is in transition phase. A number of enterprises are coming up in short period for which physical infrastructure has already been created. These enterprises are fish culture, vermi composting, mushroom cultivation and small processing units. Once these enterprises start their production process, more tangible benefits will accrue under this program. There is enough social capital formation in terms of SHGs and WDC. Results of impact assessment are presented in Table 5.

6.4 Nongpoh Watershed (NGO)

Nongpoh watershed is a micro watershed located at the border of Meghalaya and Assam. The watershed area consists of 12.5 ha out of which 3.5 ha have been developed. The whole area belongs to a missionary NGO known as the Mozarello Orphanage[8] cum Training Centre. The center is basically an orphanage boarding school in which orphan girls from primary to high school level study. There are a total of 45 students from class-I to high school level. They work on field after school work. The watershed interventions were started in 2003 under the technical guidance of ICAR, Barapani. The funds came partly from ICAR institute and partly from externally funded schemes. A total of Rs.4.85 lac was invested in which, 75% was contributed by ICAR Barapani institute and rest by NGO in terms of labour component.

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[7] The interview with the chairperson of one of the women SHG revealed that they are involved in ginger cultivation. They have also been imparted training in processing and embroidery. The members take small loans in case of some domestic problem like illness or to meet other social obligation. No members till now had taken loan for starting any productive venture. Members make weekly contribution, which is deposited in the bank.

[8] Many pass out students of the orphanage emerged successful and have now joined the Ri-Bhoi College. The NGO is run by Sister Linda who is a well-qualified and dedicated lady to her mission.

6.4.1 Works carried out

Only one acre of land was under cultivation before watershed interventions in which paddy was usually grown. With watershed interventions, they have started animal husbandry, which includes piggery, poultry, fishery, duckery and cattle rearing. Besides introduction of livestock enterprises, many plantations of fruit plants of pineapple, banana, beetle nut, pepper, guava and peach were done on steep slope areas.

6.4.2 Impacts

The results of watershed interventions are discussed enterprise-wise.

Fishery intervention: Seven different species of fishery seeds of more than 6000 fingerlings were supplied by ICAR, Barapani in August, 2004. In 2006, the yield was sold for Rs. 33,000. The average weight per fish was 3-4 kgs and sold at a very low rate of Rs.150 per fish due to market failure. Besides selling, they had also used 50-60 kgs of fish for their own consumption. This year, they are again going to harvest the fish.

Piggery: ICAR institute supplied eight piglets to start with. In two years, they have sold 37 pigs and earned Rs.50,000 from the sale. Pork is very popular and highly valued animal product in this area. On an average, they have incurred Rs.20, 000 to rear these 37 piglets on feed and also the leaves collected by girls from farms to feed them.

Poultry: Special poultry birds of Banraja were supplied by ICAR institute at subsidized rates. Hundred birds were supplied out of which 50-60 was sold at Rs.30, 000. Rest was used within orphanage center. They are now going to start with broiler chicks.

Duckery: Ducks are reared in the water pond from last three years. They had made about Rs.8000 from duckery. Mostly they use it for orphanage consumption.

Milk production: Orphanage has two jersey cows yielding about 20-24 kg/day out of which they sell 10 kgs of milk at the rate of Rs.20/kg. Rest of milk is used for orphanage consumption.

Rabbits: ICAR institute supplied the orphanage 3 rabbits (2 female and one male) in January 2007. After 4-5 month period, they increased their size to eight. They have not sold any rabbit. They first want to increase their population as well as size. After getting good number, they will sell them in the market. The average price of rabbit is Rs.150.

Goats: The orphanage started with a pair of goats in 2004. At present, they have 16 goats. They sold them at rate of Rs.1600 per goat for large sized and Rs.700 per goat for small ones.

Pineapple: This intervention was done under watershed by ICAR in which they spent almost Rs.10, 000. Till now they had two harvests. In first harvest, they sold for Rs.7000 and second harvest for Rs11, 000. They had planted more than 2500 plants on hill slopes. Apart from sale, children also consume these fruits. Besides pineapple, other fruit plants such as banana (100 numbers), beetlenut (200), pepper (50), guava (20), and peach (20 numbers) were also planted on steep slopes. Once these fruit tress come in full bearing stage, it will generate a huge income for the orphanage besides controlling soil erosion.

The impact assessment Table 6 of Nongpoh watershed shows 1100% increase in the income generated post watershed intervention from mere Rs.17,000 to Rs.2,04,000. Although, full benefits from the watershed interventions are yet to be realized, particularly from the horticultural plantation crops.

The overall performance ranking of these four case studied watersheds is shown in Table 7. It is revealed from the table that the Nongpoh micro watershed has performed superbly well followed by Umpling-Umrynjah and Lyngiong Watersheds. The Wah-Umroi ICAR Model Watershed has not yet realized its full potential benefits as the activities and interventions are not still over.

7. LESSONS DRAWN FROM THE CASE STUDIES

We conducted case studies on four watersheds implemented by different agencies under different watershed development programs. The lessons drawn for the success of watershed development program and how it can be scaled is discussed under different sections.

7.1 Sound Institutions

Traditionally, tribes and clans in the northeast were closely knit for security from external invasion but have now moved into other social activities. Social institutions have substantial impact on the decision making process and thus any watershed initiative will have to take these institutions and people into confidence and make them believe that the initiative will have a positive impact on their livelihoods. In all these case studies, the existing traditional village institutions, locally known as, *Durbar Shnong*, played a great role in motivating the villagers and initiation of watershed development program, besides reducing transaction costs. *Durbar Shnong* formed the social base for the implementing agencies to mobilize the people under these programs. All the studied watersheds except Nongpoh Watershed do have Watershed Committee's at apex level with Watershed Associations at village level besides SHGs and Voluntary groups. These institutions were successful in working together and bringing 'collective action' among participants to sustain watershed activities. There has been enough social capital formation under these selected watersheds whose role will be now more tested after the project withdrawal, which is in offing.

7.2 Equity

As watershed development programs are generally land and water based interventions, benefits are restricted to only land owners leaving aside land less poor classes of the society. However, there are examples of watershed programs (Sukhomajri WS) in which land less people of the watershed community were also given due rights to reap benefits from the watershed programs. In the case studies, the landless people benefited in terms of employment generated under the watershed development programs. Though the number of landless families in these watersheds was very less, efforts were made by the PIAs to target this group. In Umpling-Umrynaj Watershed women's SHGs were provided training in bee keeping, tailoring, piggery, pisciculture, vermi-composting to provide help to the poor landless people. However, there was some favouritism towards private lands in watershed interventions because of local village politics of traditional institutions.

7.3 Sustainability

The sustainability of the watershed project may be judged by identifying the activities and their outcome in: (i) protecting the natural resource base, specially land and soil from environmental and ecological hazard; (ii) improving availability of water in watersheds; (iii) improving the biomass production; (iv) developing and strengthening local institutions; and (v) developing mechanisms to maintain assets created during the watershed program and on sustained basis after the project withdrawal.

On all these indicators, the case studies fared well. However, some works carried out with locally available material like stream bank stabilization by brush wood treatment in case of Lyngiong watershed at the upper catchment is not going to remain for longer period due to heavy rainfall area of the watershed. Such fragile spots need to be treated by concrete structures. For maintenance of assets after the project withdrawal, the Umpling-Umrynjah and Lyngiong Watersheds have created corpus fund and also developed mechanism to generate resources for the maintenance of these structures after project withdrawal. Such mechanism were not developed in case of Wah-Umroi Watershed implemented by the ICAR, Barapani.

7.4 Sharing Costs and Benefits

One of the key determinants for the success of watershed activities is that the expected private benefits must substantially exceed the expected private costs (Joshi *et al.*, 2004). The costs of works carried on the private individual lands were shared between the PIAs and beneficiary. Beneficiaries mostly contributed in terms of labor. Proper consensus is needed among the community members or villagers to carry out watershed works on community lands, to work out the sharing of benefits generated by the community lands. However, in most cases, it was planned by the members of Watershed Committees that the revenue generated through these community lands will be used to maintain corpus fund that may be in turn used to maintain assets after project withdrawal.

7.5 Gender Issues

More impetus is drawn now on the role of women in the watershed development programs. Meghalaya, which is dominated by the Khasi tribes, has matrilineal system of property rights. Women thus have an active role in agriculture. In case of studied watersheds, a good number of women were found to be members of watershed committees. Furthermore, a number of women SHGs were found working in different activities in capacity of entrepreneurs on new opportunities created under the watershed programs.

7.6 Market Linkages and Infrastructure

Most of the watersheds in NER region are located with poor connectivity and so was the case with the study area. The farmers were not getting the real price for their produce and they have to spend a lot to supply their products to markets. So, there is problem in input as well as output market linkages which need to be addressed by formation of village market cooperatives. Small-scale village processing industries may help in overcoming the problem of market failures and price fluctuations besides value addition of the produce. It will also be useful in considerable employment generation.

7.7 Technical Aspects

The guidelines provided under different watershed development programs have limitations in case of hilly areas of NE region. NER region has a tough terrain, poor road infrastructure and comes under high rainfall zone. Most of the works carried out for treating the prone areas have been done by locally available material as per guidelines. For example, brush wood treatment for stream bank stabilization in these watersheds is not going to last because of steep slope and high intensity of rainfall that will create havoc with these structures during monsoon season. Furthermore, the development cost per hectare as per guidelines should be more in case of hill regions where they have to transport the masonry material by head load or by employing ponies, which increase costs. It was also observed that there should be enough flexibility in the development component of watershed programs and activities should not be restricted as per guidelines but more demand driven as per local needs as well as suitable to biophysical base of the area. In fact, there is a need for a separate nation wide watershed development program for hill regions and guidelines need to be developed separately for such programs. Timely availability of funds was also mentioned by the PIAs as a constraint in effective implementation of watershed programs.

7.8 Watershed Ownership and Management

One important lesson drawn from the present case studies is that the programs carried at micro level and under one management protocol produce quick and more desired results, as was observed in case of Nongpoh watershed. This is because the benefits derived go to an individual or institution and decisions are taken at the same end, which has potential to give quick and tangible results.

8. CONCLUSIONS AND FUTURE DIRECTIONS

Watershed development projects have been taken up from time to time under different programs launched by the government of India in the north eastern region. The study concludes that the watershed programs have helped in raising income, generating employment and conserving the natural resource base as well as motivating people to abandon *jhum* practice. It is suggested that watershed program can be a vehicle of development to alleviate poverty by raising farm productivity and generating employment opportunities in marginal and fragile environments. The peculiar nature of region and its problems and opportunities signifies an even greater scope for watershed programs at a larger scale with some modifications in the programs and guidelines.

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Table 1: Net sown and irrigated area in North Eastern States

Name of State	Net sown area (000' ha)	% of reported area (000' ha)	Net irrigated	NIA as % of NSA
Arunachal Pradesh	164	2.98	42	25.61
Assam	2774	35.34	172	6.20
Manipur	217	11.16	40	18.43
Meghalaya	227	10.19	60	26.43
Mizoram	98	4.70	16	16.33
Nagaland	305	19.27	67	21.97
Sikkim	110	16.37	9	8.18
Tripura	280	26.69	40	14.29
NE average		18.22		10.68
All India		46.06		39.11

Table 2: Impact indicators from the sampled watershed studies (N=37)

Indicator	Particulars	Unit	Mean	Minimum	Maximum
Efficiency	B/C ratio	Ratio	1.79	1	4.04
	IRR	Percentage	19.40	10.5	39.25
	Agricultural Productivity	Percentage	28.89	1.75	73
Equity	Employment	Person days/ha/year	164	21	795
Sustainability	Irrigated area	Percentage	60.25	11.5	122.72
	Cropping intensity	Percentage	24.67	1	65
	Reduction in *jhum* area	Percentage	33.69	2	90
	Reduction in soil loss	Percentage	63	32	97

Table 3: Impact of watershed development program in Umpling-Umrynjah WS

	Particulars/Indicators	Unit	Before	After	Change (%)
1.	Cropping pattern		Mono-cropping	Double and mixed cropping	
2.	Cropping intensity	%	138	213	75
	1. YIELD				
	(i) Rice	Kgs/acre	650	910	40.0
	(ii) Maize	Kgs/acre	300	380	26.6
	(iii) Ginger	Kgs/unit	200	295	47.5
	2. Change in livestock composition and yield				NO
3.	Farmers practicing *jhum* Cultivation	%	90	7	-92.00
4.	Area under *jhum* cultivation	acres	1325	72	-94.56
5.	Reduction in soil loss erosion	%			95.00
6.	Increase in House hold income	%			23.00

Table 4: Watershed performance in Lyngiong WS

	Particulars/Indicators	Unit	Before	After	Change (%)
1.	Cropping pattern		Mono-cropping	Double and mixed cropping	
2.	Cropping intensity	%	122	187	65
	1. YIELD				
	(i) Winter paddy	Kgs/ha	1945	2493	28.17
	(ii) Spring paddy	Kgs/ha	3448	4000	16.00
	(iii) Autumn paddy	Kgs/ha	1169	1482	26.77
	(iv) Maize	Kgs/ha	1465	1550	5.80
	(v) Pineapple	Tones/ha	4	6	50.00
	(vi) Ginger	Qtls/ha	4.2	6	45.00
2.	Change in livestock composition and yield			Piggery, goat, fishery, poultry	
5.	Reduction in soil loss erosion	%			17
6.	Increase in House hold income	%			20

Table 7. Performance ranking of watershed indicators.

Table 5: Watershed interventions and its impact in Wah Umroi WS

Particulars/Indicators	Unit	Before	After	Change (%)
1. Cropping pattern		Mono-cropping	Double and mixed cropping	
2. Cropping intensity	%	120	172	52
1. YIELD				
(i) Rice		632	850	34.5
(ii) Maize		287	368	28.22
(iii) Ginger		224	305	36.16
2. Change in livestock composition and yield				NO
5. Reduction in soil loss erosion	%			32
6. Increase in House hold income	%			60

Table 6: Impact of watershed interventions on the Nongpoh micro-WS

Particulars/Indicators	Unit	Before	After	Change (%)
1. Cropping pattern		Mono-cropping	Double and mixed cropping	
2. Crops grown		Rice only	Pineapple, Beetlenut Pepper, Guava, Peach	
2. Change in livestock compositi on and yield		Nil	Fishery, duckery, piggery, poultry, goats, cows, rabbits etc.	
5. Reduction in soil loss erosion	%			100
6. Increase in income	%	Rs.17,000	Rs. 2,04,000	1100%

Indicator	Parameters	Umpling- WS Umrynjah	Lyngiong WS	Wah Umroi WS	Nongpoh micro-WS
Efficiency	Agricultural productivity	****	****	***	*****
	Returns to investment	****	****	***	*****
Equity	Employment				
	Benefits to landless	****			
Sustainability	Corpus fund generation	****	***	**	
	Soil & water conservation	****	***	***	****
	Institutional development	****	****	****	
	Diversification of activities and enterprises	*****	*****	****	*****
Over all Rank		****	****	***	*****

Very Good *****, Good ****, Fair ***, Poor **

MEETING INDIA'S FUTURE WATER NEEDS: POLICY OPTIONS

Upali Amarasinghe[1], Tushaar Shah[2] and Peter McCornick[3]

Abstract

This paper discusses emerging water crisis in India with the business as usual water use patterns and ways of averting it. Increasing reliance on groundwater has been contributing to pockets of unsustainable water use in many basins. This trend is likely to continue and many river basins will face severe regional water crisis in the next half century. However, proper understanding of the negative impacts of downstream water users, artificial recharge of groundwater could facilitate sustainable water use. Increasing water use efficiency, reducing uncontrolable pumping, increasing water productivity and crop diversification could help in mitigating the groundwater related water crisis. Growth in industrial, services and domestic sectors, water demand in the future shall outpace additional irrigation. This, coupled with increasing desire for a clean and reliable water supply in these sectors, and increasing focuses on environmental water needs shall demand large intra-or inter-basin water transfers.

1. INTRODUCTION

The dominance of foodgrains and the prominence of surface irrigation in India's agricultural production are gradually changing. Recent trends show that agriculture is diversifying to cater to the changing domestic consumption patterns and increasing export opportunities; and groundwater irrigation is expanding, even outside the irrigation command areas, to meet the increasing demand of water in agriculture. The agricultural diversification, often to high value crops and livestock, generally requires costly inputs. Application of many of these inputs depends very much on a reliable water supply. So far, groundwater was the primary source that provided the required reliability in the irrigation sector. However, uncontrolled groundwater exploitation is bringing high social and environmental cost to some regions, and jeopardizing the reliability of the supply. Substantial part of many river basins will soon reach this category with continuing groundwater expansion (Amarasinghe et al., 2007). However, proper water management strategies and interventions can avoid unsustainable water use patterns in many basins. Otherwise India will face a severe water crisis, perhaps in the near future for some regions and most certainly within the next 4-5 decades for many regions.

This paper discusses the magnitude of India's looming water crisis and the short to mediumterm solutions that could mitigate it. It highlights longterm water demand situations under the business as usual trends and other contingencies that may require largescale water transfers as proposed under the National River Linking Project (NRLP) of India. And it also highlights recharging groundwater to increase the groundwater stocks; promoting water saving technologies for increasing water use efficiency; formal or informal water markets and providing reliable rural electricity supply for reducing uncontrolled groundwater pumping; and increasing research and extension for enhancing agricultural water productivity, i.e., more crop and dollar for every drop of consumptive water use, as short to medium term goals.

In longterm, surface water shall still play a prominent role. The depth to the groundwater in some regions has fallen drastically. But the groundwater is still being pumped out, even at elevated costs, to meet various needs. With increasing disposable income, people and industries located in the groundwater-stressed areas, may be ready and also can afford to pay for what would now be the more reliable supply, surface water.

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Even farmers' willingness to pay for a reliable surface water supply may increase with improved incomes from agricultural diversification. This may already be true in some areas where stress for fast depleting groundwater resources is high. At the rate of the present economic growth, the transfer projects of a magnitude to those proposed under the NRLP in purely financial terms may not be a serious concern in a few decades, provided that they address the environmental and social concerns.

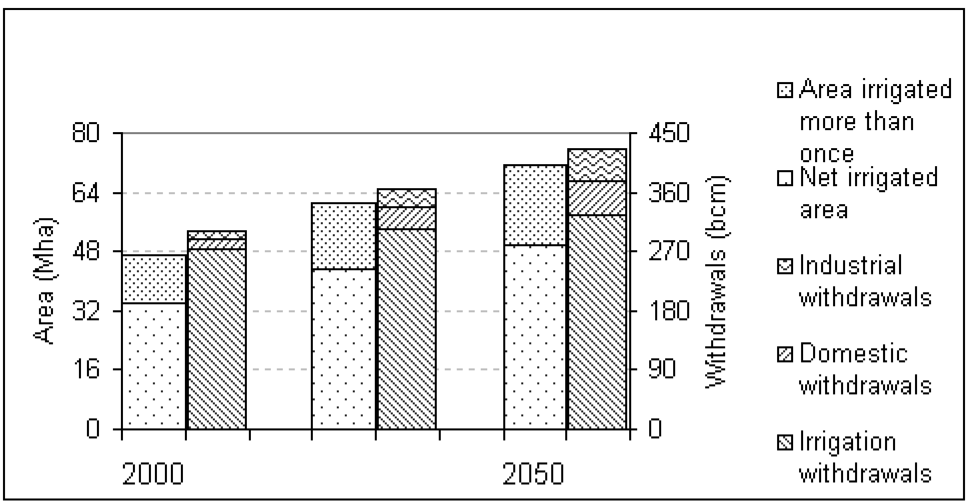
This paper is organized into three sections. In addition to the introduction above, the next section discusses the impending water crisis, and offer short- to medium- term solutions to avert the crisis. In the final section, we discuss the conditions that may necessitate large-scale water transfers between river basins.

2. REGIONAL WATER CRISIS AND MEDIUM-TERM OPTIONS

India already withdraws about 273 cubic kilometer (km^3) or 61% of the total available groundwater per annum (Amarasinghe et al., 2007). The recent trends show that groundwater irrigation will continue to be the major source for future growth in irrigated areas. The business as usual scenario (BAU) irrigation demand, which was based on recent trends of land-use patterns, projects that groundwater irrigation is expected to add at least 14 mha of additional irrigated area between 2000 and 2025 (Figure 1), and a further 10 mha by 2050 (Amarasinghe et al., 2007). The BAU scenario projection determines that 31 km^3 of additional groundwater withdrawals or a 13% increase will be required by 2025, and a further 22 km^3 by 2050.

If these trends continue, India will be withdrawing more than three-quarters of the available sustainable groundwater resources (both natural recharge from rainfall and recharge from return flows) by 2025, and

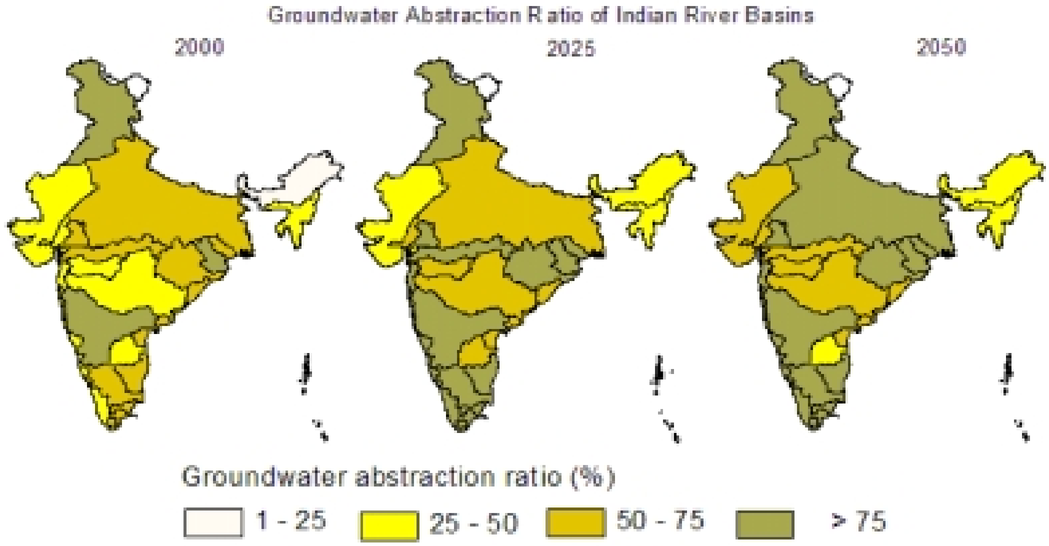
Figure 1: Groundwater irrigated area and withdrawal projections



about 85% by 2050. This, indeed, will push several river basins into physical water scarcity and unsustainable water use category (Figure 2). If the BAU trends continue, four basins will have over abstracted and another six basins will have withdrawn more than three-fourths of the total available groundwater. And many other basins will have large pockets of unsustainable ground water use.

On the other hand, if groundwater withdrawals are to remain at the 2000 level, then the additional surface withdrawal requirement will increase further by 65 km^3 by 2025. The peninsular basins, some of which are already water scarce, will require more than half of the total additional surface water withdrawals projected for the country, that is more than 35 km^3. Given the past investment trends and the growth of canal irrigation, it is difficult to envisage adding this quantity of surface water in the next 25 years. And given the extent of

Figure 2: Groundwater abstraction ratios of Indian river basins



already committed surface water resources, such demands may also not be met in the peninsular rivers without diverting from elsewhere.

From overall economic investment perspective groundwater is a much cheaper option than surface water development. On an average, development of one ha of surface irrigated area costs more than three times the cost required for developing one ha of groundwater irrigated area (GoI, 2006). Groundwater development has been generally undertaken with private sector and or users sharing a significant part of the cost. Moreover, groundwater irrigation also generates higher crop production benefits, provided that adequate groundwater stocks are available to ensure reliability. However, given the critical nature of groundwater depletion and the related issues, can this resource underpin further development of the agriculture sector in the near future, and also prevent a water crisis? These are pertinent questions to be answered, at least addressing the long-term water needs.

3. MEDIUM TERM OPTIONS FOR SUSTAINING GROUNDWATER IRRIGATION

Artificial groundwater recharge could enhance the groundwater stocks, have positive impacts, and generate various social and environmental benefits. As has been practised in some developed countries, India can start to actively manage its aquifers. Presently it depletes its groundwater stocks before the monsoon months and then recharges these with the monsoon run-off (Shah, 2007). Existing small tanks and ponds, numbering more than 5,00,000 throughout India, which are already augmenting the natural groundwater recharge, can be modified to further increase recharge, while meeting the drinking water demand for the humanbeings and livestock (Sakthivadivel 2007). Also, new small tanks and ponds need to be designed and constructed with a view towards optimizing groundwater recharge, where appropriate. We need to know more about the negative impacts of groundwater recharge on downstream users before embarking on large-scale recharging programmes, especially in water scarce river basins.

Rainwater harvesting programmes, such as johads in Alawr district in Rajasthan (Sakthivadivel, 2007) and also groundwater recharge movements in Saurashtra and Kutch (Shah and Desai, 2002), have proven to rejuvenate the groundwater resources available for irrigation. However, some interventions, such as rain water harvesting in the upstream catchments, have been shown to reduce the inflows to existing reservoirs downstream (Kumar et al., 2006a), and can incur more cost than the benefits they generate. The existing knowledge on surface and groundwater interaction across river basins in India is generally site-specific and not sufficient to identify the locations where such negative impacts can occur, nor in fact to determine where and how to improve groundwater recharge. Further research is required to identify the locations where artificial groundwater recharge harness water; the quantity of water that can be harnessed and extent to which it meets the additional demand; and the net social benefits that these programmes bring out.

Increasing groundwater irrigation efficiency by an additional 5% from the level assumed under the BAU scenario (70%) can reduce the additional groundwater demand in 2025 by about 20 km^3 or two-thirds, assuming that these savings can be made at the basin scale. Recent research shows that modern irrigation technologies-sprinklers and drip irrigation are operating at 70-85% efficiency in some irrigation systems in India (Kumar et al., 2006b; Narayanmoorthy, 2006). Modern irrigation technologies also improve the uniform distribution of the irrigation water, reduce non-beneficial transpiration, and in general have higher productivity than the traditional flood irrigation methods. However, adoption of these technologies in India has been very slow. And these technologies were mainly adopted for a few crops, such as fruits and vegetables, in the groundwater irrigated areas (Narayanamoorthy, 2006, Kumar et al., 2006b). Further research and extension are needed to determine the potential of such irrigation technologies in the Indian context, their net economic benefits and practical modalities to scale them up where appropriate. In addition, it is imperative that it be determined that these interventions would result in actual water savings, and not result in transfer water from other users further down the basin, as has been the case elsewhere.

Reducing uncontrolled groundwater pumping could mitigate over abstraction in many basins. In 2000, India withdrew about 273 km^3 of groundwater to meet only 151 km^3 of crop consumptive water-use demand. Indeed, proper policy and institutional interventions can reduce over abstraction even when traditional irrigation methods are utilized. Formal or informal water markets (Somanathan and Ravindranath, 2006; Banerji et al., 2006), and regulating and/or providing a reliable rural electricity supply (Shah and Verma, 2000) have been shown to have some effect on controlling unnecessary pumping and increasing water-use efficiency. Replicating these interventions, with adjustments to satisfy local socio-economy, could help arrest the uncontrolled groundwater pumping in many water-stressed river basins.

Improving Crop Productivity presents the greatest opportunity for reducing the additional irrigation requirement. If water productivity stagnates at 2000 levels, India will require 1029 km^3 by 2050 to meet the agricultural consumptive water use demand, which is in effect the same as the estimates of potentially utilizable water resources of India, and simply unattainable. Therefore, it is imperative that the productivity of water be continuously increased. India's crop water productivity of grains of consumptive water use for irrigated and rainfed areas (0.64 and 0.34 kg/m^3 respectively) is, in comparison with other countries, stubbornly low. The water productivity of non-grain crops under irrigated and rainfed conditions is also low, and vary significantly across districts (Table 1).

By increasing grain crop water productivity by 1% per annum, the respective CWU could be maintained at present day levels while meeting the increased demands for grain. Increasing the productivity a little further, to 1.4% annually, would even account for the CWU demand for all crops (Amarasinghe et al., 2007). These scenarios demonstrate a significant opportunity to avoid a future agricultural-driven, water crisis. The latter scenario is equivalent to doubling the yield over the next 50 years, which given the past trends in India, is setting a very high goal. On the other hand, given the remarkable achievements of other countries over the last few decades, India does have the potential

India's research and technological capacities are increasing. Knowledge generation in new commodities research, remote sensing, geographic information systems, and advances in water management systems are second to none in the developing countries. India also has a sound agricultural research system spread across all regions. The immediate focus then should be how to combine these rich resources with proper extension systems to promote rapid growth in crop productivity. India needs to effectively use the advances in research and technology to identify opportunities for high productivity and also high potential zones for different crop and livestock production systems. As the value of water is increasing, agricultural production systems should be promoted in zones where they have a high value for each drop of consumptive water use and where there is adequate water supply for irrigation, such as in the lower part of the Ganga Basin. The recent trends of

Table 1: Irrigated, rainfed and total water productivity of grain and non-grain crops

State	Water productivity (WP) of grains and non-grain crops								
	Irrigation			Rainfed			Total		
	Grain area as a fraction of total	WP of grains	WP of non-grains	Grain area as a fraction of total	WP of grains	WP of non-grains	Grain area as a fraction of total	WP of grains	WP of non-grains
	#	$*/m³	$/m³	#	$/m³	$/m³	#	$/m³	$/m³
Andhra Pradesh	0.76	0.17	0.41	0.45	0.11	0.72	0.59	0.16	0.56
Assam	0.99	0.22	0.19	0.78	0.10	0.72	0.79	0.11	0.72
Bihar	0.93	0.13	1.66	0.86	0.14	1.43	0.90	0.13	1.55
Chattisgarh	0.95	0.10	1.47	0.91	0.10	0.50	0.92	0.10	0.69
Gujarat	0.37	0.08	0.23	0.45	0.12	0.57	0.42	0.10	0.31
Haryana	0.76	0.17	0.16	0.84	0.12	1.37	0.77	0.17	0.19
Himachal Pradesh	0.89	0.13	2.28	0.85	0.13	1.99	0.86	0.13	2.03
Jammu and Kashmir	0.81	0.13	1.34	0.88	0.14	4.10	0.85	0.14	2.43
Jharkhand	0.71	0.11	2.18	0.91	0.11	0.83	0.89	0.11	1.17
Karnataka	0.60	0.15	0.34	0.69	0.12	0.63	0.66	0.13	0.44
Kerala	0.50	0.16	0.39	0.09	0.16	0.83	0.17	0.16	0.78
Madhya Pradesh	0.87	0.07	0.36	0.56	0.10	0.40	0.64	0.09	0.39
Maharashta	0.56	0.07	0.51	0.67	0.08	0.21	0.65	0.07	0.34
Orissa	0.83	0.11	1.44	0.75	0.07	0.72	0.77	0.09	0.89
Punjab	0.87	0.25	0.24	0.57	0.13	4.21	0.86	0.24	0.39
Rajasthan	0.59	0.07	0.20	0.84	0.07	0.36	0.75	0.07	0.24
Tamil Nadu	0.64	0.20	0.49	0.55	0.22	1.09	0.60	0.20	0.64
Uttar Pradesh	0.83	0.15	0.26	0.80	0.14	2.12	0.82	0.14	0.44
Uttaranchal	0.73	0.20	0.25	0.91	0.11	1.26	0.83	0.15	0.35
West Bengal	0.85	0.21	1.23	0.66	0.17	1.17	0.73	0.19	1.18
India	0.76	0.15	0.36	0.68	0.11	0.69	0.71	0.13	0.50

Source: Authors' estimates are based on PODIUMSim methodology
* - Values of crop production, estimated using the average (1999-00) of the unit export prices of crops in the FAOSTAT Database (FAO, 2005) are used to make comparison between the grain and non-grain crops.

agricultural diversification, which are associated with changing consumption patterns, should also facilitate this revolution.

Agricultural diversification, if properly planned, could also help reduce additional irrigation demand. The BAU scenario projections, as discussed in the previous two chapters, show that the increasing consumption of animal products is transforming the demand and the production patterns of cereals (Table 2). Over the period (2000-25), maize, primarily for livestock feeding, will contribute to more than one-third of the total grain demand increase (45%). Between 2025 and 2050, this contribution is expected to be 83% of the total grain demand increase. Also, food demand for high value non-grain crops, such as oilseeds, vegetables and fruits, is

Table 2: The demand and production of grain and non-grain crops with their irrigation requirements and

Crop	Crop demand[i] (million tonnes)			Crop production: Total[i] (million tonnes)			Crop production: Share from Irrigation (%)			Irrigation requirement[ii] (net-evapotranspiration) (km^3)			Total[i] (million tonnes)			Irrigation withdrawals (km^3)		
	2000	2025	2050	2000	2025	2050	2000	2025	2050	2000	2025	2050	2000	2025	2050	2000	2025	2050
Grain crops																		
Rice	82	109	117	89	117	143	69	70	71	24.1	25.0	26.0	74	73	72	261	239	207
Wheat	67	91	102	72	108	145	95	99	99	23.0	25.0	26.3	64	72	76	132	135	122
Maize	16	50	121	12	28	65	32	51	38	1.4	4.0	5.1	1	3	3	3	5	6
Other cereals	21	23	16	19	21	13	14	19	38	2.2	2.4	2.7	5	5	6	10	9	9
Total cereals	187	273	357	193	274	365	71	76	75	50.8	56.4	60.1	144	153	158	406	388	344
Pulses	14	18	21	13	18	19	17	17	18	2.8	2.9	2.8	6	6	5	11	10	8
Non-grain crops																		
Oilcrops	48	103	133	31	73	97	31	56	68	6.1	18.7	25.2	13	37	49	25	66	76
Vegetables	75	150	189	74	149	227	44	64	69	1.7	3.3	3.8	3	5	6	6	10	10
Fruits	47	78	123	46	83	106	46	60	63	1.7	3.0	4.0	5	9	12	10	16	18
Sugar	26	42	55	30	46	60	94	93	100	4.2	5.1	6.6	41	48	60	80	87	95
Cotton	2	4	6	2	4	6	50	65	71	3.0	5.9	7.9	16	28	38	31	50	59
Other crops	-	-	-	-	-	-	-	-	-	5.6	11.3	7.3	18	26	18	36	48	28
Total grains	52[i]	73[i]	90[i]	54[i]	74[i]	93[i]	67	72	72	53.6	59.3	62.9	149	159	163	417	398	352
Total non-grains	106[i]	198[i]	284[i]	96[i]	187[i]	266[i]	51	65	71	22.3	47.2	54.8	95	154	183	188	277	286
Total	158[i]	272[i]	374[i]	150[i]	261[i]	359[i]	57	67	71	75.9	106	117	245	313	346	605	675	638

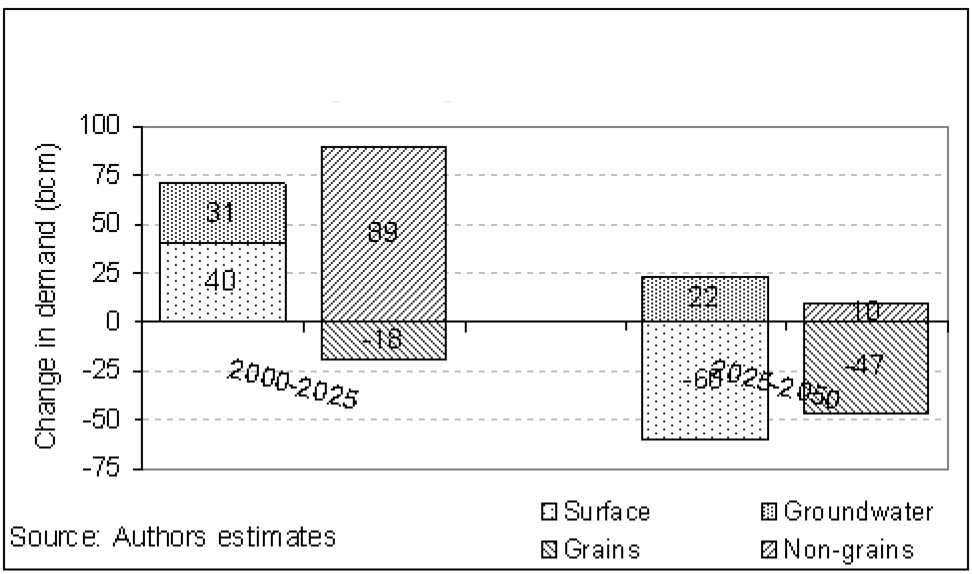
i – Total demand and production for grain and non-grain crops are estimated using the average 1990-2000 export prices.
ii – Irrigation requirement or net evaporation is the difference between evapotranspiration and effective rainfall
Source: Authors' estimates based on PODIUMSim

also increasing. The share of value of non-grain crop production is expected to increase, from 51% in 2000, to 63 and 69% by 2025 and 2050 respectively.

As a result of the changing consumption patterns, food production patterns will change. The production of irrigated non-grain crops, as compared with irrigated grain crops, will increase much faster. According to the BAU scenario, as much as half the irrigated area will be under non-grain crops by 2050, compared to only 29% in 2000; 71% of the crop production (grains and non-grain crops) will be produced under irrigation by 2050, compared to 67 and 51% in 2000. Major implications of this agricultural diversification are:

- consumptive water use demand of grain crops, in comparison to non-grain crops, increases very slowly;
- with increasing reliance of groundwater and increasing water-use efficiency in groundwater, the irrigation demand for grain crops will decrease from the 2000 levels (Figure 3), and
- almost all additional irrigation demand will be for non-grain crops, and much of that will be from groundwater (Figure 3)

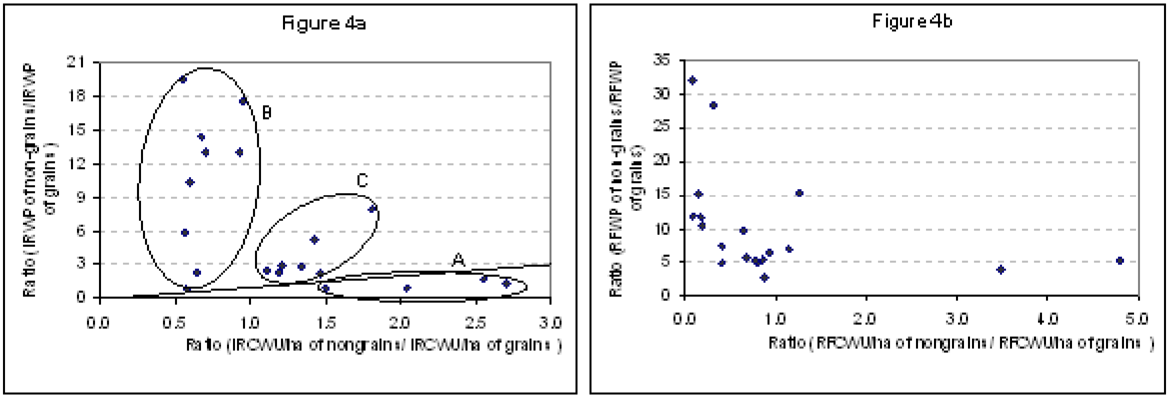
Figure 3: Change in demand in surface and groundwater irrigation for grain and non-grain crops



Most of the non-grain crops, usually produced for urban markets or for exports, can bring in high returns. However, in order to reap these benefits, high-value crops require the timely application of expensive inputs. A reliable irrigation supply is a critical prerequisite for timely input application, and also an input by itself in water- stressed crop growth periods. More recently, groundwater has been the major source of this reliable irrigation supply in the context of diversifying agricultural production. It is likely that this trend will continue, at least into the near future. Therefore, an immediate challenge is to identify the cost-effective physical and institutional interventions for sustaining the groundwater irrigation growth.

Agricultural diversification could also be promoted in conjunction with improvement in water productivity. Figure 4 shows a glimpse of where this can be done at the state level. The X-axis in figure 4a is the ratio of the CWU (m^3/ha) for non-grain and grain crops produced under irrigation, and the Y-axis is the ratio of the water productivity (kg/m^3 of CWU) for non-grain and grain crops grown under irrigated conditions. Figure 4b shows the same ratios for rainfed production.

Figure 4: Consumptive water use/ha and water productivity differences between grain and non-grain crops in irrigated and rainfed areas of different states



For the irrigated conditions there are three distinct clusters (Figure 4a). The states in cluster A, that is Punjab, Haryana, Uttar Pradesh and Uttaranchal, have substantially higher CWU/ha for non-grain crops than grain crops, but lower productivity for every drop of CWU. These states have high irrigated grain area and irrigated yield. Thus, the difference between the water productivities of irrigated grain and non-grain crops is lower. Crop diversification in states in this cluster according to the current cropping patterns may yield little or no benefits. These states can continue to grow grains, increase the yields and trade the production surplus to other states as has been the case in the past. The benefit of that per every cubic meter of water depleted is as high as the benefits that non-grain crops generate.

The states in cluster B are mainly in the east, namely Assam, Orissa, West Bengal, Bihar, Chhattisgarh, Jharkhand and also Jammu and Kashmir in the North and Kerala in the South. These states have significantly high irrigated area under grain crops and a substantial part of that is rice. Moreover, rice crop has low yields and higher CWU than the irrigated non-grain crops in the state. Thus, this group has the highest potential for improvements in water productivity in grain crops. Many states in this group are also relatively water abundant, and they can continue to grow water intensive grain crops and increase water productivity through growth in yield. On the other hand, due to limited land resources many small to medium land holders are poor in these states. So, crop diversification can also generate substantial benefit to these farmers. Cluster B states should have a combined strategy, increase the yields of grain crops while diversifying cropping patterns in small to medium land holdings with low productivity. The production surpluses of non-grain crops in this cluster can meet the production deficits of the states in cluster A.

In cluster C, states like Tamil Nadu, Andra Pradesh, Karnataka, Maharashtra, Madhya Pradesh and Gujarat, and Rajasthan, are relatively water scarce than those in cluster B. Irrigated non-grain crops in these states consume more water than the grain crops, but generate significantly more benefits. Crop diversification can benefit these states the most. It should be promoted as a solution in medium-term to meet the increasing agricultural water demand and also to meet the increasing demand for non-grain food crops and feed grains.

Rainfed non-grain crops in all states have significantly higher water productivity than rainfed grain crops (Figure 4b), and many areas will benefit from crop diversification. On the other hand, major rainfed states also have very low productivity compared to irrigated crops. These states have a significant scope for increasing crop yields. Small quantity of supplemental irrigation in the critical period of crops growth could even double the rainfed yield (Bharat et el., 2006).

Recognizing that the above analysis is constrained by the fact that the analysis was done at the state level, it demonstrates that there is a scope for improvements in productivity and crop diversification. An analysis at a smaller spatial unit, such as district or sub-basins, should provide a better picture where these improvements can de done and what interventions required. A preliminary analysis shows a significant variation of water productivity exists across districts and also across different land-use patterns. A more detailed analysis at the district level, combining information on climate, physical and institutional factors, and geo-hydrological variation should provide a more rigorous estimate of the likely extent of crop diversification and growth in water productivity.

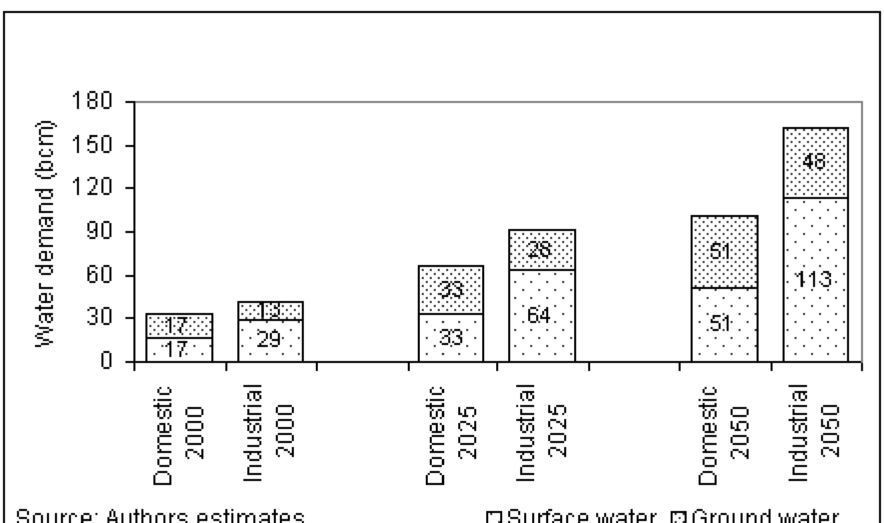
4. CONTINGENCIES FOR LARGE INTE-BASIN WATER TRANSFERS

As presented above, there are a number of physical and institutional interventions which, if given due attention and support, can assist India to meet its water demand for food production in the short- to medium-term. Also, over the long term, combined with the expected demographic changes and shifts in consumption patterns, the need for investments in large-scale infrastructure for irrigation needs to be planned and developed. That said, there are situations even under the business as usual scenario water demand projections and also under other contingencies, which may justify water transfers of the magnitude proposed under NRLP or water transfers of even larger scale. Increasing groundwater stocks, improving crop productivity, and diversifying for less water consumptive crops could mitigate the short- to medium-term water crisis in India. However, there appear situations that justify large inter-basin water transfers, such as some of those proposed under the NRLP over the long-term. Such conditions include: increasing domestic and industrial water demand, providing a reliable water supply for high-value crops, growing pressure on the groundwater systems, escalating energy prices, and allocating minimum river flows for protecting the environment. In each case, the characteristics and timing of such developments will depend on socio-economic, environmental, and agricultural conditions within the given basin and locality.

4.1 Domestic and Industrial Water Demand

The demand of water in domestic and industrial sectors, according to the BAU scenario, will increase several fold over the period 2000-2050 (Figure 5). Domestic water demand is projected to increase by 204% over the period 2000-2050, and the industrial water demand will increase by 234% over the same period. It is expected that these sectors will generally secure their water from surface water sources, and given the expected increasing affluence of both sectors, the users will be able to pay for a reliable and high quality surface water resource. Some of this may come by reallocating from the agriculture sector. However, the increasing the demand for surface water of both the sectors (118 km^3 over the period 2000-2050) is expected to outpace the reallocation from the irrigation sector. Over this period, surface irrigation demand is expected to decrease by 20 km^3, according to the BAU scenario, but this would still require that a further 100 km^3 of surface water supply

Figure 5: Domestic and industrial water demand projections of India



be developed for domestic and industrial sectors. A substantial part of this additional surface water supply is projected to be for states that are already on the physical water scarcity threshold. These states are Andra Pradesh, Tamil Nadu, Gujarat, Maharashtra and Karnataka, where water availability for further development is a severe constraint or the cost of further development is prohibitively expensive if it has to be conveyed from distant locations. So these states, even under the BAU growth patterns, may require some intra- or inter- basin water transfers to meet the demands of domestic and industrial sectors. In addition, groundwater depletion in most of these states is already high, and further development of this resource for irrigation will exacerbate this situation, and increase the tension between agriculture and other sectors.

It is also likely that India's industrial and service sectors could shift gear and grow much faster than envisaged in the BAU scenario. The BAU scenario assumed that the per capita gross domestic product (GDP) will, on an average, grow at 5.5% annually, and the contribution from the industrial and service sectors will further increase. Given the present economic growth patterns (9 to 10% GDP growth) these assumptions are conservative. Many of the well to do states, with better industrial infrastructure now, will inevitably contribute more to a scenario of high industrial and service sector growth. And many of the water scarce rich states may be willing to pay water rich poor states to meet their future water requirements, thus creating the conditions to both finance and develop large inter-basin water transfers, similar to the situation with the Lesotho Water Highlands Project (Shah et al., 2006).

4.2 Agricultural diversification

It is imperative that India needs to diversify its agriculture to meet future food demands. Much of the diversification will be towards high-value agricultural products. Returns from surface irrigation systems at present are very low compared to rainfed lands, because much of the command areas grow foodgrain, while high-value crops are grown outside the command areas, using groundwater. Crop diversification could change the chronic low productivity of these systems, but only if a reliable water supply can be secured. There are already movements of growing high-value crops with a reliable water supply for urban markets or export. Should this gather momentum, water scarce southern and western India, with their increasing income from high-value agriculture, may be willing to invest for inter-basin water transfers. However, if low productivity of these surface irrigation systems persists, and further irrigation sources have to be developed, including inter-basin transfers, to meet the demands for high-value crops it will be a significantly more expensive solution both in terms of economics and water resources.

4.3 Rising Cost of Energy

Irrigation expansion in India in the last two decades was primarily due to small-scale lift irrigation systems using mostly groundwater, but also surface water. These systems are highly flexible and provide reliable irrigation supply on demand. Yet, this mode of irrigation development is, in most cases, highly energy intensive. So far, the energy supplies of many states are highly subsidized. But the cost of energy, whether it be electricity or diesel, has been rapidly increasing in recent times. States can no longer continue to provide these subsidies as they are an impediment to economic growth in other sectors. As energy prices increase, the farmers may opt for direct surface water for irrigation or reduce their pumping costs by groundwater recharge. Thus, rising energy cost could be another condition from the agriculture sector that supports, to some extent, the development of large-scale inter-basin water transfers. Conceivably there could also be an indirect argument for inter-basin transfers where concurrent development of hydropower could provide increased supplies of electricity, however, from an economic perspective this resource would be better utilized in the industrial and service sectors.

4.4 Environmental Water Demand

As a result of increasing economic activities, the quality and quantity of water in some rivers are at a threatening low level. As a result, water demand for the environment could become a priority. At least, a minimum flow requirement (MFR) provision could be established in most river basins.

Smakhtin and Anputhas (2006) provided a methodology for assessing the MFR of Indian river basins. This methodology depends on hydrological variability and environmental management class that rivers ought to maintain. Table 3 shows the estimated MFR for the environmental management class “C.” The class “C” classifies rivers as “moderately disturbed”. Many river basins in India are in the class C category, where the habitats and biota of rivers have already been disturbed, but the basic ecosystem functions are intact. The management perspective in these basins is to preserve the ecosystem to such an extent that disturbances associated with socio-economic development are still possible.

Table 3: Environmental water demand to be met from the potentially utilizable surface flows :

River basin	Potentially utilizable surface water resources[1] (PUSWR)	Un-utilizable surface water resources[2]	Minimum flow requirement (MFR)[3]	MFR to meet from PUSWR[4]
	km^3	km^3	km^3	km^3
Brahmaputra	22	607	287	0
Cauvery	19	2	4	2
Ganga 250	275	152	0	
Godavari	76	34	18	0
Krishna 58	20	14	0	
Mahanadi	50	17	12	0
Mahi 3	8	1	0	
Narmada	35	11	6	0
Pennar 6	0	1	1	
Sabarmati	2	2	0.5	0
Subernarekha	7	6	2	0
Tapi	15	0.4	2	2

1 - PUWR is from CWC 2004; 2 – Un-utilizable water resources – TRWR-PUSWR;
3 – MFR is from Amarasinghe et al., 2006.; 4 – The difference between the third or fourth column.

Environmental management class “C”, in general, proposes an MFR in the range of 12-30% of the mean annual run-off. Particularly, the Brahmaputra river basin’s MFR is estimated as 46%, and for the Mahi river it is 7%. According to these estimates, the estimated unutilized part of the water resources in many basins is higher than the required MRF. Only three basins, the Cauvery, Pennar and Tapi, are at levels that require re-allocation of potentially utilizable water resources to meet this relatively low environmental water demand. But the interpretation of these results require some caution.

The MFR, presented in this report, is based on annual river flows. However, due to monsoonal rainfall patterns, the monthly flows of Indian rivers vary significantly. If the demand is estimated at a monthly basis, the environmental water demand of some basins could be more, and the PUWR will have to meet part of this demand. As a result, the effective water supply available for other sectors could diminish in many basins. This would be another instance where inter-basin transfers could be required to satisfying the water demands of all sectors.

5. CONCLUSION

According to the business as usual water-use patterns, India is heading for a severe regional water crisis. Groundwater over-abstraction is the main cause for this. Many basins will have large pockets with unsustainable groundwater use. In the absence of major surface water development projects, reliance of groundwater in the long- to medium- term will increase. Artificial groundwater recharge can greatly enhance the groundwater stocks and shall facilitate the groundwater abstraction and sustainable water use. However, the negative implications of groundwater recharge on the downstream water users require further understanding. Increasing groundwater irrigation efficiency and other demand management strategies shall also be helpful for reducing the groundwater over-abstraction.

The increase in water productivity offers the greatest opportunities for reducing the additional irrigation demand. Impact of this on unsustainable water use will be significant as groundwater will be the major source of water for crop production. Doubling the water productivity over the next five decades shall require no additional irrigation requirement. However, given the direct and indirect contribution of irrigation to crop yield growth over the past decades, it shall require major investments in research, development, and extension on better management of other inputs. Crop diversification could also offer opportunities for increasing the value of water use. Many peninsular river basins, which are already water scare, can benefit from crop diversification. Crop diversification in already high water productivity areas, such as in north and north-west, shall need further understanding as the water productivity of grain crops in these areas are as high as the water productivity of no-grain crops. However, crop diversification would help the poor small farm holders in the east, although they have the water resources for meeting the requirements of water intensive crops.

Increasing dependency on groundwater, and water savings and reallocation of irrigation water shall still not meet all water requirements of other sectors. Increasing willingness and also affordability to pay for clean and reliable water supply would increase the pressure for surface water resources. Such scenarios will likely to emerge soon in states with high economic growth, and also water scarce. Most of them are located in peninsular India. And meeting additional surface water demand in these basins may require large intra- or inter-basin water transfers.

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COMPLICT AND INEQUALITY IN SURFACE IRRIGATION: A SOCIO-ECOLOGICAL PERSPECTIVE

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Abstract

This paper attempts to understand the role of institutions and governance, in explaining unequal access to canal water under different rules of the game. Two states at different levels of agricultural productivity with different rules of distribution of canal water are chosen to study the problem at project level. While Bihar, at low level of agricultural productivity, represents absence of scientific method of distribution of water, Punjab offers high level of agricultural productivity with the warabandi system. The two case studies offer interesting similarities and dissimilarities in terms of unequal access to water by the tail enders and mechanisms needed to mitigate this inequality. Some similarities are: (a) the tail enders suffer the most with low access to water forcing them to adopt only low water intensive crops in comparison to the head reach and mid reach farmers; and (b) the farmers supplement canal water with ground water. The dissimilarities noticed are: (a) while over exploitation of ground water in Punjab has reached levels beyond natural recharge of aquifers in several places; in Bihar, with low withdrawal of ground water and natural endowment of high water table, such a situation has not arisen; (b) the breaking of canal and water courses for own benefit by the powerful with political clout is rampant in Bihar, rarely attracting a penalty from the irrigation department; (c) the water market for tubewell water (Rs.70 to 80 per hour) has developed in Bihar partly mitigating inequality in access to canal water by the tail enders; no such phenomenon is common in Punjab. The plausible reason for the low density of tubewells in Bihar in contrast to Punjab is low incomes making affordability of tubewell an issue, and (d) cooperative efforts by farmers to lay down pipes through neighbors' plots to minimize loss of water has succeeded in Punjab; in Bihar such efforts succeeded initially at a small scale but could not sustain without government assistance. The absence of scientific rule for distribution of canal water and the weak canal governance system aggravates the misery of tail enders. In such a scenario, the mitigation of unequal access to water by the tail enders is facilitated by the development of water markets at high cost in a complex situation with tiny holdings and lack of cooperation among the farmers.

1. INTRODUCTION

Expansion of surface irrigation in seventies and eighties was followed by a rising gap between the potential created and the utilization of potential of irrigated area. The degree of utilization of irrigated potential varies across schemes with different scales (large, medium and minor). One feature is common to states at different levels of agricultural development, i.e., despite expansion of irrigation potential, the gross irrigated area in most states declined in the nineties and continues to decline. The increasing inefficiency of the canal irrigation system is also associated with highly unequal distribution of water between the head reach and the tail end farmers (Shah, 2001). This inequity and inefficiency manifests in supply of excess water at the head reach leading to waterlogging and salinity and high scarcity of water at the tail end (Vashishtha, 2007). In fact, the scarcity at the tail end is very severe at some locations not just for a season or two but for several consecutive years threatening the very livelihood of the tail end farmers. In that situation, the tail-enders depend highly on ground water, many of whom buy tube well water from their resourceful neighbors to save their crops (Meinzen-Dick, 1996; Palmer-Jones, 1994). It is also observed in the literature that while the buy-sell phenomenon of ground water is beneficial to both the buyer and the seller in financial terms in the short run, excessive dependence on ground water resulting in lowering of water table could pose a major threat to all jeopardizing the

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ground water balance in the long run (Morris, 2007). The above scenario raises several questions that need probing:

(i) What steps has the local community (mainly farmers in the command area) taken to mitigate unequal distribution of canal water, especially when the state irrigation authorities have virtually failed to take corrective measures?

(ii) Do farmers operating under different rules of distribution of water (in different regions) react differently against unequal access to water by the tail enders? Are farmers prepared to invest/contribute to the common pool to take corrective steps to improve local access to water?

(iii) Are tail-enders able to mitigate the suffering inflicted by lack of access to canal water through purchase of tube well water from neighbors?

This study aims at examining the above questions with the help of evidence collected from the field and is organized as below. Section 2 outlines the main objectives of this study and the methodology of conducting the field study. Section 3 describes the main features of sample locations. The field observations are presented in section 4. The last section 5 presents the concluding observations and policy implications.

2. OBJECTIVES AND THE METHODOLOGY

2.1 Objectives

Keeping in view the issues discussed, the paper, in a socio-ecological perspective, focuses on the following objectives:

1. To discuss the relative access of tail enders vs. head reach farmers to surface water in a canal command area, the nature of conflicts arising thereof and the socio-ecological problems associated with it.
2. To explore the role of local community (group of farmers in the canal command area) and other institutions in mitigating the impact of unequal access to surface water under diverse institutional arrangements of distribution of canal water.
3. To discuss whether the emergence of water markets has helped mitigate inequity in access to canal water and also the consequences associated with external diseconomies (declining water table), if any.

2.2 Methodology

Given the nature of research issues, it was decided to focus on 2 states for a comparative study, the main criteria of selection of states being (i.) they represent different levels of agricultural development, and (ii) they have different sets of rules for distribution of canal water at the village/water course level. As regards the choice of irrigation project, it was guided by prior knowledge about the nature of inequality and the conflict involved in the distribution of canal water. Whether or not the farmers took initiative to mitigate the intensity of conflict arising due to unequal access to canal water also featured in the choice of projects. Coming to the choice of village, it was dictated by the location. One village from each location (head, middle and tail end) was selected for field visits for intensive observations and discussion with the village leaders (well-informed individuals) and a group of farmers at each location. Although we did not conduct a farmer level survey, we did draw upon other studies based on farmer level data. It may be pointed out that the main insight relating to the existing water institutions and their functioning came from village level information and focused group discussions. Interaction with different stakeholders helped understand the ground reality on conflict and its resolution by the community. All this information was supplemented by secondary data of villages and districts selected for the study. This exercise is expected to share regional experiences for improving water access to the deprived groups and also form the basis for initiating an effective dialogue at different levels.

The 2 states viz. Bihar and Punjab were selected for a comparative study. These 2 states are at different levels of per capita state domestic product and agricultural productivity. While Punjab is in the top level of agricultural productivity, and high value of per capita state domestic product, Bihar is in the category of bottom level of states in respect to both these parameters. The per capita income (at 1993-94 prices) of Punjab is about four times that of Bihar. As regards poverty ratio (percentage of population below poverty line), Bihar has 42.6% for rural and 42% for the entire State in comparison to Punjab's poverty ratio of only 6.33% and 6.2% for rural and entire state, respectively. Even compared to the all India situation, Bihar fares poorly in terms of poverty ratio (Table 1). The physical yield of major food grain crops gives a good idea of the relative agricultural productivity levels in different states. Punjab's yield of rice and wheat is more than 2 times that of Bihar. Even for maize, the yield of Punjab is more than one-and-a- half times that of Bihar (Table 2).

Table 1: Income and Poverty Level in Bihar, Punjab and India

	Bihar	Punjab	India
Per Capita income (Rs.)			
2003-04	3,776	18,364	11,799
2004-05	4,159	19,354	12,416
Poverty Ratio (2004-05)			
- Rural	42.59	6.35	28.29
- Urban	32.42	5.75	25.62
- All	41.99	6.16	27.62

Poverty ratio refers to percentage of population below poverty line as taken from Planning Commission, GoI, New Delhi.

Table 2: Productivity of Major Food grain Crops, 2003-04: Bihar, Punjab and India

(kg/ha)

S. No.	Crop	Bihar	Punjab	India
1	Rice	1386	3694	1978
2.	Wheat	1903	4200	2696
3.	Course cereals	1816	2675	1107
4.	Maize	1682	2982	1875

The 2 states have very different system of canal water distribution. Punjab's *warabandi* system is designed to have an equitable distribution of canal water, at least by design. Bihar does not have such a scientific system at all. The turn of head-reach and tail end farmers for distribution of canal water is not scientifically worked out by the state irrigation department. Discussion with Bihar government officers and local scholars indicates that since initially there was no water shortage in Patna, the efforts to develop an equitable system did not receive attention. After deterioration in the maintenance of the canal system, the issue of equitable distribution has assumed importance. In the absence of a *warabandi* system, the decision of the irrigation department to discharge water in the distributaries is influenced by the pressure exerted by different interest groups (stakeholders) for favoring their constituency.

3. SAMPLE SITES

Having chosen the 2 states for this study, the choice of site for intensive study involved the following steps: one irrigation project-within each state; a canal or distributory within a project; village (and district) in each project; and some stakeholders in each location of the distributory. Appropriate projects and sites were selected in district Jalandhar of Punjab and district Patna of Bihar. The basic information on the sample sites is contained in Table 3.

Table 3: Irrigation Project and the Sample Sites

Zone	State	Irrigation project	Reach/Location at the distributory	Village corresponding to reach/location
North	Punjab	Bist Daob canal (district: Jallandhar)	- Head - Middle - Tail	Mullah Bediyan Khanpur Sarali
East	Bihar	Sone Canal Maner distributory (district: Patna)	- Head - Middle - Tail	Dhanesar Pura Datiana Korhar

3. 1 Punjab

Cropping Pattern: In *Bist Doab* canal command area, the farmers grow three crops in each season - wheat, sugarcane and green fodder in kharif, and paddy, maize and vegetable (potatoes) in rabi. Some farmers also allocate land in limited proportion to grow mint during zaid season. The cropping pattern in the mid reach and tail end villages is quite similar to that observed is the head reach villages (Table 4). It is obvious that in both the crop seasons, the present cropping pattern is water intensive. The irrigation water requirement is met from canal as well as groundwater sources.

Table 4: Cropping Pattern of Villages located at different reaches: Jalandhar (Punjab)

Sl. No	Season	Crops at different reaches		
		Head	Middle	Tail end
1	Kharif	Wheat, Sugarcane & green fodder	Wheat, green fodder	Wheat, green fodder
2	Rabi	Paddy, maize & Potato	Paddy, maize	Paddy, maize
3	Zaid	Mint	Not specified	Not specified

Source: Group Discussion with village leaders / other stakeholders

3.1.1 Source of Irrigation

Groundwater is the major source of irrigation in all the selected villages. The area of head reach village is spread on both the sides of the canal with undulating topography, rendering one side of the canal unfavorable for gravity irrigation. The area under canal irrigation varies at different locations from one-fourth to one-half of the irrigated area. The major proportion i.e. 50-75% water requirements is met from groundwater. In the mid reach village, the irrigation water requirement is fulfilled by canal and groundwater sources in equal proportion. Because of insufficient supply of canal water at the tail end, it meets only less than one-fifth of the total irrigation requirement (Table 5).

Table 5: Source of irrigation at different locations: Jalandhar (Punjab)

S. No.	Source	Proportion (%) of irrigated area		
		Head	Middle	Tail
1	Canal water	25-50*	50	15-20
2	Groundwater	50-75	50	80-85

Source: Field Observations

(* This case is rather unusual due to undulating topography of the head reach village)

3.1.2 Groundwater Table

The discussion with the village elders and knowledgeable individuals shows that the depth of groundwater varies from location to location. According to the village leaders the water depletion has been faster in the last five years than in the previous years. The decline in the water table at the tail end (25 to 30 feet) is far greater than that observed at other reaches. Relatively higher decline in the water table at the head reach (10ft) than at the middle reach (2 to 3ft) is an uncommon phenomenon arising due to the peculiar undulating topography of the head reach village (Table 6).

Table 6. Depth of and Decline in Groundwater Table at Different Location. Jalandhar (Punjab)

Particulars	Location of selected villages		
	Head	Middle	Tail
Depth of Water Table (ft)	200-220	200-230	250-270
Decline in water table is the last 5 years (ft)	10	2-3	25-30

3.2 Bihar

3.2.1 Cropping Pattern

At the head reach villages, farmers grow paddy in kharif, and wheat in *rabi* season. In the middle reach paddy, maize and groundnut in kharif, and wheat and vegetables in the rabi season are grown. At the tail end, paddy, maize and green fodder in Kharif and wheat, gram and green fodder in rabi are the main crops (Table 7).

Due to the availability of sufficient water at the head reach the farmers allocate their land to water intensive crops such as paddy in kharif and wheat in rabi season. The cultivation of less water intensive crops like gram and mustard was absent. At the middle reach, the farmers allocate certain proportion to other crops such as maize and groundnut in kharif and vegetables in the rabi season. At the head and middle reach, the farmers also grow less water intensive crops (e.g; gram and green fodder). The proportion of agricultural land allocated to different crops varies significantly even within a location.

Table 7: Cropping Pattern of Villages located at Different Reaches: Patna (Bihar)

Sl no.	Season	Crop at different reaches		
		Head	Middle	Tail end
1	Kharif	Paddy, green fodder	Paddy, maize and groundnut	Paddy, maize, green fodder
2	Rabi	Wheat, green fodder	Wheat, vegetables	Wheat, gram and green fodder

3.2.2 Source of irrigation

A very clear pattern of relative use of surface and ground water across different reaches is noticeable. The contribution of surface (canal) water declines drastically as one moves from the head reach village to the middle reach, and finally to the tail end. Canal water meets more than 90-95% of irrigation requirement at the head reach, 40-50% requirement at the middle reach and none at the tail end (Table 8). The canal maintenance is so poor and the tail enders are almost totally deprived of canal water. Obviously, the dependence on ground water increases as one moves from head to the middle and then to the tail end. Since the availability of electricity is extremely limited and voltage fluctuations are high, the farmers have to reply mainly on diesel pump sets for lifting ground water. This is why tail end villages have quite a good number of diesel pump sets (approx 50). It was noticed that the problem of water scarcity has increased in recent years and almost 8-10 tube wells have been added at the tail end every year in the last three years.

Table 8: Main Source of Irrigation at Different Reaches / Location: Patna (Bihar)

S. No.	Source	Proportion (%) of Irrigated area		
		Head	Middle	Tail end
1	Canal water	90 - 95	40 - 50	Zero
2	Ground water	5 - 10	50 - 60	100

Source: As in table 1.

3.2.3 Ground Water Table

It is observed that the groundwater table varies across different reaches (Table 9). The fluctuation in the level of groundwater across seasons is relatively low at the head reach village. Low availability of canal water helped recharge groundwater at head reach and prevented decline in water table. In the villages located at mid and tail reaches the aquifer depleted at a fast rate in the last five years; example, by 10 ft in the middle reach and by 15 - 20 ft at the tail end.

Table 9. Depth of and Decline in Ground water Table at Different sites: Patna (Bihar)

Particulars	Location of selected villages		
	Head	Middle	Tail
Depth of water table (ft) 100-150	100-150	120-180	
Decline in water table in the last 5 years (ft)	Nil	8-10	15-20

4. DISCUSSION ON FIELD OBSERVATIONS

4. 1 Punjab

The main observations made on the basis of field visits are:

4.1.1 Unequal Access to Canal Irrigation

The accessibility to canal water at different locations varies significantly. Although it may be attributed partly to undulating topography, the major factor is the lack of accountability of irrigation department for maintenance of tributaries and water courses. Further, the rotational procedure of canal water distribution that is supposed to be revised every year[2] has not been changed for the last one decade. It is surprising that the local farming community has not taken up this issue with the irrigation department.

4.1.2 Concentration of Water Intensive Cropping Pattern

Water intensive crops like paddy and wheat are common in all locations in spite of canal water being scarce at the tail end. The shortage of canal water is compensated through ground water lifting.

4.1.3 Emergence of Alternative Institutional Arrangement

The irrigation department has failed in its responsibility of maintaining and developing the irrigation structures (Stephen, 2002). The void is being filled on a limited scale by an alternative institutional arrangement in the form of users' cooperation. Farmers took initiative to organize themselves to repair and construct water courses leading to improvement in accessibility of water. Those who did not participate in this venture did not benefit. This led to differences between the farmers' group. The farmers sorted the issue by making the process

[2] In certain areas, the rotation takes place on Diwali.

more inclusive. Farmers have succeeded in laying down cemented pipe lines in the fields to help eliminate potential disputes over water access. This collective effort was attempted at the minor irrigation level as well. The neighboring villages have also made similar arrangements. It is noteworthy that this has been achieved through farmers' own resources without any direct support from the irrigation department.

4.1.4 Absence of Canal Water Theft

In the sample sites, the incidences relating to water theft (or siphoning of canal water) were non-existent. It may be attributed to the spirit of vigilance among the farming community. This sends a strong signal that breaking water course and/or siphoning off water will be reported to irrigation authorities inviting stringent punishment.

4.1.5 Non-existence of Water Markets

In the selected villages, there is hardly any buying and selling of ground water. In a few cases if water is sold, it is because of social considerations, not for financial gain.

4.1.6 Charges for Canal Water and Electricity Use

In Punjab, as per the announcement made by the then government, the canal water and electricity used in agriculture were available without any charges or at very little cost. This has resulted in several adverse situations such as: (i) overdrawing of groundwater even beyond recharge capacity; (ii) revenue deficit and lack of resources for improving transmission expanding capacity for electricity board because of zero or small cost of electricity; and (iii) higher price of electricity for domestic use due to cross-subsidization (from Rs. 1/unit to Rs. 4/ unit in couple of years). The farming community has its own perceptions regarding such political concessions (Dubash, 2007; Kumar, 2005). They feel that free power is of no use to them in the long run. Since power is not available for more than 8 hrs/day, they would be willing to pay for power used for extraction of groundwater for improved quality and quantity.

4. 2 Bihar

The following main findings are based on field observations:

4.2.1 Unequal Access to Canal Water

It is obvious from Table 6 that the dependence on canal water for irrigation declines sharply from head reach to middle reach and tail end. The situation at the tail end is so bad that water has not reached there at all for the last so many years. In contrast, the head reach farmers' dependence on ground water is only 5-10% as they get a major part of their water requirement from canal water. As a result, the head reach farmers are able to devote a much higher proportion of their cultivated area to paddy and wheat.[3]

4.2.2 Extension of Command Area Causing More Scarcity ofWater

The village leaders mentioned that there was substantial water in Maner canal until 1964-65. Water from Sone river was diverted to the newly constructed canal that caused reduction of water in the Maner canal affecting the farmers adversely in its command area. Some of the farmers reported that they had taken up the matter of restoring the share of water in this canal with the irrigation department. It did not give any results due to lack of effective leadership and political support in favor of farmers in the command area of newly con-

[3]Figures on area under paddy and wheat are not given in Table 5 but this phenomenon was confirmed by the village leaders and panchayat functionaries. However, as a part of food security and survival strategy farmers at the tail end do grow paddy and wheat even though they obtain much less yield than obtained by the head reach farmers.

structed canal.[4] The expansion of canal network without commensurate increase in discharge of water has aggravated the difficulty of farmers, especially tail enders.

4.2.3 Negligence of Maintenance, Blockage of Canal and Conflicts

The canal has not been cleaned properly since almost 25 years. Whenever cleaning was undertaken it was done only in small segments which failed to maintain a free flow of water to farmers at different reaches. Water courses are also poorly maintained (Gulati et al., 2004). In certain cases, canals had eroded completely and resulted in unchecked water flow from one field to the other, leading to accumulation of excess water near the outlet. Farmers reported that such unregulated water flow causes loss of fertilizer applied in the fields located near outlet. Because of undulating land, the farmers with higher level of land tend to block distributory to raise water level and attempt to siphon it off to meet their water requirement. Influential and powerful farmers, mainly big land-lords with political clout are more likely to be involved in the blockage of canal irrigation than small and marginal farmers (Saleth, 2004).[5] This kind of activity on the part of some influential individuals in the area has provided too much of water at the mid reach village resulting in over-irrigation at those sites (interestingly, head reach farmers are not involved in it) and led to severe scarcity of canal water at the tail end villages.[6]

4.2.4 Emergence of Water Markets

During the summer, the shortage of water reaches up to one-third to one-half of the total requirement even at the mid reach. As mentioned earlier, since the canal water does not reach at the tail end, the farmers depend entirely on the ground water. The resourceful farmers have installed pump sets (mainly diesel) which enables them to draw ground water not only for their own use but also for sale to others. Well owners charge Rs.70 – 80/hr for water. It is observed that even poor farmers, including the marginal ones, manage to irrigate their land by buying water from other farmers. This of course, is done at a high cost in the absence of availability of canal water. The emergence of water market does help poor farmers to mitigate the extreme shortage of water partly (Barah, 1993; Meinzen-Dick, 1996; Vashishtha, 2003).

4.2.5 Emergence of Informal Institutional Arrangement

Certain informal institutional arrangements evolved to help the system from complete collapse. A group of farmers restored some water courses. This phenomenon is not prevalent in the entire village. This group was informal and included different category of farmers – big as well as small. Most of them had contiguous piece of land. However, it could not expand its base in the entire village. This group also approached the irrigation department, government of Bihar, for financial help to repair and maintain the channel and water courses but without success.

4.2.6 Encroachment on Canal Area

The villagers of tail end reported that since 1977, there was no availability of water in the canal. Taking advantage of this situation, some individuals encroached the land area. Surprisingly, a group used it even for construction of shelters. Due to unlawful activities at the tail end the canal bed area has shrunk and is now converted into a small drain.

4.3 Comparative Picture

No doubt, Punjab and Bihar case studies present a contrasting picture, they also have some broad similarities in respect of inequality in access to canal water and canal administration. Some of these aspects are presented below:

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[4] Similar evidence was noticed in Haryana in Hansi-Bhutana link canal which was constructed in the recent past. The farmers in the adjacent canal command area protested and asked for restoring their original share of water prior to the construction of canal.

[5] A similar phenomenon is observed in Haryana by Vashishtha (2003).

[6] It was also reported that part of the scarcity is due to diversion of canal water for use in non-farm activities.

4.3.1 Tail Enders are the Most Deprived Lot

In both Punjab and Bihar, access to canal water is very low as compared to the head reach and mid-reach farmers. In Bihar, however, the tail enders are pushed to the extreme situation of almost complete deprivation in terms of access to water. The unchecked siphoning off of water from canal by powerful elements reflects the status of socio-political milieu in rural Bihar.

4.3.2 Neglect of Canal Maintenance and Watercourses

This aspect is common to both the states. In the case of Bihar, this neglect is pushed to a desperate level due to the virtual financial bankruptcy of the irrigation department. Irrigation rates are very low in both states and the state governments do not intend to offend the farmers by raising irrigation tariff. In Bihar, an additional factor is the low agricultural productivity and high rural poverty, which discourages the state government to face risk involved in raising tariffs. In Punjab, the level of productivity and poverty per se is not the major issue. However, the stagnant productivity and declining profit levels in agriculture production may be an important deterrent for the state government to raise tariff levels.

4.3.3 Socio-ecological Problems

Certain features common to both Bihar and Punjab may be noted: (i) availability of excess water and raising of water intensive crops at the head-reach irrespective of the overall shortage of water; (ii) significant decline in ground water table, especially at the tail end (decline in water table at the tail end is much sharper in Punjab than in Bihar). Since, the ground water table is already too low in Punjab and over-exploitation of groundwater has gone beyond the recharge capacity of aquifer in many places (Singh, 2006), the environmental consequences of decline in water table are more serious and imminent in Punjab than in Bihar; (iii) minor encroachment in canal and distributory takes place in Punjab too but in the case of Patna, (Bihar) encroachment in the form of settlement in the canal bed at the tail end is extreme; (iv) the political economy of very low power tariff (or zero tariff) for lifting ground water is quite similar in both states. However, the environmental negative externalities of power tariff policy are more serious and imminent in Punjab as compared to Bihar due to (a) the extent of over exploitation of ground water that has already taken place in Punjab; and (b) continuing incentives favoring water intensive crops (e.g. paddy) and discouraging crop diversification (Singh, 2007).

4.3.4 Water Markets

There is little evidence of water markets in Punjab. In contrast, in Bihar there exists market for ground water and the pump set owners charge Rs.70-80 per hour for supplying ground water to their neighbors. A plausible reason for absence of ground water markets in Punjab may be the widespread ownership of tube wells and pump sets by many farmers. This is facilitated by the reasonably high level of agricultural productivity (vis-à-vis all India), relatively larger average land holdings and consolidation of land holdings (Shah, 1993). In contrast, in Bihar, the productivity level is too low, average landing is small, and holdings are fragmented rendering installment of tube well and pump sets unaffordable by individual farmers. The ground water market in Bihar helps partly mitigate inequality in access to canal water even for the marginal farmers (Singh et al. 2007).

4.3.5 Informal Institutional Arrangement

In Punjab, the farmers managed to evolve an informal cooperative mechanism and pool their resources for repairing damaged water courses and laying down pipes through fields of different plot owners to minimize waste of water and avoid potential conflict. Siphoning off canal water is rare and there is respect for running the *warabandi* system. This is not observed in Bihar. The farmers attempted, on a very limited scale, to organize themselves and restored a few water courses. However, this experiment could not be extended to the entire village. The tiny land holdings, low productivity, fragmented society on caste basis and the apathy of the state government machinery to the problems and difficulties of the people made the cooperative venture difficult to sustain. Further, lack of respect for allowing free flow of water by the unscrupulous and powerful elements is a big challenge to the poor and fragmented units to organize themselves into an effective and cohesive group. It is important to emphasize that a combination of factors (economic, social and institutional) poses a big problem for restoring a credible governance system for canal administration.

5. CONCLUSIONS

Poor distribution of canal water to the middle and tail end users has lead to sever and unsustainable withdrawal of ground water in Punjab and creation of water markets in Bihar. Addressing local institutions, the size and distribution of land holdings and support from public authority are a pre-requisite to bringing about any improvement in canal water distribution, preventing water losses and conserving ground water.

In case of Punjab, the environment is already conducive to surface water management since the size of landholdings is large, farmers have sufficient revenue to undertake repair, the *warabandi* system or system of taking turns for access to water already exists. If local institutions are more active and work with communities, they can have equitable distribution of water to the tail end users as well. In case of Bihar, the small size of land holdings and poor income of farmers act as major deterrents. Further, the institutions set up for management of canal water are inefficient and partial. The first step towards addressing distribution in Bihar would thus be reforming the institutions and making them more accountable.

Reasonably good level of agricultural productivity coupled with relatively large and consolidated land holdings do provide incentive for return in investment of a joint venture for repair of water courses and laying down of pipes to avoid wastage of water, the factors that are missing in Bihar.

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IRRIGATION MANAGEMENT AND ITS EFFECT ON PRODUCTIVITY UNDER PARAMBIKULAM ALIYAR PROJECT IN TAMIL NADU *

K. Sivasubramaniyan *1

Abstract

While at the national level, area under surface irrigation has been increasing, in Tamil Nadu, it has been declining. There is an increased reliance on groundwater sources of irrigation. This highlights the need for improving quality and reliability of canal irrigation in order to increase net irrigated area and improve water productivity in agriculture. In surface irrigation systems, where scarcity in supply is experienced, conjunctive use of groundwater helps to achieve better yield. However, in larger surface irrigation, which supplies water to dry crops – there is a need to assess the effect of conjunctive use in different segments of the command taking into account several other factors such as climatic conditions, local rainfall and sub surface geology. This is because not all parts of the command area get adequate supply, which in turn leads to poor recharge of wells. The paper looks at conjunctive use for irrigation management in the Parambikulam Aliyar Project in Tamil Nadu.

1. INTRODUCTION

Irrigation continues to draw around 4/5 of the total water available in India. India's net sown area is around 141 million hectares and the net irrigated area is about 55 million hectares. This is nearly 40% of net sown area. Given the acute shortage of land for cultivation, India must concentrate on increasing the area under irrigation to improve land and water productivity. Successive Five Year Plans have played a prominent role in expansion and improvement of irrigation by facilitating direct investment through public sector. During the Nine Five Year Plan periods from 1950-51 to 2001-02, India invested a total of Rs. 1556 billion in irrigation (GoI. PC. X FYP. Vol. II. 894).

Although investment and area under irrigation have increased over time, sustainability across states is questionable. In absolute terms while canal irrigation in India has been gradually increasing, in Tamil Nadu it has been decreasing. In Tamil Nadu, the area irrigated by canals decreased from 8.4 lac hectares during 1950-69 to 7.1 lac hectares during 1990-04. During the same period, area under tank decreased from 8.5 lakh hectares to 5.1 lac hectares. However, in the same period the net area under well irrigation more than doubled from 5.7 lac hectares to 13.7 lac hectares (Table 1). There are no other sources of irrigation in Tamil Nadu. Combining all sources, the total area under irrigation was 26 lac hectares during 1990-04. The share of net irrigated area to net sown area was 39% for all-India, whereas, the same for Tamil Nadu was 48%. More importantly, although Tamil Nadu has reached a higher percentage of net irrigated area to net sown area, it has already reached its maximum potential. Any further increase in the net irrigated area can be possible only through increasing the efficiency of water use, especially in the surface sources.

In Tamil Nadu, the rapid growth and relative importance of groundwater as a source of irrigation demonstrates the progressive improvement in the quality of irrigation in terms of assured, adequate and timely supply of water to crops. Especially in the surface irrigation systems where scarcity in supply is experienced,

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[1]. The wells located in the poor surface supply region are less reliable than those located under well-fed region.

[2]. There are numerous studies on the impact of irrigation on land use, cropping and productivity, but they seldom deal with institutional aspects. The available literature is reviewed in Vaidyanathan 1985.

conjunctive use of groundwater helps to achieve better yield. However, in larger surface irrigation, which supplies water to dry crops – there is a need to assess the effect of conjunctive use in different segments of the command taking into account several other factors such as climatic conditions, local rainfall and sub surface geology. This is because not all parts of the command area get adequate supply, which in turn leads to poor recharge of wells[1].

Comprehensive studies of the way surface irrigation systems are managed and the relation between management and productivity are rare[2]. There is good reason to believe that centralized bureaucratic management with little or no user participation leads to inefficient irrigation, which contributes to poor quality of irrigation provided by state run systems. This has long been emphasized in irrigation management literature (see Coward, 1980; Downing and Gibson, 1974). Recent studies underscore this point even more forcefully (see Chambers, 1988; Vaidyanathan, 1991; 2006; Sengupta, 1991; Ostrom, 1992; GoI, 1992; IIMI, 1994, Sivasubramaniyan, 1985, 2007). In India, concrete studies or even descriptions of the way water is managed in different types of surface systems are relatively few. Even few studies are mainly concerned with the institutional aspects and not with systematically exploring variations in management practices across different systems, and what effect management, as distinct from other factors, has on productivity (Vaidyanathan and Janakarajan, 1989).

This paper seeks to get a proper understanding of the impact of canal irrigation on productivity. Its distinctive feature is to provide analytical information on present status and detailed account of the changes that happened in the Parambikulam Aliyar Project (PAP) command and the sample blocks with comparable concepts and schedules as used 20 years ago. The changes are analysed in terms of allocation of supply in different canals, water distribution and management among blocks at field level and changes in cropping pattern and productivity. Such diachronic studies of the same group are rare.

1.1 Study Area and Methodology

The Parambikulam Aliyar Project (PAP) in which the study was undertaken is an inter-state multi-valley and multi-purpose project. It was commissioned in early 1960s and started functioning from mid-1960s with an initial annual command area of 80,000 acres[3] and increased to 4.3 lakhs in the mid 1990s. From 1995-96 onwards the government introduced a four-zone irrigation pattern in the overall command area of 4,31,000 acres served by the PAP. Further, in order to distribute the canal supply fairly in the command a new distribution pattern called the Alternate Sluice Irrigation System (ASIS) was introduced in August 2000. Under the ASIS the command area can get its irrigation supply once in two years by rotation. Further, the PAP follows a cropping system of "irrigated dry crops" which entails irrigation of a larger area with a given quantity of water.

The study of irrigation impact on productivity has been done at three levels. First, by documenting the characteristics of the PAP system and its management as a whole, the way it was designed to work and the way it actually works and the way the deviations have been accommodated. Second, by obtaining a meso-level picture of the working of institutions and water allocation in the 12 selected distributaries of the PAP system (see flow chart). Third, by conducting a micro level enquiry of the entire sample cultivators in the representative sample of 100 blocks served by the selected distributaries.

The paper is organized in five sections. Following the introduction, section II provides detailed information on the methods of water distribution in PAP at farm level across selected distributaries in the latest two spells. Section III briefly discusses the cropping pattern adopted in the PAP command in the last three years preceding the survey. Section IV analyses the outcome of cropping in terms of productivity across zones in spell and non-spell years. Final section provides the summary of the earlier sections.

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[3]. This area increased to 2,40,000 acres in mid-1980s to be irrigated once in 18 months with a three zone irrigation pattern and a further increase of 1.75 lakh acres permitted up to 1994-95. [1]

2. BLOCK LEVEL MANAGEMENT OF WATER DISTRIBUTION

In any irrigation system the final outcome in terms of crop productivity depends upon how best the irrigation system and its distribution networks are maintained and water distribution is effectively managed in all parts of the command. Let us first discuss the distribution of water in the PAP command. The responsibility of water allocation up to main/branch canal is vested with the Public Works Department (PWD). Within each distributary, the right for maintenance of channels and distribution of water solely rests with the Village Water Users Association (VWUA). By taking into account the total command area under all sluices in a distributary the quantum of supply required is decided by the PWD officials and the office bearers of the VWUA. Throughout the length of each distributary, several sluices are located. Each sluice serves many blocks under it. Based on the total command area available in each block and the number of days of water release from the main/branch canals to the distributary, suitable rationing system is followed. Mostly this is based on the number of hours water could be supplied per acre in a day. This could be multiplied by the number of days of water release from the main/branch canal.

In almost all the blocks hour based murai[4] system is followed and adjusted among farmers based on the extent of command area available in each block (Table 2). Within each block, the responsibility for construction and maintenance of field channels and regulation of water distribution rests wholly with farmers. In all distributaries and in all blocks surveyed, there appears to be a well-defined system of field channels for carrying water to individual plots, with more or less fixed alignments. The area under the channels is individually owned and managed. The channels are all unlined. During spell period, all farmers cleaned these channels individually as per their cultivation limit. This process has been working smoothly throughout the PAP.

Within the block, one can observe a wide variety of sharing arrangements with specified rules as stipulated by the VWUAs. These are supervised by the Territorial Committee Members (TCMs) as and when required. As shown in Table 2, most distributaries get the canal supply for 7 days in a turn of 21 days duration (7 days supply 14 days off). In a few other distributaries, especially in the Udumalpet canal[5], farmers get 10 days supply but those distributaries are split into two and provide irrigation 5 days each in turn. This arrangement ensures adequate supply to the tail end blocks. This pattern is followed, where the distributary's intake point as well as the breadth and depth is less than the required level. Apart from adopting this general distribution pattern farmers also follow some other pattern.

For instance, the total command area in a block is 21 acres. Water is released for 7 days in the distributary. Hence, supply hours per acre is 8. This is the theoretical calculation. However, in practice the following procedure is adopted for water distribution. As per the turn, each acre is given first 2 hours per day: (a) If a farmer owned only one acre he could use 8 hours supply during the turn. But the actual supply allotment is only 2 hours per day. Hence he can irrigate only (120/480=25 minutes) ¼ an acre during the first round of the turn. (b) If a farmer owned more than one acre of land in the command, say 4 acres, it is easy for him to irrigate 1 acre fully by the allotted time of (4X2) 8 hours supply in the first round. Accordingly, during the first turn of 7 days supply each farmer gets 4 rounds of supply (with 2 hours each). The exact duration of supply given depends upon the possession of holdings in the command area by a farmer. The most important point is, whether the entire area has been irrigated or not depends upon the quantity of supply released in the distributary and the farmers' ability to supplement their well water along with the canal supply.

In a few other blocks of the 3.4.500 distributary, when enough supply was available 6 hours supply per acre per turn was allotted. When deficit supply was reported, the supply was reduced to 4 hours per turn to all farmers. If one round supply was over and still the supply continues a second round of further 2 hours supply per acre was allowed. This turn system facilitates the utilization of well water to irrigate the command in the initial supply period and adjust the PAP supply to provide more water to non-well farmers to crop their land fully initially.

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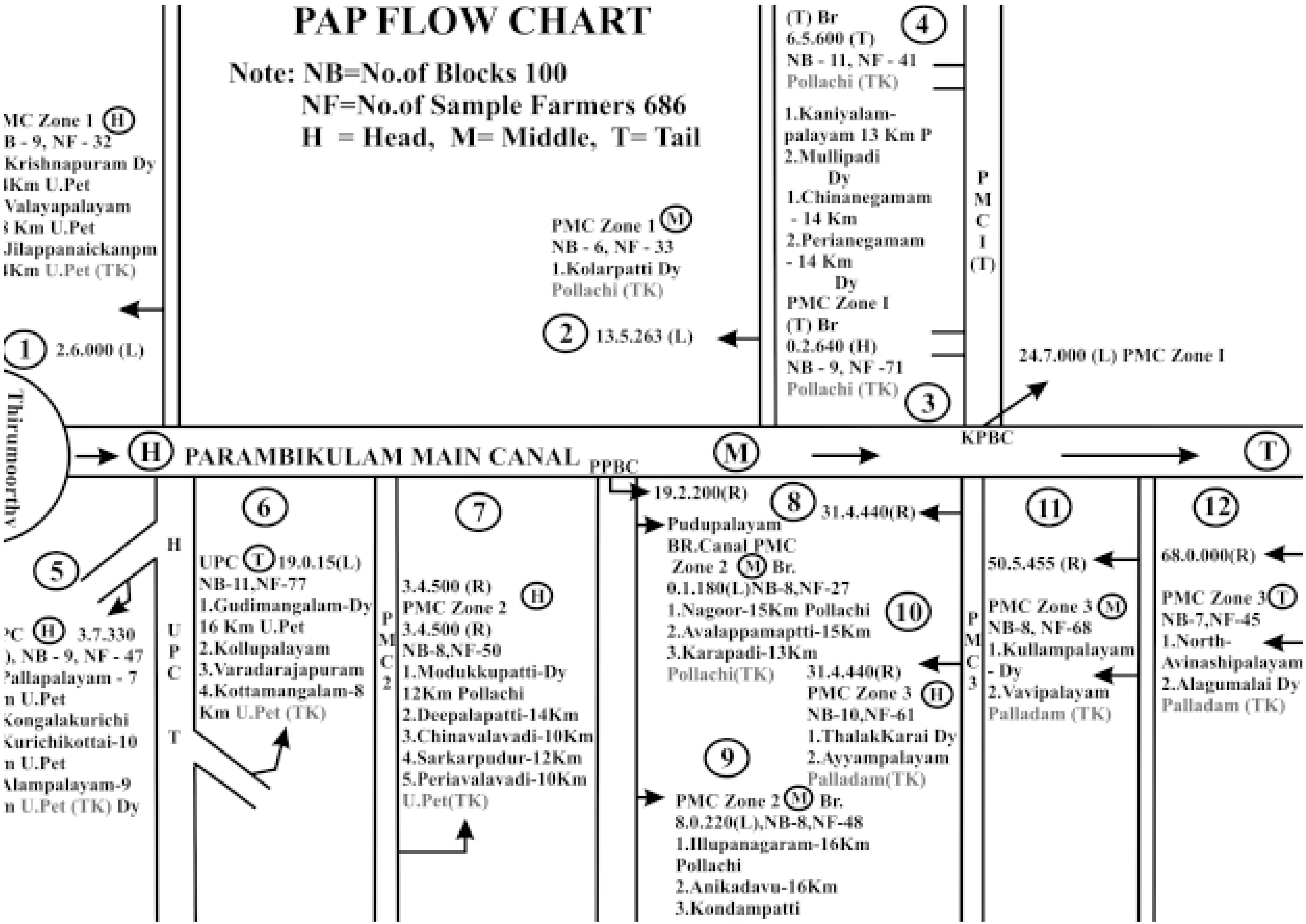
[4] A time bound system of water rationing adopted at block level both in normal and deficit supply periods to share the canal supply either equitably or fairly to all farmers within each block by the direction of VWUA.

[5] This canal takes off from the PMC at mile 0.6.000 and serves about 58,000 acres in 4 zones.



PAP FLOW CHART
Note: NB=No.of Blocks 100
NF=No.of Sample Farmers 686
H = Head, M= Middle, T= Tail
PARAMBIKULAM MAIN CANAL
Thirumoorthy
PPBC
KPBC
2.6.000 (L)
B - 9, NF - 32
Krishnapuram Dy
U.Pet (TK)
PMC Zone 1
NB - 6, NF - 33
1.Kolarpatti Dy
Pollachi (TK)
13.5.263 (L)
(T) Br
6.5.600 (T)
NB - 11, NF - 41
Pollachi (TK)
1.Kaniyalam-palayam 13 Km
2.Mullipadi Dy
1.Chinanegamam - 14 Km
2.Perianegamam - 14 Km Dy
PMC Zone I
(T) Br
0.2.640 (H)
NB - 9, NF -71
Pollachi (TK)
24.7.000 (L) PMC Zone I
3.7.330
NB - 9, NF - 47
UPC
UPC
19.0.15(L)
NB-11,NF-77
1.Gudimangalam-Dy
16 Km U.Pet
2.Kollupalayam
3.Varadarajapuram
4.Kottamangalam-8 Km U.Pet (TK)
3.4.500 (R)
PMC Zone 2
3.4.500 (R)
NB-8,NF-50
1.Modukkupatti-Dy
12Km Pollachi
2.Deepalapatti-14Km
3.Chinavalavadi-10Km
4.Sarkarpudur-12Km
5.Periavalavadi-10Km
U.Pet(TK)
19.2.200(R)
Pudupalayam
BR.Canal PMC
Zone 2 Br.
0.1.180(L)NB-8,NF-27
1.Nagoor-15Km Pollachi
2.Avalappamaptti-15Km
3.Karapadi-13Km
Pollachi(TK)
31.4.440(R)
31.4.440(R)
PMC Zone 3
NB-10,NF-61
1.ThalakKarai Dy
2.Ayyampalayam
Palladam(TK)
PMC Zone 2 Br.
8.0.220(L),NB-8,NF-48
1.Illupanagaram-16Km
Pollachi
2.Anikadavu-16Km
3.Kondampatti
50.5.455 (R)
PMC Zone 3
NB-8, NF-68
1.Kullampalayam - Dy
2.Vavipalayam
Palladam (TK)
68.0.000(R)
PMC Zone 3
NB-7,NF-45
1.North-Avinashipalayam
2.Alagumalai Dy
Palladam (TK)

It is evident that in almost all distributaries and blocks the farmers follow well-laid criteria and procedures for regulating the sequence and duration of irrigation to farms in the command. The commonly observed aspect is that in almost all distributaries PAP supply was inadequate even to raise dry irrigated crops. The only option is supplementing PAP water with well water wherever possible. Further, in a year, two PAP spells were possible; one in summer and the other in winter. The latter one was always considered favorable due to its coincidence with the northeast monsoon. However, spells given during drought years (between 2002 to 2004) are totally ineffective, including the monsoon spells.

The most interesting aspect of the PAP irrigation is that although each spell is given to a particular command once in two years, the command area farmers are not hesitant to receive the meagre supply lasting for only 30 to 35 days (intermittently) in a spell period of 135 days. This is the success of the PAP irrigation. Another interesting aspect is the conversion of coconut crop from wet to dry crop in the PAP command. This was possible mostly by adopting high-tech drip irrigation, for almost 80 to 90% of the entire coconut area. Only limited head reaches to PMC and farmers located close to main canals did not adopt this drip system.

3. CONDITIONS OF CANAL WATER SUPPLY DURING THE LATEST TWO SPELLS[6]

To understand the actual working of water allocation to the main and branch canals from the dam and its allocation to various distributaries it is necessary to have a look at the number of days of water released to the main and branch canals in each spell. Annually, based on the dam storage, two spells may be possible. The latest spell periods fell in the 12 distributaries under 4 zones during the years were 2004-05 and 2005-06. The last spell periods were 2002-03 and 2003-04. It should be noted that between these two spells the later was severely affected by drought. As a result, the number of days of supply released in the main and branch canals was reduced considerably, to around 30 days less than the normal spell period, which is 135 days (4½ months). In our reference periods, the maximum number of supply days in the latest spell is 94 and the drought spell is 66. Based on this information let us discuss the supply position in each of the selected distributary. The survey information is put down in summary form in Table 3. The conditions of water supply and mechanisms adopted by farmers to overcome the deficit supply in each distributary are given in Table 4.

The ASIS in the PAP is designed to provide canal supply to the lengthy distributaries every year, which have a command area of more than 1000 acres. In those distributaries, the command area is divided into two zones and supply is given to one zone each year. Accordingly, the zones are arranged as 1 and 3; and 2 and 4. For instance, a lengthy distributary is divided into zones 2 and 4, in which zone 2 may get the first spell in a year and zone 4 may get the first spell supply in the next year and vice versa. As a result, canal supply can flow in the distributary every year, which helps to recharge the groundwater through both the canal flow and its irrigation supply. This pattern, as perceived initially when the design was formulated, helps well farmers to sustain their supply throughout the year. However, it may not be feasible for small distributaries, which fall below 1000 acres command, which are classified under one zone and can get the canal supply only alternate year.

3.1 Supply Pattern in the PAP Canals and Distributaries

Since the timing of the spells differs from zone to zone, and the conditions of water supply vary from season to season, the experience of each zone is discussed separately. Annually, two zones get the PAP supply in normal dam storage period. For all 4 zones one spell takes 2 years. Each spell takes 4 ½ months (135 days), which irrigate an approximate command area of 94,000 acres. To better analyze the water supply conditions distributaries can be grouped in the following zones:

3.1.1 PMC zone 1

This zone has three distributaries. The latest spell started on 6 January 2006 and ended on 5 May 2006. The duration of the spell was 119 days, 16 days short of 135 days. However, actual supply days in the PMC

[6] Latest two spells: Latest and Last spells. The former represents the spell years 2004-05 and 2005-06 and the latter represents the spell years 2002-03 and 2003-04. A spell year accounts from June 1 to May 31.

Zone	Distributary sl. nos.	Latest spells	Quantity *	Last spells	Quantity
I	2,3 and 12	2005-06	17.292	2003-04	5.322
II	1,5,6,7, 8,9 and 10.	2004-05	13.200	2002-03	6.844
III	4 and 11.	2004-05	13.200	2002-03	6.844
IV	1,7 and 10.	2005-06	17.292	2003-04	5.322

Note: Distributary sl. nos. as per Table 3.

were 91 days and the same for the three zone 1 distributaries is between 38 and 42 days. 42 days supply, which gives six irrigation supplies during the 135 days period is considered normal. This is roughly based on the calculation of 7 days supply for one half of the zone, another 7 days for remaining half of the zone and next 7 days dam closure for irrigation and recharge of the dam. Except one distributary, which had 38 days supply, other two received normal supply in this spell.

During the 38-year period (1967-68 to 2004-05) the average supply of water released in both PMC and UPC was 13.152 TMCft per annum. If one divides this period into two and counts the average which indicates the first period (1967-68 to 1985-86), supply in both the canals was 12.826 TMCft and in the next period (1986-87 to 2004-05) the average quantum was 13.638 TMCft. Hence, it is probable to take the average of 13 TMCft as the normal supply for both PMC and UPC. Based on this calculation, if one analyses the supply given in the two canals during the latest spell year (2005-06), which indicates that although the supply days were slightly less than normal, because of adequate storage, the quantum of supply released was more than average (17.292 TMCft) which is nearly 4 TMCft more. Whenever the spell coincided with the dry season (January to May) the total supply realized and released may be less than that with the monsoon spell (August to December). Since the latest spell was considered normal, the sample farmers surveyed in all the distributaries expressed some satisfaction on the quantum of supply available. Of the 22 blocks covered in the zone 1 distributaries, 19 blocks got ‘regular but not full supply’, and 3 blocks got ‘neither regular nor full supply’. Amongst the reasons for inadequate supply 8 blocks reported ‘excess tapping in the upstream distributary’ and 14 blocks revealed ‘inadequate storage position’ in the dam. Regarding effect on water supply on the crop, only a fourth of the blocks reported to change crop pattern and the remaining blocks ‘managed the supply with well water’. This contrast is mainly due to the fact that the supply given to them during the previous spell was much worse. Hence on a comparative basis farmers viewed the supply in this spell as favourable. In addition, the quantum of main canal supply released in the latest spell was 28% more than the average.

The previous spell, 2003-04, which began on 11 December 2003 and ended on 21 January 2004 was, by contrast, a drought spell. Even in the main PMC the supply lasted only 27 days and the selected zone 1 distributaries each received only 12 days supply. Not only this zone, but all the 3 other zones were also severely affected in this previous spell period. The quantum of supply released in this spell year was 5.32 TMCft, (59% less than average). This was mainly due to continuous and severe drought in the entire state including this PAP command.

In zone 1 distributaries, all the 22 blocks reported received ‘neither regular nor full supply’ and majority of them informed that ‘inadequate storage position’ was the main reason for poor supply. As of crop effect, half the blocks reported complete crop failure, one third managed with well water and a quarter managed by changing crop pattern and by reducing crop area. More or less same effect was noticed for the other zone distributaries, especially for the last spell period. This effect was evenly distributed throughout the PAP because the dam storage itself dwindled considerably for two consecutive years and monsoon failed totally (for more details see Tables 3 and 4).

* Indicates the quantity of supply in TMCft released in the PMC and UPC. Three lengthy distributaries are divided into two zones each. Long-term average quantum of supply released from the Thirumurthi Dam was 13 TMCft per annum.

3.1.2 PMC zone 2

The latest spell in this zone started on August 20, 2004 and ended on December 31, 2004. This spell lasted 133 days which is only 2 days less than the normal period. Actual number of days supply available in PMC in this spell was 90 and for the Udumalpet canal it was only 71. Both the sample distributaries of UPC are also included in zone 2. Altogether 7 distributaries out of 12 selected come under zone 2. There are, however, significant differences between distributaries in terms of supply days, which are a minimum of 29 days in the tail distributary of PMC to a maximum of 50 days in the head distributary under the PPBC of PMC. In the remaining distributaries the supply days were between 33 and 45 (see Table 3). Although supply to all the distributaries was releazed in the last week of August 2004, the closing dates differed considerably; majority of distributaries were closed in the last week of December 2004, and two others were closed on 10th and 18th December 2004. This difference also makes variation in the total number of days supply given to different distributaries. The quantum of supply released in the PMC & UPC in 2004-05-spell year was 13.200 TMCft, which is close to the long-term average supply.

The location advantage of distributaries in getting supplies is clearly seen in this spell period. Not only the duration of spell was longer in the PMC (90 days) but also in the head reach distributary in the PPBC, which received a maximum of 50 days supply. However, in the same PPBC's tail end distributary received only 35 days supply. Apart from this, in UPC one can notice the location advantage between the head and tail distributaries. In this canal, the former distributary received 45 days supply compared to only 34 days to the latter. It is important to note that after the year 2000, no extension of supply was granted to any distributary. Even during continuous drought years the distribution and allocation mechanism did not change. This shows that the supply system has become rigid now. However, during severe drought years, some supply was released to local tanks for cattle needs and other purpose.

In terms of quantum of water supplied to the distributaries in both the latest and last spells, the data recorded in the respective section offices provide some interesting results. For a clear understanding, the data is modified in terms of the quantum of supply received per acre in the two spells. Of the 7 distributaries coming under zone 2, PMC feeds five and UPC feeds the remaining 2. As per PAP's irrigation pattern one TMCft can irrigate 12 acres of command. By adopting this norm the following points emerge (Table 5).

Even in the latest spell which was considered normal, all distributaries under PMC and the head distributary of UPC received less than the expected supply. Only the tail distributary of UPC received marginally higher quantum. In the latest spell, the percentage of deficit ranged from 25 to 46. It should be noted that the deficit increases steadily when one moves from head to tail distributaries in the PMC. However, this is reverse in the case of UPC. The number of turn supplies given during this latest spell was 5 in majority of the distributaries except in sluice numbers 3, 4 and 7. The latter two distributaries received a supply turn of 6 each and the former one received a maximum turn of 8 in that spell. Due to more turns, the number of days supply given was increased compared to all other distributaries. However, in the tail distributary (31.4.440) of PMC the number of turns given was only 4.

The last spell in zone 2 started on February 1, 2002 and ended on July 31, 2002. This spell was considered unsatisfactory. Since the spell started in summer, it had less number of actual supply days, which is 66 in PMC and 56 in UPC. The supply in this period was erratic. Whenever dam storage improved, supply was released. As a result, all 7 distributaries received only 4 turns. This resulted in poor supply to all distributaries and the deficit ranged from 20% in the head distributary of UPC to around 55% in the PMC distributaries. In one of the PMC distributaries, deficit was as high as 84%; but this was because only a limited number of farmers used the supply. Actual supply released in this spell year in PMC was 6.844 TMCft. This is only half of the average expected supply for a spell. Across distributaries, the number of supply days in this spell ranged from a minimum of 16 to a maximum of 27 under PMC and 27 to 51 under UPC distributaries. In the distributary, which had less number of supply days, farmers stopped receiving PMC supply in the middle of the spell itself and only limited number of farmers cropped the land. Again, in the head reach distributary (3.7.330) of UPC an unusually high number of days of supply were given. This is because in each turn more number of days of supply (which is 13 days) were given. However, the supply position was verified with the responses gathered from the survey, which indicates that the given supply was neither regular nor full. As a result, majority of farmers reported crop failure. This situation was applicable to other distributaries also. This reveals that the data maintained by the PWD section offices cannot be wholly reliable, especially in the drought spells. This was also noticed in the earlier survey[7].

Due to poor supply given in this spell almost all farmers in all the blocks reported that supply was neither regular nor full. Majority of farmers felt that inadequate storage in the dam was the main reason for this deficit. Some farmers felt that this inadequate supply was caused by excess tapping in the upstream of the distributary. Due to poor supply, around half the respondents reported that their crop failed completely; one third of them managed the crop with well water; and the remaining reduced the crop area and changed the crop pattern.

Although supply was released, the number of turns was accounted, and the quantum of supply taken in a spell in each distributary was noted, it is not clear whether the given supply to all farmers in a particular distributary was enough in either of the spells. This is because the PAP supply was given with a long gap of at least 21 days even in normal spell. During drought spell, like this one, for months together there was no supply. In the block level interviews, all the blocks in all the distributaries in zone 2 reported neither regular nor full supply. This resulted in complete crop failure in most farms including well farms. Effect of wells in supplementing canal supply was also reported to be very poor except in the head distributary (2.6.000) of PMC.

3.1.3 PMC zone 3

The latest spell in this zone started on January 16, 2005 and continued up to May 26, 2005. The spell lasted for 130 days, 5 days short of 135 days. However, the actual number of days of flow available in the main canal was only 64 (see Table 3). In this zone only two sample distributaries exist. The first one is the tail end (6.5.600) of KPBC and the next is the tail distributary (50.4.445) of PMC. While the latter distributary received a supply of 26 days, the former received only 20 days. Although both the distributaries received 5 turns in this spell, the number of days supply in each turn varies widely between 2 and 7 in 6.5.600 and 2 and 10 in 50.4.445 distributary. Only in the first couple of turns, the number of days supply given was normal (7 to 10 days); after that each turn received less than 4 days supply. The other important measure, i.e., the quantum of supply received indicates that while 6.5.600 distributary received only a third of the entitled quantum, the tail distributary (50.4.445) received a little less than a half in the latest spell. As a result, the deficit was more than 50% in both distributaries (Table 6).

The last spell of this zone was even worse, which started on September 9, 2002 and ended on January 12, 2003. Although number of days counted is 125 – a shortfall of 10 days to normal – the actual flow in the main canal was only 57 days. Apart from that, the respective distributaries received the supply only for around 25 days. In each distributary, the number of turns supply was available was 4. However, the number of days supply given was maintained as 6 to 7 in each turn. In terms of quantum of supply received, the share of 6.5.600 distributary was only a fourth of the entitled supply and for 50.4.445 distributary it was 42%. In both distributaries the deficit was over 55%.

Of the 19 blocks surveyed in zone 3, only 3 blocks reported regular but not full supply in the latest spell. In all remaining blocks, the supply was neither regular nor full. All the blocks in the head reach and half the blocks in the tail reach reported excess tapping in the upstream distributary as the main reason for irregular and inadequate supply. Due to poor supply almost half the blocks in both distributaries resorted to reduction in the cropped area. One third of blocks changed cropping pattern and very limited blocks managed the crop by supplementing well irrigation. During the last spell, the pattern had changed dramatically. All the blocks in both the distributaries reported neither regular nor full supply. Majority of the blocks reported that inadequate storage in the dam was the prime reason for deficit supply. All kinds of measures such as reduced crop area, changed crop pattern and resorting to well water, were adopted to save the crop. Hence, it may be clear that none of the spells was useful to provide adequate supply to any of the blocks in both distributaries.

[7]. "According to official records the weekly turn systems was more strictly enforced, with water reportedly supplied on most if not all the days in most of the turns. But one may doubt whether this is true in terms of the quantum of the water supplied" (Vaidyanathan and Janakarajan: 1989: 249-50).[2]

3.1.4 PMC zone 4

This zone has 3 distributaries with 13 blocks out of 27 and the remaining 14 blocks are covered in zone 2. All of them are located in the PMC. The latest spell for this zone started on August 21, 2005 and ended on December 31, 2005 with a period of 132 days. However, the actual flow days in the main canal was only 94, which is the highest flow days compared with all the three other zones. The number of days supply received by each of the three distributaries decreased from head to tail of the PMC, which are 39 days, 38 days and 35 days (see Table 3). Relative to zone 3 distributaries, all the three distributaries of this zone received a little more supply in the latest spell and each one got 5 turns with 7 days supply in each turn. The first turn also got 10 days supply in all the three distributaries. Even then, the quantum of supply received by each one fell short by about 40% (see Table 6).

The block level survey shows that around half the blocks reported received 'regular but not full supply' in the latest spell. The remaining blocks got 'neither regular nor full supply'. The reasons for irregular and inadequate supply were mainly excess tapping in the upstream distributaries and inadequate storage position in the dam. Similar responses were reported across the blocks. Interestingly, the effect on crop shows that none of the blocks let the crop wither in the latest spell. Most farmers managed the short supply by supplementing with well water. In the middle and tail distributaries the farmers in a few blocks also managed the supply by reducing the crop area. However, these responses were completely the opposite when the last spell was considered, where majority of farmers in most blocks let their crop wither and farmers in some blocks reduced their crop area. Only limited blocks had access to well supply (see Table 4).

Last spell for this zone was given from April 1, 2003 to October 17, 2003. Here, the number of days spell covered was 200. However, the number of actual supply days in the main canal was only 53 and in the three distributaries; 13 in the head and middle distributaries and 27 in the tail distributary. The important point is that the dam storage was bare minimum in that spell year. As a result, whenever storage improved, it was released subsequently; hence the gap between the spells was large. Actually, the head and middle distributaries got only 2 turns of supply each with 7 days duration. Between the two turns, the gap was more than 4 months. In the last tail distributary 3 turns were possible, with 13 days supply in the first turn and 7 days supply in the remaining. Even then, the gap between supply was almost the same like the other two distributaries. Due to less number of turns, the quantum of supply received was very less. The deficit ranged from 57% to 80% in all three distributaries.

The above account indicates that the PAP supply even during the normal spell period was inadequate to feed the needs of the cropped area. During drought, the supply totally failed to protect crops, which in turn led to complete crop failure. Even well supply did not help to protect crops. Under this circumstance, let us discuss the role of wells in the PAP command and the type of crops grown by using canal and well supplies.

3.2 Role of Wells in the PAP Command

A noteworthy feature of the PAP command is the existence of wells along with canal irrigation. Almost all the sample distributaries have wells. The wells increased by 51% between 1966-85 and 20% after that. The slowdown of wells in the later period does not mean that the interest in going for wells has decreased. Contrary to this, the field situation indicates that farmers are more interested in installing bore wells. The current situation is that each well has at least one bore to supplement well supply.

According to information collected at block level, 5 out of 100 blocks surveyed do not have wells. A large majority (55%) of wells currently in use were dug even before the advent of the PAP. One-third of total distributaries surveyed have developed wells only after the PAP. Apart from that wells, which are located close to the main canals, have adequate recharge during good monsoon spells. In a few tail end distributaries, well supply was relatively poor even after the monsoon. It was reported that during non-spell summer season wells did not get recharge and most wells were non-functional. As a result, either well supplies or canal supply were adequate to grow even dry irrigated crops. The effect of main and branch canal supply has been realized only by farmers located very close to it. Farther the location of fields from the main or branch canals, lesser the supply and recharge of the wells.

The important feature of PAP wells is the non-existence of water markets. This is mainly because of poor recharge of wells and widespread use of well water to supplement canal supply in the command. Bore well construction took place only in the last 10 to 15 years (Table 7). As per the survey, on an average, every two wells have a bore and its depth ranges from 400 to 1250 feet. The depth of wells is around 100 ft. Most wells, which have depth of less than 50 ft, did not yield supply even during monsoon. Bores are most concentrated in the head reach distributaries and the middle and tail reaches have fewer bores. Majority of wells were reported to have energized pump sets with electrical power, though some wells do use engine oil.

Although wells are widespread in the PAP command, the quantum of supply pumped from these wells was limited, which was not adequate to supplement the canal supplies even during the normal supply period in majority of the distributaries. As per the block level survey, both the supplies – PAP and wells – are inadequate to feed the command. Under this situation, it is necessary to investigate the type of crops grown by the farmers by using the available water supplies in the command and to see how best to optimize yields which are effective in sustaining agriculture in the command.

4. CROP PATTERN IN THE PAP COMMAND

Access to and sources of irrigation have a significant bearing on the cropping pattern. The command areas under PMC and UPC grow a large variety of crops, the more important among them being coconut, maize, cholam, groundnut, vegetables, chilies and onion. For analytical purposes they can be grouped into 5 categories: i) annuals and perennials; ii) makkacholam and cholam; iii) rain-fed crops; iv) fodder and vegetables and v) irrigated dry crops. Except rainfed crops all others require proper irrigation; otherwise yield may retard. Annuals and perennials require yearlong irrigation and how much water it requires depends upon the type of technology used (such as drip irrigation). In the PAP command, only coconut crop gets drip irrigation with 80- 90% coverage.

As noted, PAP was designed to supply water only for irrigated dry crops. However, this policy came into practice only during the last 10 years. Previously paddy was also grown extensively in the command. Perennial crops grown in the command are coconut, mango, perunelli, tamarind and sugarcane. Coconut covered a little more than 50% and all other perennials account for only about 5%. Makkacholam or maize is an important seasonal crop in all distributaries. It is grown both during spell and non-spell periods. Its coverage during the spell period was 30 - 35%. However, its distribution varies across reaches of the command. Other irrigated crops such as cholam, groundnut, onion and vegetables occupy a considerable extent during the spells. Based on the cultivation undertaken by well and non-well farmers in the command area of the selected distributaries the following points are made. Overall summary is given in Table 8.

1. The non-well farmers also raise annual crops in majority of distributaries. This is due to three reasons. (a) Some farmers who do not own wells in a particular block have access to their own well water from adjacent blocks in which they also owned lands; and (b) Farmers who own wells in the non-command area also use their well water in the command. This area is considerably more in the tail distributary (6.5.600) of KPBC. In all other distributaries, the extent of this area is relatively less which ranges from less than an acre in the head distributary (31.4.440) of tail reach in PMC to nearly 19 acres in the head distributary (0.1.180) of middle reach in PPBC. The later distributary farmers did not own wells in any other locality. However, they raised coconut solely depending upon rain. This is possible mainly due to the prevailing black cotton soil. But, the yield of crop is considerably less.

2. In all distributaries, both well and non-well farms, the area devoted for annual and perennial crops remains either constant or in a few cases increases across survey years (2003-04 to 2005-06). This indicates that wells are contributing more to the growth of perennial crops.

3. Maize was the main crop during the spell period. Marketing for this produce was very good since the Suguna Poultry Feed Mill is located in this area and demand for maize is always high. Hence, farmers prefer this crop. Taking all distributaries together, and across reference years, maize cultivation was one-third of total cultivated area among non-well farmers; and one-fourth among well farmers in 2004-05. It

declined to around 15% in both types of farmers in 2005-06 (a non-spell year for many sample distributaries) and it had only about 10% between both categories of farms in 2003-04 (a severe drought year). Hence, PAP supply mostly induced seasonal cropping in the command.

4. During the spell year, area under rain-fed crops raised by well farms decreased considerably. The reduction was half that of the non-spell year, whereas for non-well farms the reduction was only 15%. It may be noted that during spell period wells farmers mostly used available supply for perennial crops hence the rain-fed crops got less importance.
5. Fodder and vegetables as well as irrigated dry crops occupy only around 10% of the total cultivated area in each of the three reference years. There has not been much difference in area under cultivation of these crops between spell and non-spell years. However, drought spells reduces its area across distributaries.

As indicated, based on the availability of assured water source, farmers decided the cropping pattern. Unless well water was supplemented, perennial crops like coconut were not feasible. As an exception, in one of the black cotton soil distributary (0.1.180) some farmers raised coconut without depending on well supply. However, their yield level was very poor. It is important in this context, to see how effective was the cropping intensity and productivity of crops across distributaries and between reference years.

5. CROPPING INTENSITY AND PRODUCTIVITY

The varying conditions of water availability across distributaries and years naturally have an impact on productivity per unit of land. Table 9 presents an estimate of the gross value of output per unit of area held by sample farmers in each selected distributaries. The physical output of each crop as reported by respondents was valued at the average wholesale price prevailing in Coimbatore district during the years 2003-04 to 2005-06. The value of output is estimated per unit of gross cropped area (measured in season acres), and the crop area to the area of plots held by the reporting farmers for each of the distributaries. Productivity per unit of plot area is equal to the product of cropping intensity (CI) and the value of output per unit of gross cropped area.

In 2004-05, which was a spell year for zones 2 and 3 of the PMC and for UPC, the average productivity per acre of plot area was the highest (Rs. 6650) in zone 2, followed by zone 3. In these distributaries the CI is low (1.19) and medium (2.04). This high productivity (compared to all distributaries) in the tail and middle reach distributaries was possible mainly due to cultivation of vegetables like pumpkin, papaya and green chilies by a few farmers. These crops fetch a higher price in the market compared to other crops. This can be called precision farming. Low productivity (Rs. 1032) was found in the tail distributary in zone 3 followed by the middle distributary (0.1.180) in zone 2. Here the CI was 1.84 and 1.72. These two are peculiar distributaries, where the later is located in the black cotton soil. Hence, majority of farmers did not use canal supply but raised only rainfed cholam and Bengal gram. Since monsoon was not favourable, the yield declined considerably. Although a few coconut farmers used the distributary spell supply, the previous years' drought affected the coconut yield and productivity considerably. The former distributary did not get adequate supply from the spell due to its tail end location and coconut was a major crop. Most farmers reported that their crop failed altogether in the spell. Hence, though CI was high, productivity was low. This may be termed as failed cropping or survival farming. In the remaining distributaries in zone 2 and 3, including those located in the UPC, the yield was between the maximum and minimum, which is normal in this area. In these distributaries, the CI ranges from 2.16 to 1.42 but the productivity ranges between Rs. 2776 to Rs. 4949. This shows that CI and productivity are not positively correlated. This is mainly due to poor canal supplies and drought situation during the monsoon.

For zones 2 and 3, 2003-04 and 2005-06 were non-spell years and the former was affected by severe drought hence the well supply was also very poor. However, the latter year experienced a reasonable monsoon. All distributaries (except the tail end one 50.4.445) experienced relatively low productivity in both the years compared to the spell year (2004-05). Between two non-spell years, 2005-06 was better. Although the tail end distributary (50.4.445) in zone 3 was in the non-spell category, the productivity was much better than all other distributaries. This was mainly because of coconut cultivation and good groundwater position, which helped to get more crop yield.

For zones 1 and 4, 2004-05 was a non-spell year. The overall CI of the 6 distributaries falling in these zones ranged from 1.02 to 2.86. However, the productivity ranged from Rs. 1249 to Rs. 4472. Here also one can notice low CI but reasonable productivity. High CI but low productivity was also found in many of the distributaries. This indicates the type of crops (low, high value) grown and the level of output attained by these crops were most important to decide the productivity variations across distributaries. This inference is mainly because in the middle distributary (13.5.263) of zone 1 the entire command was cropped with coconut. All farmers have wells. The CI is the highest among all the distributaries, however the average productivity was only moderate at Rs. 2204. The reverse was the case in the tail distributary (68.0.000) of zone 1, where the CI was the lowest (1.02) but the productivity was high at Rs. 3938. In the former distributary only coconut was grown, whereas in the latter other annual crops like papaya and seasonal crops like onion were grown. These crops also fetch more price than coconut.

Further, the above observation can also be related to the spell year for zones 1 and 4. Since the spell year 2003-04 was drought hit, productivity level was minimal almost in all distributaries in these zones. However, the CI did not change much. This was due to existence of perennial crops such as coconut. The other reasonable spell year for these zones was 2005-06. Here one can notice that all distributaries attained higher productivity and more or less high CI. This shows that spells with adequate supply can enhance productivity to a considerable level than those with poor supply spells. The latter spells invariably led to crop failure resulting in heavy monetary loss.

6. CONCLUSION

In the PAP system, the usual practice of supplying water in each spell for 135 days was erratic and not followed in accordance with the specified rules. The normal practice of 7 days supply in each turn was not followed in any of the distributary in majority of spells. Between normal (mostly in winter) and drought (mostly in summer) spells, the supply pattern was more erratic during the summer spells; and insufficient water availability led to heavy crop loss. Continuous drought led to enormous crop loss to farmers in one of the spells chosen for the survey. It may be attributed to the fact that when the ASIS method was adopted in August 2000, it was remarked in the G.O. that this ASIS is followed on an “experimental basis”. Hence, the PWD authorities themselves were not sure on the effectiveness of the new system. Hence, the ASIS is still evolving and the PAP supply pattern is experimental too. Further, it is important to note that the PAP is a “supply” based irrigation system. Hence the farmers demand for adequate water for better cropping if not met.

Generally, the head reach distributaries get relatively more supply – either by way of increase in the quantum of daily supply or by increasing the number of days of turn supply – than the tail end distributaries of either the main or the branch canals. However, this is not always the case for all distributaries. Special features in terms of soil type, proximity to streams, alignment of the canal distributary with reference to its command, and topography make a significant difference in getting water supply. This is clearly captured in our study. Further, canal seepage, the nature of the soil and the geology are most important to determine recharge of wells. During the 20-year period the field level water distribution changed a lot. Previously from dam to field, water was allocated only by the PWD officials. Now, the entire distributary supply is managed by the VWUAs. The PWD’s water allocation ends at the main or branch canal itself. This pattern is efficient which is clear from the survey.

Maize is an important crop during dry spells. Since coconut crop was raised in more than half the cultivated area throughout the PAP one can say that well irrigation helps to develop crops for more than 50% in the command and canal irrigation supplements the wells during dry spells. Wells get recharged during monsoon seasons. Maize and coconut occupy nearly three fourths of cultivated area in the PAP command in any given year. Due to erratic supply pattern, the productivity of these crops is below average even in irrigated condition. The effect of irrigation (in terms of productivity) is more in the dry areas than wet areas. In the PAP command, the tail reach distributaries are located in the drought-affected region (Palladam taluk in Coimbatore district). The tail distributaries sluice numbers 10 to 12 are located only in this region. There the productivity and CI are evidently more compared to other distributaries in other reaches.

In many distributaries, non-well farmers also get access to well irrigation, which is a recent phenomenon. Hence, the exact effect of productivity in non-well farms during spell and non-spell periods is difficult to derive from this survey, which requires specific study by separating well and non-well farmers in the PAP command. However, the evidence from the study suggests that cropping intensity and productivity under well farms are relatively more than non-well farms. The PAP system partially helps the command area farmers to reap the benefits of canal irrigation. During normal supply years average productivity was realized and in drought years heavy crop loss was experienced.

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Table 1: Trends in Net Area Irrigated by Sources from 1950-51 to 2004-05 (Area: lac ha.)

Source	1950-51 to 1969-70 area	% to NIA	1970-71 to 1989-90 area	% to NIA	1990-91 to 2004-5 area	% to NIA
INDIA						
Govt. & private canals	101.9	41.6	150.4	39.1	160.7	29.0
Tanks	43.0	17.5	34.0	8.8	22.8	4.1
Wells+ tubewells	76.7	31.3	175.9	45.7	338.3	61.0
Other sources	23.5	9.6	24.6	6.4	32.5	5.9
Total NIA	245.1	100.0	384.9	100.0	554.3	100.0
Net Sown Area	1319.5		1403.2		1413.9	
TAMIL NADU						
Govt. & private canals	8.4 (8.2)	36.5	8.6 (5.7)	33.1	7.1 (4.4)	27.3
Tanks	8.5 (19.7)	36.8	7.3 (21.5)	28.2	5.1 (22.3)	19.5
Wells+ tubewells	5.7 (7.4)	24.9	9.8 (5.6)	37.7	13.7 (4.0)	52.6
Other sources	0.4 (1.8)	1.8	0.3 (1.1)	1.0	0.2 (0.5)	0.6
Total NIA	23.0 (9.4)	100.0	26.0 (6.7)	100.0	26.0 (4.7)	100.0
Net Sown Area	57.4		59.3		54.2	

Source: Indian Agricultural Statistics, 1985-86, 1989-90, Vol.I, Ministry of Agriculture, GoI. New Delhi. www.indiastat.com, Area for all India since 2000-01. GoTN, TN- An Economic Appraisal, various issues.

Note: Figures in brackets indicate source wise percentage compared to India.

Table 2: Methods of Water Distribution within Blocks in the Selected Distributaries in the PAP Command

Sl. No.	Name of distributary/ mileage/ reach/zone	No. of blocks	Min & Max hours of supply per acre/turn	Main features of water distribution within blocks
1.	Krishnapuram 2.6.000 PMC (HH) 2 & 4	9	4.40 - 18.40 hrs in 7 days	In a spell (135 days supply in the main canal) totally 6 turns are possible. A turn system consists of 7 days supply and 15 days off. In each turn 2 wettings are possible for most blocks. Farmers are given a time schedule to follow one by one. Top down supply pattern is followed. VWUA is very active.
2.	Kolarpatti 13.5.263 PMC (HM) 1	6	7.20 - 10.30 hrs in 7 days	The entire commend has been grown with coconut and fully drip system followed. Since half the tail distributary is unlined, the tail blocks always receive poor supply. However, supply was shared fairly and judiciously. Wells are considered most important in this distributary. VWUA is normal.
3.	Negamam 0.2.640 PMC (HT) 1 KPBC	9	3.15 - 7 hrs in 7 days	In this head distributary, water sharing was effective and fair in normal supply period. However, during deficit period, illegal tapping was common. Inclusion of non-ayacut was reported.
4.	Mullupadi 6.5.600 PMC (HT) 3 KPBC	11	4.40 - 7 hrs in 7 days + sole use	In this tail distributary, illegal tapping by upstream farmers during night was common. Disputes are more. Poor supply led to reduction in cropped area by many farmers. Murai system is followed to reduce disputes. VWUA is not effective.
5.	Alampalayam 3.7.330 UPC (H) 2	9	5 - 7 hrs in 5 days + mutual sharing	Fixed and rigid turn system is followed. Due to improper location of head sluice, always deficit supply was available in the distributary. This is inadequate even for dry crops cultivation. The PAP supply has no effect on recharge of wells in summer and even during monsoons with poor rainfall. Groundwater supply is very poor. Functioning of VWUA is poor.
6.	Gudimangalam (19.0.150 UPC (T) 2	11	4 - 6 hrs in 5 days	Top down irrigation method is followed. Turn system is strictly followed. Full (rush) supply is maintained in all five days supply period. Farmers themselves through the direction of VWUA manage the turn system and it is very active. Groundwater supply is inadequate.
7.	Modakkupatti 3.4.500 PMC (MH) 2 & 4	8	4 + 2 or 6 hrs in 7 days	Top down irrigation ensures better supply to tail enders. Strict turn system is followed. Groundwater supply is inadequate even during winter months. Due to location advantage, the head & middle dy farmers get adequate supply whenever the PMC supply is released. VWUA is active.
8.	Poosaripatti 0.1.180 PMC (MM) 2 PPBC	4	5 - 7 hrs in 7 days + liberal use	This dy passes along the block cotton soil and no lining was done. Seepage and percolation is heavy. Since most farmers did not use the PAP supply, the tail enders only use it liberally for their coconut groves. VWUA is normal (average).
9.	C. Nagoor 8.0.220 PMC (MT) 2 PPBC	8	3 - 4 hrs in 6 - 7 days	Two waterings in a turn are possible. Internal adjustment between well and non-well farmers are reported. They mutually cooperate with each other. This helps avert minor disputes & induced farmers to crop entire ayacut. VWUA is active.

Sl. No.	Name of distributary/ mileage/ reach/zone	No. of blocks	Min & Max hours of supply per acre/turn	Main features of water distribution within blocks
10.	Thalakkarai 31.4.440 PMC	10	1 - 2 hrs in 7 days	Majority of farmers raised coconut groves. Hence, 2 hours rotation helps to get 3 to 4 drip supplies or 2 normal supplies are possible in a turn. Minor conflicts arise due to construction of improper field bothies, which led to poor supply to the tail enders. VWUA is active.
11.	Kullampalayam 50.4.445 PMC (TM) 3	8	1.45 - 3 hrs in 7 days + liberal use	Coconut is a major crop (80%). Unlined dy channel affects supply. Also, the elevated ayacut in some blocks detained farmers to use PAP supply. Hence only others are using the supply liberally. Groundwater recharge is very good. VWUA is active.
12.	Alagumalai 68.0.000 PMC (TT) 1	7	4 - 5 hrs in 7 days +sole use	Coconut is limited. Groundwater recharge is favourable due to adjacent location to the PMC. Even non-command wells, supply water to the command. In one block a lone farmer solely utilizes the PAP supply. No competition. VWUA is active.

Source: Survey 2006-07

Note: As per turn system 7 days on and 10 days off supply is given in the dy. The main canal is closed for 4 - 5 days to enhance storage from the feeder canal for the next turn. Normally, 5 - 6 turns are possible in a season depending on dam storage.

PMC = Parambikulam Main Canal, UPC = Udumalpet Canal, KPBC = Kovil Palayam Branch Canal, PPBC - Pudupalayam Branch Canal, Reach: H = Head, M = Middle, T = Tail (HH = Head Reach Head Distributary)

Table 3: Number of Days Water Released in the Main Canal and Selected Distributaries

Sl. No.	Distributary mileage & zone		No. of days supply given in the main canal		No. of days supply given in the distributary	
			Latest Spell	Last Spell	Latest Spell	Last Spell
1.	2.6.000 PMC	2 &	90	66	40	23
	Do	4	94	53	39	13
2.	13.5. 263 PMC	1	91	27	39	12
3.	0.2.640 KPBC	1	91	27	38	12
4.	6.5.600 KPBC	3	64	57	20	27
5.	3.7.330 UPC	2	71	56	45	51
6.	18.7.550 UPC	2	71	56	34	27
7.	3.4.500 PMC	2 &	90	66	33	27
	Do	4	94	53	38	14
8.	0.1.180 PPBC	2	90	50	50	16
9.	8.0.220 PPBC	2	90	66	35	22
10.	31.4.440 PMC	2 &	90	53	29	24
	Do	4	94	53	35	27
11.	50.4.445 PMC	3	64	57	26	24
12.	68.0.000 PMC	1	91	27	42	12

Note: 40 to 45 days supply in the distributary and 90 to 95 days supply in the main canals provide a satisfactory normal spell. Below which it is considered drought spell

Source: Office of the Sub-Division, Thirumurthi Dam Section, 2007

Table 4: Water Supply Conditions in the Selected Distributaries

Sl. No.	Distributary & ZONE	No. of Sample Blo-cks	LATEST SPELL PERIOD (2004-05 and 2005-06)										LAST SPELL PERIOD (2002-03 and 2003-04)									
			No. of blocks which received			Reasons for irregular & IA supply		Effect in the Crop					No. of blocks which received			Reasons for irregular & IA supply		Effect in the Crop				
			Regular & Full supply	Regular but not Full supply	Neither regular not Full supply	Excess tapping in the upstream	IA Storage posi-tion	Low yield	Redu-ced crop-ped area	Complete crop failure	Crop pattern changed	Manag-ed with well water	Regular & Full supply	Regular but not Full supply	Neither regular not Full supply	Excess tapping in the upstream	IA Storage posi-tion	Low yield	Reduced cropped area	Complete crop failure	Crop pattern changed	Manag-ed with well water
			1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
1.	2.6.000 PMC 2&4	6 3	- -	4 2	2 1	2 1	4 2	- -	- -	- -	2 -	4 3	- -	- -	6 3	2 -	4 3	- -	- -	4 1	1 -	4 2
2.	13.5.263 PMC 1	6	-	6	-	-	6	-	-	-	-	6	-	-	6	-	6	-	-	2	-	4
3.	0.2.640 KPBC 1	9	-	6	3	6	3	-	-	-	4	5	-	-	9	3	6	-	-	6	3	-
4.	6.5.600 KPBC 3	11	-	-	11	11	-	-	6	-	4	1	-	-	11	6	5	-	-	9	-	2
5.	3.7.330 UPC 2	9	-	-	9	6	3	-	3	-	2	4	-	-	9	5	4	-	-	5	4	-
6.	18.7.550 UPC 2	11	-	11	-	-	11	-	3	-	2	6	-	-	11	-	11	-	5	3	-	3
7.	3.4.500 PMC 2&4	3 5	- -	2 3	1 2	1 2	2 3	- -	2 3	- -	- -	1 2	- -	- -	3 5	2 1	1 4	-	2 1	1 3	-	- 1
8.	0.1.180 PPBC 2	4	-	-	4	-	-	4	-	-	4	-	-	-	4	-	4	-	-	-	4	-
9.	8.0.220 PPBC 2	8	-	8	-	-	8	-	-	-	3	5	-	-	8	-	8	-	3	3	-	2
10.	31.4.440 PMC 2&4	5 5	- -	4 3	1 2	2 2	3 3	- -	2 1	- -	1 1	2 3	- -	- -	5 5	2 2	3 3	- -	2 2	2 2	1 1	- -
11.	50.4.445 PMC 3	8	-	3	5	5	3	-	3	-	2	3	-	-	8	3	5	-	2	2	1	3
12.	68.0.000 PMC 1	7	-	7	-	2	5	-	-	-	2	7	-	-	7	2	5	-	2	2	-	3

Note: - indicates nil. **Source:** Survey data 2006-07.

Table 5: Expected and Actual Supply Received by Distributaries under Zone 2

Sl. No.	Distri butary Mileage	No.of Sample Blocks	Expected Quantum Mcft/Acre	Quantum of Supply given (Mcft/acre)		Quantum of deficit during latest and last spells (mcft)		% of deficit during latest and last spells	
				Latest Spell	Last Spell	Latest	Last	Latest	Last
PMC 2									
1	2.6.000	6	0.083	0.062	0.035	0.021	0.048	0.25	0.58
2	3.4.500	3	0.083	0.058	0.037	0.025	0.046	0.30	0.55
3	0.1.180	4	0.083	0.058	0.013	0.025	0.070	0.30	0.84
4	8.0.220	8	0.083	0.054	0.034	0.029	0.049	0.35	0.59
5	31.4.440	5	0.083	0.045	0.037	0.038	0.046	0.46	0.55
UPC 2									
6	3.7.330	9	0.083	0.061	0.066	0.022	0.017	0.27	0.20
7	19.0.150	11	0.083	0.088	0.036	-0.005	0.047	-0.06	0.57

Note: Expected supply is 1 mcft for 12 acres.

Source: Derived from the data recorded in respective section offices.

Table 6: Expected and Actual Supply Received by Distributaries under Zone 3 and 4

Sl. No.	Distri butary Mileage	No.of Sample Blocks	Expected Quantum Mcft/Acre	Quantum of Supply given (Mcft/acre)		Quantum of deficit during latest and last spells (mcft)		% of deficit during latest and last spells	
				Latest Spell	Last Spell	Latest	Last	Latest	Last
PMC 3									
1	6.5.600	11	0.083	0.029	0.019	0.054	0.064	0.65	0.77
2	50.4.445	8	0.083	0.037	0.035	0.046	0.048	0.55	0.58
PMC 4									
1	2.6.000	3	0.083	0.048	0.017	0.035	0.066	0.42	0.80
2	3.4.500	5	0.083	0.052	0.020	0.031	0.063	0.37	0.76
3	31.4.440	5	0.083	0.047	0.036	0.036	0.047		

Note: Expected supply is 1 mcft for 12 acres.

Source: Derived from the data recorded in respective section offices.

Table 7: Number of Wells Dug and Bores Developed in Different Periods in the PAP Command

Sl. No.	Distributary & Reach	Zone	Canal	Wells Before 1965	Wells 1966-85	Wells After 1985	Total Wells	No. of Bores (since 1995)							Bore Density
								1	2	3	4	5	10	Total	
1	2.6.000 HH	2	PMC	11	2	12	25	6	9	2	1			18	0.72
		4	PMC	7	3	3	13	2	2	1	1			6	0.46
2	13.5.263 HM	1	PMC	24	11	8	43	9	4	2				15	0.35
3	0.2.640 HT	1	PMC	34	11	9	54	10	15	2				27	0.50
4	6.5.600 HT	3	PMC	15	8	6	29	6	3				1	10	0.34
5	3.7.330 HH	2	UPC	23	1	5	29	9	8					17	0.59
6	19.0.150 HT	2	UPC	29	9	8	46	16	4	2				22	0.48
7	3.4.500 MH	2	PMC	10	0	1	11	1	4					5	0.45
		4	PMC	10	2	5	17	6	3		1			10	0.59
8	0.1.180 MM	2	PMC	0	0	1	1	1	1					2	2.00
9	8.0.220 MT	2	PMC	13	18	8	39	2	3		2			7	0.18
10	31.4.440 TH	2	PMC	10	12	1	23	1	15					16	0.70
		4	PMC	10	19	1	30	4	14	2				20	0.67
11	50.5.445 TM	3	PMC	28	15	5	48	13	8	2	2	1		26	0.54
12	68.0.000 TT	1	PMC	21	15	3	39	11	4					15	0.38
	Grand Total			245	126	76	447	97	97	13	7	1	1	216	0.48

Note: Reach indicates the location of distributary from the Thirumurthi Dam.

H = Head. M = Middle. T = Tail. First H, M, T indicates the reach from the Dam. Second H, M, T indicates location of distributary. HH=Head reach Head distributary. MH = Middle reach Head distributary. TH = Tail reach Head distributary.

Source: Field survey 2006-07

Table 8: Summary of Crop Pattern in the PAP Command, 2003-04, 2004-05 & 2005-06 (Area in acres)

Details	W/ NW	2003-04						2004-05						2005-06					
		Annual & Perennial Crops	Macca Cholam & Cholam	Rain-fed Crops	Fodder & Vegetables	Irrigated Dry Crops	Total	Annual & Perennial Crops	Macca Cholam & Cholam	Rain-fed Crops	Fodder & Vegetables	Irrigated Dry Crops	Total	Annual & Perennial Crops	Macca Cholam & Cholam	Rain-fed Crops	Fodder & Vegetables	Irrigated Dry Crops	Total
Grand Total	Nw	132.7	50.5	220.3	11.2	5.5	420.2	134.4	196.6	217.7	26.1	17.8	592.5	134.4	96.0	307.1	37.7	12.9	588.0
	W	1082.1	128.5	148.5	69.7	10.9	1439.7	1095.4	435.6	89.0	148.0	45.0	1813.0	1103.3	240.1	152.7	200.2	79.3	1775.6
	All	1213.0	179.0	368.6	80.9	16.4	1857.9	1227.8	632.1	306.7	174.1	62.8	2403.6	1235.7	335.1	459.8	256.6	94.3	2381.4
% to total	Nw	32	12	52	3	1	100	23	33	37	4	3	100	23	16	52	6	2	100
	W	75	9	10	5	1	100	60	24	5	8	2	100	62	14	9	11	4	100
	All	65	10	20	4	1	100	51	26	13	7	3	100	52	14	19	11	4	100

Note: Perennial and annual crops are counted as season acres. Nw = Non-well. W = Well.

Perennial and annual crops = Mango, Perunelli, Tamarind, Coconut and Sugarcane.Rainfed crops = Bengal gram, black gram, coriander, cumbu, yellow cholam, kollu

Fodder cholam, horse gram, mocchai, fox gram, & Thattai payaru.Irrigated Dry Crops = Cotton, Green gram, Gingelly, Pasi payaru, Onion, Green fodder, Radish.

Source: Field survey 2006-07

Table 9: Cropping Intensity and Productivity, 2003-04, 2004-05 & 2005-06 (Productivity in terms of Rs)

Sl. No	Distributary	Zone	Canal	W/ NW	2003-04			2004-05			2005-06			Spell / Non Spell		
					CI	O/GCA	O/PA	CI	O/GCA	O/PA	CI	O/GCA	O/PA			
1	2.6.000 (HH)	2	PMC	Nw	Nil	Nil	Nil	1.00	160	160	1.00	272	272	NS	S	NS
				W	1.33	846	1123	1.84	1546	2849	1.83	1102	2017			
				All	1.29	846	1093	1.82	1526	2776	1.81	1090	1969			
		4	PMC	Nw	1.27	632	802	0.90	392	351	1.00	1636	1630	S	NS	S
				W	1.99	523	1039	1.98	891	1766	1.94	1757	3411			
				All	1.88	534	1004	1.82	855	1557	1.80	1748	3148			
2	13.5.263 (HM)	1	PMC	W	2.84	435	1236	2.86	771	2204	2.88	1162	3353	S	NS	S
				All	2.84	435	1236	2.86	771	2204	2.88	1162	3353			
3	0.2.640 (HT)	1	PMC	Nw	1.33	36	48	2.15	888	1907	2.22	1808	4017	S	NS	S
				W	2.16	340	733	2.20	525	1154	2.24	954	2136			
				All	2.05	315	646	2.19	570	1249	2.24	1061	2373			
4	6.5.600 (HT)	3	PMC	Nw	1.82	124	225	1.99	293	584	2.05	422	863	NS	S	NS
				W	1.68	212	356	1.76	739	1298	1.90	928	1759			
				All	1.73	178	307	1.84	559	1032	1.95	730	1425			
5	3.7.330 (H)	2	UPC	Nw	0.68	1359	921	1.06	3411	3599	0.88	1996	1764	NS	S	NS
				W	1.46	1138	1661	1.60	2214	3540	1.48	1712	2534			
				All	1.22	1175	1436	1.43	2481	3558	1.30	1771	2300			
6	19.0.150 (T)	2	UPC	Nw	0.55	915	506	0.98	3538	3476	0.69	1648	1138	NS	S	NS
				W	1.15	1357	1566	1.57	2471	3874	1.25	2469	3094			
				All	1.00	1295	1295	1.42	2659	3772	1.11	2339	2595			
7	3.4.500 (MH)	2	PMC	Nw	0.88	2375	2083	0.88	4174	3658	0.88	2723	2386	NS	S	NS
				W	2.10	1596	3351	2.26	1620	3667	2.10	2179	4580			
				All	1.71	1724	2945	1.82	2014	3664	1.71	2268	3877			
		4	PMC	Nw	1.06	1312	1385	0.88	1177	1030	0.90	4250	3816	S	NS	S
				W	2.67	1363	3633	2.50	1516	3790	2.62	2173	5692			
				All	2.13	1354	2882	1.96	1465	2868	2.04	2478	5066			
8	0.1.180 (MM)	2	PMC	Nw	1.33	642	851	1.49	801	1198	1.55	976	1511	NS	S	NS
				W	3.00	34	102	3.00	53	158	3.00	81	242			
				All	1.58	469	739	1.72	606	1042	1.76	749	1321			
9	8.0.220 (MT)	2	PMC	Nw	0.44	1025	447	0.96	5888	5648	1.02	3677	3767	NS	S	NS
				W	0.59	2124	1262	1.25	5544	6925	0.94	5786	5419			
				All	0.56	1939	1086	1.19	5604	6650	0.96	5298	5063			
10	31.4.440 (TH)	2	PMC	Nw	0.74	1837	1355	1.18	3774	4447	1.00	2496	2504	NS	S	NS
				W	2.15	1254	2696	2.34	2151	5041	2.36	2143	5054			
				All	1.93	1288	2489	2.16	2288	4949	2.15	2168	4660			
		4	PMC	Nw	1.32	3680	4877	1.40	3965	5561	1.48	10210	15095	S	NS	S
				W	1.95	1590	3095	2.06	2114	4348	2.15	3190	6859			
				All	1.88	1739	3277	1.99	2247	4472	2.08	3697	7698			
11	50.4.445 (TM)	3	PMC	Nw	1.24	1595	1981	1.47	5254	7734	1.57	5470	8566	NS	S	NS
				W	2.04	1063	2166	2.19	1948	4260	2.22	2822	6261			
				All	1.88	1133	2129	2.04	2424	4954	2.09	3218	6722			
12	68.0.000 (TT)	1	PMC	Nw	0.74	1682	1238	0.77	3219	2483	1.28	9151	11669	S	NS	S
				W	0.99	2158	2141	1.08	3942	4241	1.84	5921	10887			
				All	0.95	2094	1985	1.02	3848	3938	1.74	6329	11022			

Note: W = Sample Farmers with Wells; NW = Sample Farmers without Well. CI = Cropping Intensity (adjusted). O = Output; GCA = Gross Cropped Area; PA = Plot Area. NW = Non well. W = Well. Location: H= Head. M = Middle. T = Tail. PMC = Parambikulam Main Canal. UPC = Udumalpet Canal.
Source: Field survey 2006-07

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WATER, HUMAN DEVELOPMENT AND ECONOMIC GROWTH: SOME INTERNATIONAL PERSPECTIVES

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Abstract

The recent years have seen renewed interest in understanding how growing threats to water security affects future progress in human development and economic growth of nations. The underlying concern is that water insecurity could decouple economic growth and progress in human development. The international development discourse is, however, characterized by unhealthy debates with divergent views. Though scholars have provided robust evidences to the effect that water security catalyses human development and economic growth, number of regions for which these evidences are available is too limited for a global consensus on this issue. Water poverty index(WPI), conceived and developed by Sullivan (2002), and the international comparisons now available from Laurence, Meigh and Sullivan (2003) for 147 countries enable us to provide an empirical basis for the argument.

In order to realistically assess the water situation of a country, which can capture the crucial attributes like access to water for various uses; level of use of water in different sectors; condition of the water environment; and technological and institutional capacities in water sector, a new index named Sustainable Water Use Index (SWUI) was derived from WPI. In this paper, the authors first analyze the nature of linkage between water situation of a country, vis-à-vis access and use, water environment and institutional capabilities in the water sector on economic growth. For this, data on sustainable water use index derived from WPI; human development and per capita GDP (ppp adjusted) for 145 countries, and data on global hunger index (GHI) for 117 countries are analyzed. In order to illustrate how creating water storages supports economic growth of countries which fall in hot and arid, tropical climates index, data on per capita dam storage were analyzed for 22 countries.

The regression analyses between SWUI and per capita GDP show that improving the water situation, vis-à-vis improved access to and use of water, institutional capabilities in water sector and improved water environment, through investments in water infrastructure, creating institutions and making policy reforms, can support economic growth of a nation. This is explained by the regression between SWUI and HDI, which showed that increase in SWUI raised the indicators of human development, paving the foundation for growth. This strong linkage can be partly explained by the reduction in malnutrition and infant mortality with improvement in water situation as indicated by the strong inverse relationship between SWUI and GHI. Whereas regression between per capita GDP and decomposed HDI shows that a country's progress in human development has little to do with its economic prosperity, and that a country can achieve good indicators of development even at low levels of economic growth, through welfare oriented policies which encourage investments in water, health and education infrastructure. This means, economic growth is not a pre-requisite for solving water related problems. Instead, countries should invest in water infrastructure, institutions and policy reforms to achieve human development and sustain economic growth. Further analysis shows that hot and arid tropical countries, the investment in large water storages had helped support economic growth. Also, it seems to reduce malnutrition and incidence of child mortality. Finally, the study also provides a methodology for analyzing the linkage between water situation in a region and its economic growth.

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1. INTRODUCTION

As water scarcity hits many developing regions of the world, internationally, there is a renewed interest in understanding how growing threats to water security affects future progress in human development and economic growth of nations (see Grey and Sadoff, 2005). The international development debate is, however, heavily polarized between those who believe that policy reforms in the water sector would be crucial for bringing about progress in human development and those who believe that economic growth itself would help solve many of the water problems, which countries in their economic transition and many backward regions, are facing today (HDR, 2006: pp66). Such debates, that are often not healthy, are causing delays in deciding investment priorities in water sector, particularly in the developing world (Biswas and Tortajada, 2001). The underlying concern here is that water insecurity could decouple economic growth and progress in human development.

There is rich theoretical discussion on the returns on investment by countries in water infrastructure and institutions (Sadoff and Grey, 2005). Many scholars and international agencies have provided robust evidences to the effect that water security can catalyze human development and growth (World Bank, 2004; 2006a & 2000 b; Briscoe, 2005). But, the number of regions for which these evidences are available is too limited for evolving a global consensus on this complex issue. Till recently, there were no authentic and comprehensive database on various factors influencing water security for sufficient number of countries which are at different stages of human development and economic growth. This contributed to the complexity of the debate. The water poverty index (WPI), conceived and developed for countries by Sullivan (2002), and the international comparisons now available from a recent work by Laurence, Meigh and Sullivan (2003) for 145 countries enable us to provide an empirical basis for enriching the debate.

But, the WPI is a composite index consisting of five sub-indices, viz., water access index, water use index, water endowment index, water environment index and institutional capacities in water sector. In order to realistically assess the water situation of a country, which can capture the crucial attributes like access to water for various uses; level of use of water in different sectors; condition of the water environment; and technological and institutional capacities in water sector, a new index called Sustainable Water Use Index (SWUI) is derived from WPI. The paper provides empirical analysis using global database on SWUI and many other water and development indicators to enrich the debate "how water security is linked to human development and economic growth".

2. THE GLOBAL DEBATE

The debate on the linkage between water, economic growth and development is characterized by divergent views. While the general view of international scholars, who support large water resource projects, is that increased investment in water projects such as irrigation, hydropower and water supply and sanitation acts as engines of growth in the economy, while supporting progress in human development (for instance see Briscoe, 2005; Braga, 2005; HDR, 2006). They harp on the need for investment in water infrastructure and institutions. Grey and Sadoff (2005) suggest that there is a minimum platform of water security, achieved through the right combination of investment in water infrastructure and institutions and governance, which is essential if poor countries are to use water resources effectively and achieve rapid economic growth to benefit vast numbers of their population. They suggest an S-curve for growth impacts of investment in water infrastructure and institutions in which returns continue to be nil for early investments. They argue that for poor countries, which experience highly variable climates, the level of investment required to reach the tipping point of water security would be much higher as compared to countries, which fall in temperate climate with low variability.[1] But, they suggest that for developing countries, the returns on investment in infrastructure would be higher that in management and *vice versa* for developed countries.

[1] Beyond which the investment in water infrastructure and institutions yields positive growth impacts.

Many environmental groups, on the other hand, advocate small water projects which, according to them, the communities can themselves manage. The solutions advocated are: watershed management; small water harvesting interventions; and community-based water supply systems; and, micro-hydro electric projects (Dharmadhikary, 2005; D'Souza, 2002).

The proponents of sustainable development paradigms believe that the ability of a country to sustain its economic growth depends on the extent to which natural resources, including water, are put to efficient use through technologies and institutions, thereby reducing the stresses on environmental resources (Pearce and Warford, 1993). Here, the focus is on initiating institutional and policy reforms in water sector. An alternative view suggests that countries would be able to tackle their water scarcity and other problems relating to water environment at advanced stages of economic development (Shah and Koppen, 2006). They argue that standard approaches to water management in terms of policies and institutions work when water economies become formal, which are found at an advanced stage of economic development of nations.

3. OBJECTIVES AND HYPOTHESIS

The objectives of the paper are to: i) analyze the nature of linkage between water situation of a country, comprising improved water access and use, water environment and institutional capacities in the water sector, and economic growth of a nation; and ii) understand the role of large water storages in boosting economic growth and changing human development indicators of countries which fall in hot and arid, tropical climates.

We have three propositions. First: improving the water situation through investments in water infrastructure, institutions and policies would help ensure economic growth through the human development route. Second: nations can achieve reasonable progress in human development even at low levels of economic growth, through investment in water infrastructure, and welfare policies. Third: countries need to invest in building large water storages to support economic prosperity, and ensure water security for social advancements. The hypotheses are: 1) improved water situation supports economic growth through the human development route; and 2) countries, which are in tropical climates with aridity, can support their economic growth through enhancing per capita reservoir storage that improves their water security.

4. ANALYSIS AND DATA SOURCES

The values of Sustainable Water Use Index were calculated by adding up the values of four of the sub-indices of Water Poverty Index, viz., water access index, water use index, water environment index and water capacity index.

The first hypothesis is tested using a regression of global data on: Sustainable Water Use Index (SWUI), and data on per capita GDP (PPP adjusted); SWUI and GHI; and SWUI and HDI. Since regression between SWUI and HDI showed a strong relationship (R^2= 0.79), the causality, i.e., whether SWUI influences GDP growth or vice versa, can be tested by running regression between per capita GDP and a decomposed HDI, which contain the indices for health and education. The underlying premise is that if economic growth drives water situation, then it should change the indicators of human development that are independent of income levels, such as health and education, and that which are inter-related with water situation. The second hypothesis is tested by analyzing the link between per capita GDP (PPP adjusted) and per capita dam storage (m^3/annum) of 22 selected countries falling in hot and arid tropical climate.

Data on per capita GDP and HDI were obtained from Human Development Report 2006. Data on GHI for 117 countries were obtained from Wiesmann Doris (2007).[2] Data on WPI for 145 countries were obtained from Laurence et al. (2003). Data on dam storage and human population in 22 countries were obtained from FAO AQUASTAT-2006.

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[2] Indicator of the proportion of the population living in under-nourished conditions and the child mortality rate (see Wiesmann, 2006).

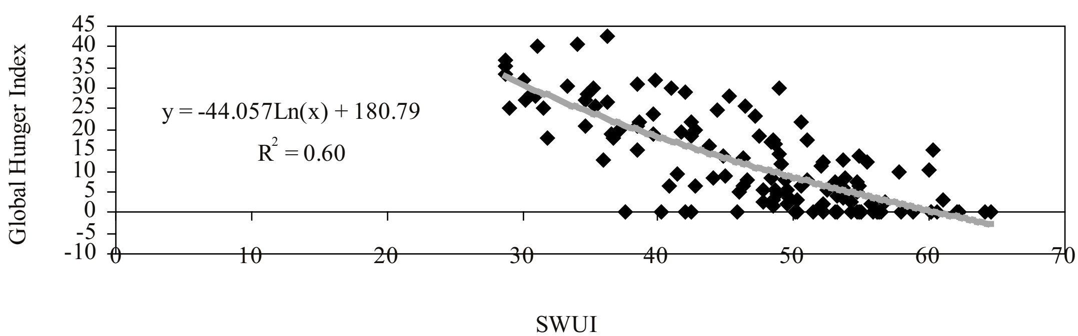
5. WATER AND ECONOMIC GROWTH

Before we begin to answer this complex question of "what drives what", we need to understand what realistically represents the water richness or water poverty of a country. A recent work by Kellee Institute of Hydrology and Ecology which came out with international comparisons on water poverty of nations had used five indices, viz., water resources endowment; water access; water use; capacity building in water sector; and water environment, to develop a composite index of water poverty (see Laurence, Meigh and Sullivan, 2003).

Among these five indices, we chose four indices to be important determinants of water situation of a country, and the only sub-index we excluded is the water resources endowment. We consider that this sub-index is more or less redundant, as three other sub-indices viz., water access, water use and water environment take care of what the resource endowment is expected to provide. Our contention is that natural water resource endowment becomes an important determinant of water situation of a country only when governance is poor and institutions are ineffective, adversely affecting the community's access to and use of water, and water environment. Examples are the droughts in Sub-Saharan African countries. This argument is validated by a recent analysis which showed strong correlation between rainfall failure and economic growth performance in these countries. That said, all the four sub-indices we chose significant implications for socio-economic conditions, and are influenced by institutional and policy environment, and therefore have human element in them. Hence, such a parameter will be appropriate to analyze the effect of institutional interventions in water sector on economy.

All the sub-indices have values ranging from 0 to 20. The composite index developed, by adding up the values of these indices, is called sustainable water use index (SWUI). It is being hypothesized that that the overall water situation of a country (or SWUI) has a strong influence on its economic growth performance.

Figure 1: Global Hunger Index vs SWUI



This is somewhat different from the hypothesis postulated by Shah and Koppen (2006), where in they have argued that economic growth (GDP per capita), and HDI are determinants of water access poverty and water environment.

It is important to provide empirical evidences to this. Worldwide, experiences show that improved water situation (in terms of its access to water; levels of use of water; the overall health of water environment; and enhancing the technological and institutional capacities to deal with sectoral challenges) leads to better human health and environmental sanitation; food security and nutrition; livelihoods; and greater access to education for the poor (see for instance UNDP, 2006). This aggregate impact can be segregated with irrigation having direct impact on rural poverty (Bhattarai and Narayanamoorthy, 2003; Hussain and Hanjra, 2003); irrigation having impact on food security, livelihoods and nutrition (Hussain and Hanjra, 2003), with positive effects on productive workforce; and domestic water security having positive effects on health, environmental sanitation, with spin off effects on livelihoods and nutrition (positive), school drop out rates (negative) and productive workforce.

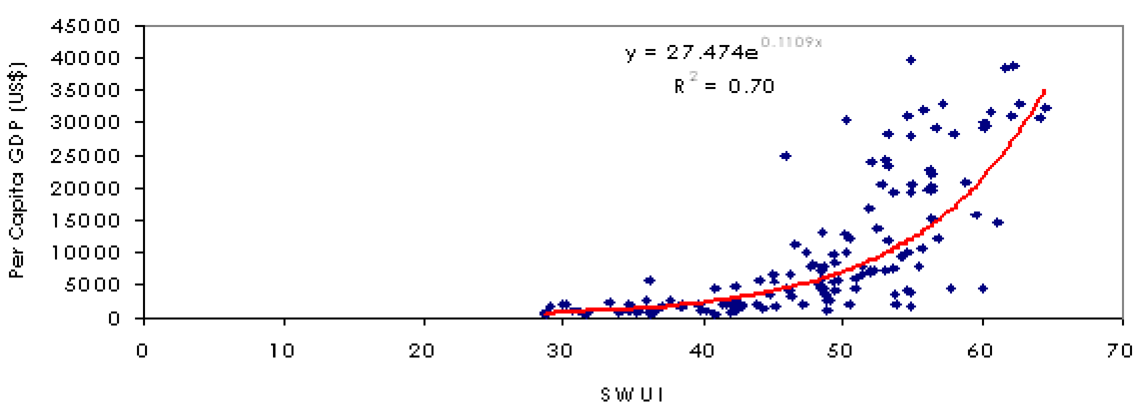
According to the Human Development Report (2006), only one in every five people in the developing world has access to an improved water source. Dirty water and poor sanitation account for vast majority of the 1.8 million child deaths each year (almost 5,000 every day) from diarrhea- making it the second largest cause of child mortality. In many of the poorest countries, only 25% of the poorest households have access to piped water in their homes, compared with 85% of the richest. Diseases and productivity losses linked to water and sanitation in developing countries amount to 2% of GDP, rising to 5% in Sub-Saharan Africa—more than the aid the region gets. Women bear the brunt of responsibility for collecting water, often spending up to 4 hours a day walking, waiting in queues and carrying water; water insecurity linked to climate change threatens to increase malnutrition to 75–125 million people by 2080, with staple food production in many Sub-Saharan African countries falling by more than 25%.

The strong inverse relationship between SWUI and the global hunger index (GHI), developed by IFPRI for 117 countries, provide a broader empirical support for some of the phenomena discussed above. In addition to these 117 countries for which data on GHI are available, we have included 18 developed countries. For these countries, we have considered zero values, assuming that these countries do not face problems of hunger. The estimated R^2 value for the regression between SWUI and GHI is 0.60. The coefficient is also significant at one per cent level. It shows that with improved water situation, the incidence of infant mortality (below five years of age) and impoverishment reduces (Figure 1). In that case, improved water situation should improve the value of human development index, which captures three key spheres of human development such as health, education and income status.

That said all the sub-indices of HDI have strong potential to trigger growth in economy of a country, be it educational status; life expectancy; or income levels. When all these factors improve, they could have a synergetic effect on the economic growth. Hence, the "causality" of water as a prime driver for economic growth can be tested if we are able to establish correlation between water situation and HDI. This we would examine at a later stage in this paper.

Before that, we would first look at how water situation and economic growth of nations are correlated. Regression between sustainable water use index (SWUI) and PPP adjusted per capita GDP for the set of 145 countries shows that it explains level of economic development to an extent of 69 per cent (see Figure 2). The coefficient is significant at one per cent level. We must mention here that Laurence, Meigh and Sullivan (2003) had estimated an R^2 value of 0.81 for WPI and HDI (Table 2: Page 5 in Laurence et al., 2003). Figure 2 shows that the relation between SWUI and per capita GDP is a power function. Any improvement in water situation beyond a level of 50 in SWUI, leads to exponential growth in per capita GDP.

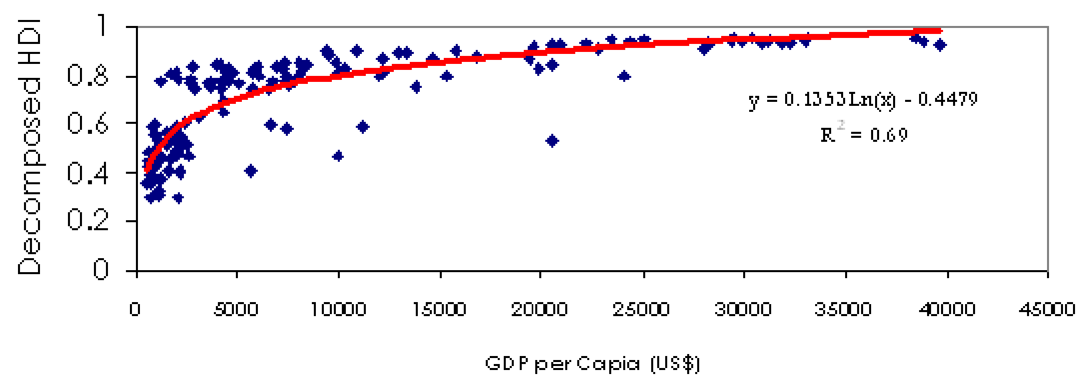
Figure 2: Sustainable Water Use Index Vs GDP Growth



This only means that for countries to be on the track of sustainable growth path, the following steps are needed: 1) investment in infrastructure, and institutional mechanisms and policies to: a) improve access to water for all sectors of use and across the board, b) enhance the overall level of use of water in different sectors, and c) regulate the use of water, reduce pollution and provide water for ecological services; and 2) investment in building human resources and technological capabilities in water sector to tackle new challenges in the sector. Regression with different indices of water poverty against economic growth levels shows that the relationship is less strong, meaning all aspects (water access, water use, water environment and water sector capacity) are equally important to ensure growth.

Major variations in economic conditions of countries having same levels of SWUI (in the range of 53-56), can be explained by the economic policies of which the country pursues. Some countries of central Asia viz., Uzbekistan, Kyrgyzstan and Turkmenistan and Latin American countries viz., Ecuador, Uruguay, Colombia and Chile have values of SWUI as high as North America and northern European countries, but are at much lower levels of per capita GDP. While North America and north, west and southern European countries have capitalist and liberal economic policies, these countries of old soviet block and Latin America have socialist and welfare oriented policies.

Figure 3: Per Capita GDP Vs Decomposed HDI



5.1 What Comes First: Economic Growth or Water Security?

International development discussions are often characterized by polarized positions on whether money or policy reform is more crucial for progress in human development (various authors as cited in HDR, 2006: pp 66). If the stage of economic development determines a country's water situation rather than *vice versa*, the variation of human development index, should be explained by variation in per capita GDP, rather than water situation in orders of magnitude. We have used data for 145 countries to examine this closely. The regression between shows economic growth levels (expressed in per capita GDP PPP adjusted) explains HDI variations to an extent of 85 %). This is in spite of the fact that HDI already includes per capita income, as one of the sub-indices.

Subsequently, analysis was carried out using decomposed values of HDI index (after subtracting the GDP index). The regression value came down to 0.69 when the decomposed index, which comprises education index and life expectancy index, was run against per capita GDP (Figure 3). What is more striking is the fact that 16 countries having values of per capita income below 2,000 dollars per annum have medium levels of decomposed index. Again 42 countries having per capita GDP (PPP adjusted) less than 5,000 dollars per annum have medium levels of decomposed human development index. As Figure 3 shows, significant improvements in HDI values (0.30 to 0.9) occur within the small range in per capita GDP. The remarkable improvement in HDI values with minor improvements in economic conditions, and then "plateauing" means that improvement in HDI is determined more by factors other than economic growth. Our contention is that the remarkable variation in HDI of countries belonging to the low income group can be explained by the quality of governance in these countries, i.e., whether good or poor.

Many countries that show high HDI also have good governance systems and institutional structures to ensure good literacy and human health. For instance, Hungary in eastern Europe; some countries of Latin America viz., Uruguay, Guatemala, Paraguay, Nicaragua and Bolivia; and countries of erstwhile Soviet Union viz., Turkmenistan, Kyrgykistan and Armenia have welfare-oriented policies. They make substantial investment in water, health and educational infrastructure, and have good governance practices.[3]

Incidentally, many countries, which have extremely low HDI, have highly volatile political systems and ineffective governance, and are characterized by corruption in government. In spite of huge external aid, consequently, the investments in building and maintenance of water infrastructure are very poor in these countries. Sub-Saharan African countries, viz., Angola, Benin, Chad, Eritrea, Ethiopia, Burundi, Niger, Togo, Zambia and Zimbabwe; and Yemen from Middle East belong to this category. Sub-Saharan Africa has the lowest irrigated to rain-fed area ratio of less than 3% (FAO, 2006, Figure 5.2: pp 177), where as Ethiopia has the lowest water storage of 20m^3/capita in dams (World Bank, 2005). How water security decoupled human development and economic growth in many regions of the world were illustrated in the recent human development report (HDR, 2006: pp 30-31).

Table 1: Pattern of Public Expenditure on Military, Health & Education and Status vis-à-vis Water & Sanitation

Name of Country	Per Capita Expenditure (US $) on		Percentage of Population Having Access to	
	Military	Health and Education	Water Supply	Sanitation
Armenia	106.626	180.444	92	83
Bolivia	54.4	291.04	85	46
Guatemala	17.252	146.642	95	86
Kyrgyzstan	38.7	127.71	77	59
Nicaragua	25.438	247.112	79	47
Paraguay	33.69	317.66	86	80
Peru	68.136	289.578	83	63
Tajikistan	26.444	44.474	59	51
Togo	24.57	58.37	52	35
Yemen	59.202	19.734	67	43
Zambia	34.891	52.808	58	55
Burundi	42.651	39.943	79	36
Ethiopia	64.26	51.408	22	13

Source: based on Data Provided in HDR, 2006: Table 19: pp 348-151 & Table 7, pp306-309

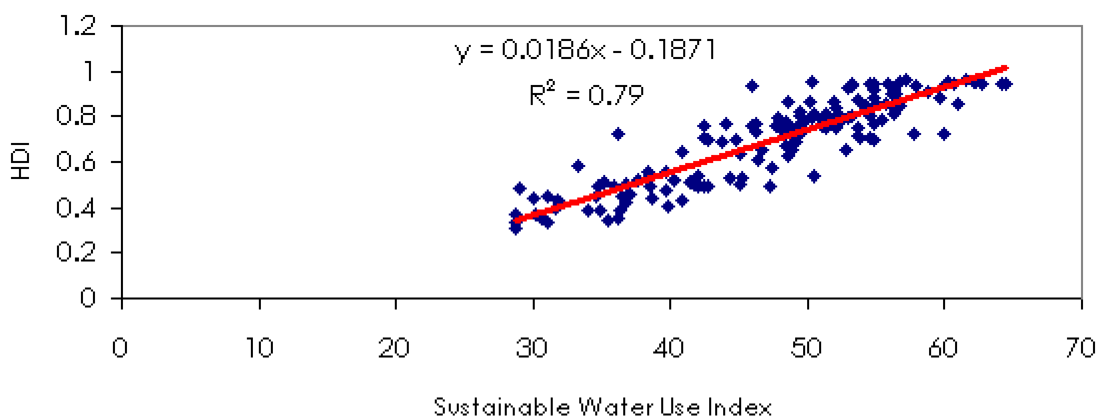
The overall public expenditure on health and education is extremely low in these African countries and Yemen when compared to the many other countries which fall under the same economic category (below US $ 5,000 per capita per annum). Over and above, the pattern of public spending is more skewed towards military (HDR, 2006) (see Table 1 based on data provided in HDR, 2006, Table 19: pp 348-351). Besides, access to water supply and sanitation is much higher in the countries which have higher HDI, as compared to those countries which have very low HDI (HDR, 2006) .

[3] For instance, the USSR had invested in a major way for building hydraulic infrastructure in central Asia (HDR, 2006). As a result, they attain high HDI even at low level of economic growth.

High incidence of water-related diseases such as malaria and diarrhea, high infant mortality, high school drop out rate mainly due to lack of access to safe drinking water; and scarcity of irrigation water in rural areas[4], poor agricultural growth, high food insecurity, malnutrition etc. are characteristic of these regions (HDR, 2006). Consequently, their HDI is very low, as also shown by the international literature which illustrates how water insecurity decouples human development from economic growth.

At the same time, regression between water situation (expressed in terms of sustainable water use index) and HDI shows that it explains variation in HDI in a much better way than the level of economic development (Figure 4). This is in spite of the fact that human development index as such does not include any variable that explicitly represents access to and use of water for various uses; overall health of water eco-system; and capacities in the water sector as one of its sub-indices. The R^2 value was 0.79 against 0.69 in the earlier case when per capita GDP is run against decomposed HDI. Also, the coefficient is significant at one per cent level. It means that variation in human development index can better be explained by water situation in a country, expressed in terms of Sustainable Water Use Index, than the PPP adjusted per capita GDP. Now, such a strong linear relationship between sustainable water use index and HDI explains the exponential relationship

Figure 4: Sustainable Water Use Index Vs HDI



between sustainable water use index and per capita GDP as the improvements in sub-indices of HDI contributes to economic growth in its own way (i.e., per capita here is the education index, and is the health index).

While an alternative to analyze the impact of a country's water situation on its economic growth performance is to look at the historical data on: cumulative investments in water sector, water access and use by population in different sectors, change in water environment, and economic conditions for individual nations, such data are seldom available on a time series basis. Under such a circumstance, the best way to go ahead is to analyze the impact of natural water endowment, i.e., rainfall on economic growth in a situation where investments in infrastructure and institutions and governance mechanisms for improving water access and use and water environment are poor. The reason is that under such situations, the water access, water use, and water environment would be highly dependent on natural water endowment.

There cannot be a better region than Sub-Saharan Africa to illustrate such effects. A recent analysis showed a strong correlation between rainfall trend since 1960s and GDP growth rates in the region during the same period, which argued that the low economic growth performance could be attributed to long term decline in rainfall which the region experienced (Barrios et al., 2004). Such a dramatic outcome of rainfall failure can be explained partly by the failure of the governments to build sufficient water infrastructure. Sub-Saharan Africa has smallest proportion of its cultivated area (< 3%) under irrigation (HDR, 2006). Due to this reason, reduction in rainfall leads to decline in agricultural production, food insecurity, malnutrition, loss of employment opportunities and an overall drop in economic growth in rural areas.

[4] This includes economic scarcity as well.

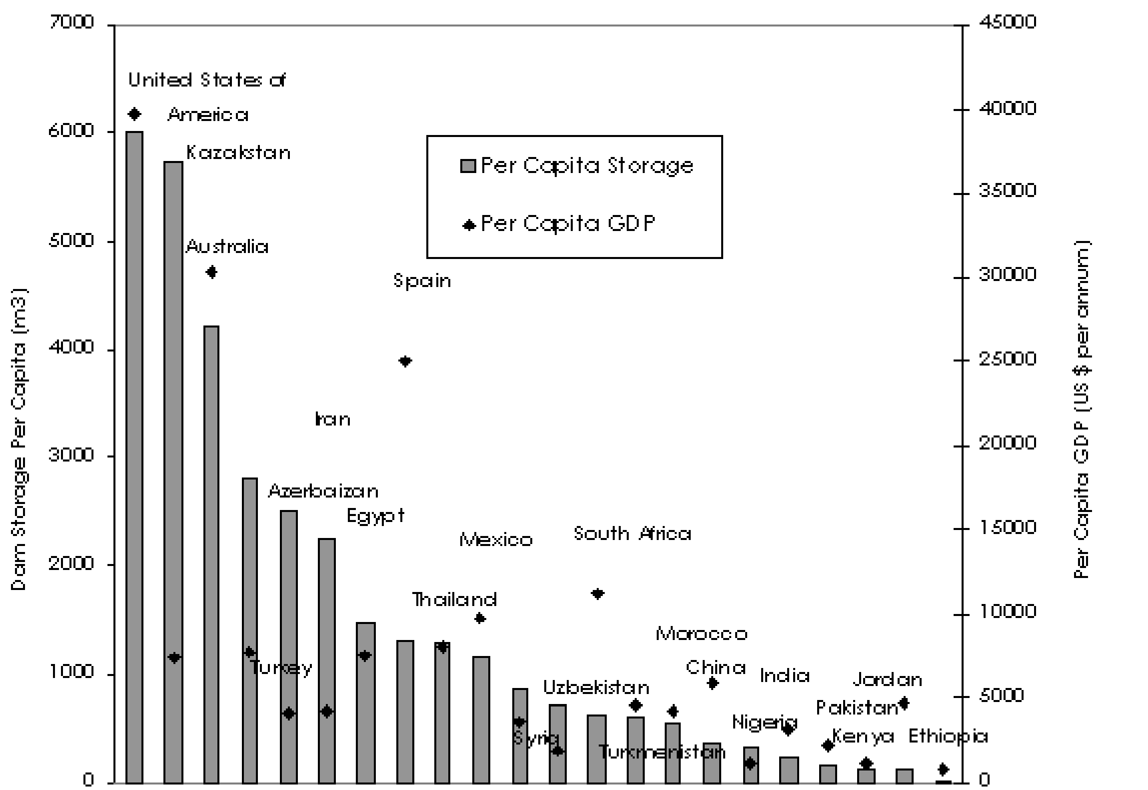
The foregoing analyses suggest that improving water situation of a country, which is represented by Sustainable Water Use Index, is of paramount importance if we need to sustain economic growth in that country. It would be rather an improper logic to consider that a country can wait till its economy improves to a certain level to start tackling its water problems. While the natural water endowment in both qualitative and quantitative terms cannot be improved through ordinary measures, the water situation can be improved through economically efficient, just and ecologically sound development and use of water in river basins.

6. STORAGE DEVELOPMENT AND ECONOMIC GROWTH

Now, water development has an important role in improving the access to and use of water, the two pre-requisites for improving the water situation (expressed in terms of SWUI) of a region, though intensive water development in river basins might reduce indicators on the water environment front. The amount of storage that needs to be created to improve access to and use of water depends on the type of climatic conditions. In temperate and cold climates, the demand of water for irrigation, which is the largest user of water in most regions with agricultural base, would be negligible when compared that in tropical and hot climates. Hence, the storage requirements would be much lower, mainly limited to that for meeting domestic/ municipal water needs and water for manufacturing. Hence, it makes logic to explore links between storage development for meeting various human needs and economic growth only in tropical and hot climates.

The sheer scale of water infrastructure in rich countries is not widely appreciated (HDR, 2006: pp-155). Many developed regions of the world that experience tropical climates had high water storage in per capita terms. The United States, for instance, had created a per capita storage capacity of nearly 6000 m^3. In Australia, the 447 large dams alone provide a per capita water storage facility of nearly 3,808 m^3 per annum or a total of 79,000 MCM per annum. Aquifers supply another 4,000 MCM per annum. Against this, the country maintains a use of nearly 1,160 m^3 per capita per annum for irrigation, industry, drinking and hydropower, with

Figure 5: Per Capital GDP and Dam Storage in selected Countries



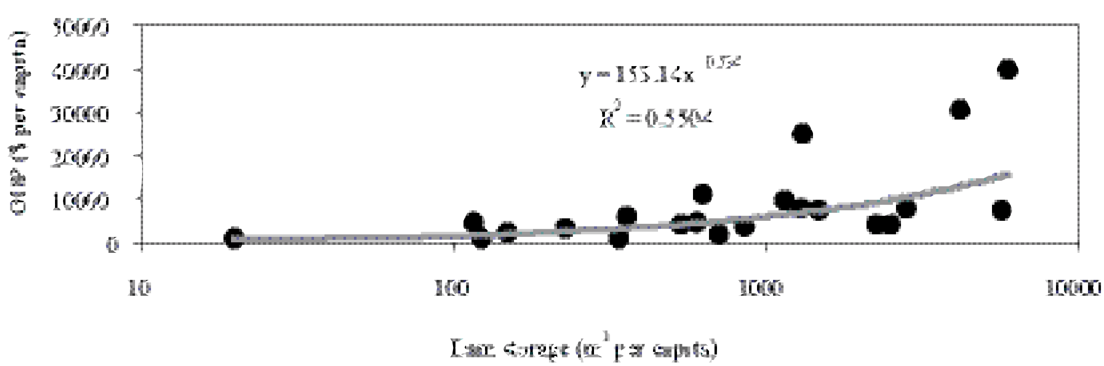
irrigation accounting for 75% of the use (source: www.nlwra.gov.au/atlas). China, one of the fastest growing economies in the world, has per capita reservoir storage capacity of 2,000 m^3 per annum through dams, and an actual storage of nearly 360m^3 per capita. This is in spite of the great technological advancements made by most of these countries in improving water use efficiencies, particularly in sectors such as irrigation and industry.

When compared to these impressive figures, India, which is still developing, has a per capita storage of only 200m^3 per annum. Though a much higher level of withdrawal of nearly 600 m^3 per capital per annum is maintained by the country, a large percentage of this (231 BCM per annum or nearly 217 m^3 per capita per annum) comes from groundwater draft. But, there are increasing evidences to suggest that this won't be sustainable. Many semi arid areas are already facing problems of groundwater over-draft, with serious socio-economic and ecological consequences as discussed in the recent work by Kumar (2007). Ethiopia, the poorest country in the world, has a per capita storage of 20 m^3 per annum. These facts also strengthen the argument that economic prosperity that a country can achieve is a function of available water storage per unit of population.

The per capita water storage and the per capita GDP (ppp adjusted) for a group of 22 countries is given in Figure 5. One can see a strong relationship between level of storage development and country's economic prosperity. The R square value is 0.55 (Figure 6), and the coefficient is significant at one per cent level. Such a relationship is understandable. Water storage infrastructure reduces risks, and improves water security.

Investments in hydraulic infrastructure had in many cases supported economic prosperity and social progress, though in some cases had caused environmental damage (HDR, 2006, based on various authors: pp140). Since 1920, the US Army Corps of Engineers had invested a sum of $ 200 billion on flood management and mitigation alone, yielding a benefit of $ 700 billion. The Tennessee Valley Authority, which built dams for hydropower, transformed the flood-prone, impoverished part of the Dust Bowl, with some of the worst human development indicators of the United States, into an agriculturally prosperous region. In Japan, heavy post war investments in infrastructure supported rapid development of hydropower, flood control and irrigated agriculture. The returns from these investments were tremendous. Until World Water II, the floods and typhoons had

Figure 6: Per Capita GDP vs Per Capita Dam Storage



resulted in losses often amounting to 20% of GNI, whereas since the 1970s, the losses never exceeded 1% of the GNI (HDR, 2006: pp 156).

The returns on investments in building water storages were more visible in India. The recent analysis using panel data on gross irrigated area and rural poverty rate for 14 states showed poverty reducing effect of irrigation, with lowest rate of poverty found in Punjab which had the highest level of gross irrigated area, which reduced over time from 1973-74 to 1993-94 (Bhattarai and Narayanamoorthy, 2003). The Bhakra-Nangal Project had transformed the economy of Punjab. The almost perennial water supply from the project enabled farmers in this region to intensify cultivation with irrigated paddy and wheat, making it the country's bread basket. Now, 90% of the cropped area in the state is irrigated, three quarter of it going to paddy and wheat.

Despite comprising less than 2% of the geographical area, Punjab accounts for 10% of rice production and 20% of wheat production in India. Agriculture accounts for 40% of the state GDP in the state, which has the highest per capita GDP amongst all Indian states (Cummings et al., 2006).

The potential positive impact of water infrastructure on economic growth in regions that experience seasonal climates, rainfall variability and floods and droughts can be better demonstrated by the economic losses that water-related natural disasters cause in such regions which lack them badly. For instance, deviation in per capita GDP from the normal values during the 20-year period from 1980-2000 correlated with departure of annual rainfall from normal values (World Bank, 2006a). In Kenya, economic losses due to floods during 1997-98 were to the tune of 11% of the national GDP, where as that due to droughts during 1998-2000 was 16% of the GDP (World Bank, 2004a and World Bank 2006b).

But, there are many critiques to the argument based on per capita storage. According to Vandana Shiva, a renowned eco-feminist from India, the norms used for estimating per capita water use is fraudulent, and a way to push the large dam agenda by the World Bank. According to her, the many millions of ponds and tanks in rural areas of India themselves capture a lot of water and supplies it to the rural population in a more democratic and decentralized way than the large dams do. But, the contribution of such storage in augmenting our water supplies is often over-estimated by environmentalists. In the case of Australia, the National Heritage Trust's report of the audit of land and water resources say, the many millions of farm dams in Australia create a total storage of 2,000 MCM per annum, against 79,000 MCM by large dams (www.nlwra.gov.au/atlas).

Nevertheless, the overall impact of water storages on economic growth would depend on the nature of uses for which the resources are developed, the effectiveness of the institutions that are created to allocate the resource and the nature of institutional and policy regimes that govern the use of the resource. As we have seen in the case of incidence of hunger, in Zambia and Zimbabwe, use of water storages for hydropower generation had not helped improve the overall economic condition of the people also. Though the per capita water storage in Israel is quite low (nearly 150 m^3 per annum), the efficiency with which water is used in different sectors is extremely high. Nearly 90% of the country's irrigated area is under micro irrigation systems. A large portion of the water used in urban areas is recycled and put back to use for irrigation. Water is not only priced on volumetric basis, water allocation to agriculture is rationed.

One could as well argue that access to water could be better improved through local water resources development intervention including small water harvesting structures, or through groundwater development. As a matter of fact, environmental activists advocate decentralized small water harvesting systems as alternatives to large dams (see Agarwal and Narain, 1997). Small water harvesting systems had been suggested for water-scarce regions of India (Agarwal and Narain, 1997; Athavale, 2003), and the poor countries of Sub-Saharan Africa (Rockström et al., 2002). But, recent evidences suggest that they cannot make any significant dent in increasing water supplies in countries like India due to the unique hydrological regimes, and can also prove to be prohibitively expensive in many situations (Kumar et al., 2006). Also, to meet large concentrated demands in urban and industrial areas, several thousands of small water harvesting systems would be required. The type of engineering interventions[5] and the economic viability of doing the same are open to question. Recent evidences also suggest that small reservoirs get silted up much faster than the large ones (Vora, 1994), a problem for which large dams are criticized world over (see McCully, 1996).

As regards groundwater, intensive use of groundwater resources for agricultural production is proving to be catastrophic in many semi arid and arid regions of the world, including some developed countries like Spain, Mexico, Israel, Australia, and parts of United States (Kumar, 2007), and developing countries such as India, China, Pakistan, Yemen and Jordan (HDR, 2006), though some of the developed countries like United States and Australia have achieved some degree of success in controlling it through establishment of management regimes (Kumar, 2007) with physical and institutional interventions like in western US, or through physical interventions alone like in Israel.

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[5] Complex engineering interventions would be required for collecting water from such number of small water harvesting and storage systems, and then transporting to a distant location in urban areas.

But, it is important to recognize the fact that in the basins that are facing problems of environmental water scarcity and degradation in the world (see Smakhtin, Revenda and Doll, 2004) are appropriate development of large water projects, and diverted river-flows for various consumptive needs. Some of these basins are the Colorado river basin in the western US; Yellow river basin in northern China; Aral sea basins, viz., Amu-Darya and Syr Darya in Central Asia; Indus basin in Pakistan and India; basins of northern Spain; Nile basin in northern Africa; basins of Euphrates, Tigris; the Jordan river; Cauvery, Krishna and Pennar basins of peninsular India; river basins of western India including Sabarmati, Banas and Narmada, located in Gujarat, Rajasthan and Madhya Pradesh in India. Most of the water demands they meet are agricultural[6]. They are also agriculturally prosperous regions. Not only they meet the food requirements of the region, most of these basins export significant chunk of the food to other regions of the world, including some of the water-rich regions, within the country's territory (Amarasinghe et al., 2004 for Indus basin and peninsular region in India; Kumar and Singh, 2005 for many water-scarce countries of the world; Yang, 2002 for China).

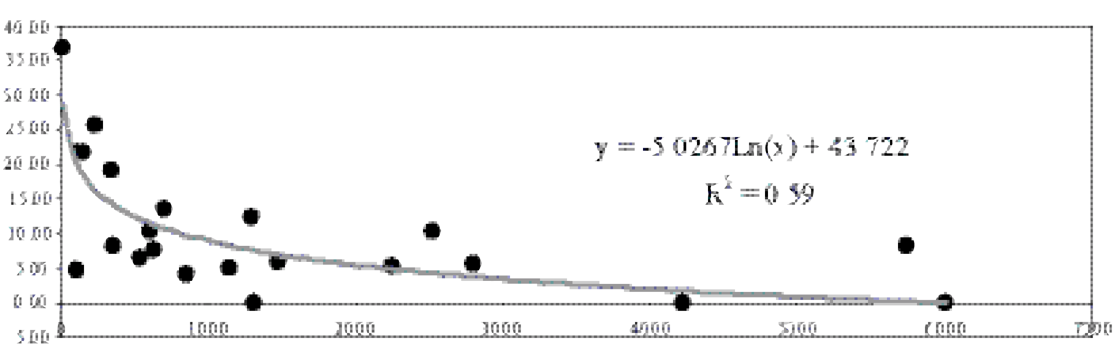
Strikingly, wherever aquifers are available for exploitation, these regions had experiencing problems of groundwater over-draft, though some developed countries had developed the science to deal with it. The most glaring examples are aquifers in western United States, aquifers in the countries of the Middle East including Yemen, Iran and Jordan; aquifers in Mexico; north China plains (Molden et al., 2001); alluvial aquifers of Indus basin areas in India; hard rock aquifers of Peninsular India; and aquifers in western and central India (GOI, 2005).

For the presence of large surface water projects, the negative impacts agricultural growth in these regions, might have caused on groundwater resources might have been far more serious. In fact, it is this surface water availability, which to a great extent helps reduce dependence of farmers as well as cities on groundwater. For instance, imported water from Indus basin through canal in Indian and Pakistan Punjab sustain intensive groundwater use in the regions, through continuously providing replenishment through return flows from surface irrigation (Ahmed et al., 2004; Hira and Khera, 2002; Kumar, 2007). Water imported from the Central Valley Project in California is used to buy back the groundwater rights of farmers using water from Ogallala aquifer in Kansas and Texas. Water imported from a large reservoir named Sardar Sarovar in Narmada basin in Southern Gujarat in India had started supplying water to rejuvenate the rivers in environmentally stressed basins of north Gujarat (Kumar and Ranade, 2004).

7. STORAGE DEVELOPMENT AND IMPACT ON MALNUTRITION AND CHILD MORTALITY

As one would expect, storage development has a direct impact on malnutrition, and infant mortality, which is captured in GHI. Here again, we have assumed zero values of GHI for developed countries viz., United States, Australia and Spain for which data on GHI are not available. Regression shows an R^2 value of 0.59

Figure 7: Global Hunger Index vs Per Capital Dam Storage



[6] In Murray Darling basin, 90% of the annual flows are diverted for agricultural use.

(Figure 7). As Figure 7 indicates, the relationship between per capita storage and GHI is inverse, logarithmic. The regression coefficient is significant at one per cent level. It means greater water storage reduces the chances of human hunger. This inverse relationship can be explained this way. For the countries, which we have chosen for the analysis, the ability to cultivate the available arable land intensively would increase with the amount of water storage facilities available. As HDR (2006: pp 174) notes, "Water security in agriculture pervades all aspects of human development". Increased availability of irrigation water reduces the risk of crop failure; enhances the ability of farmers to produce more crops to improve their own domestic food consumption of food, and take care of the cash needs. Also, increased irrigated production improves food and nutritional security of the population at large by lowering cereal prices in the region in question as the gap between cereal demand and supplies is reduced (Hussain and Hanjra, 2003 as cited in HDR, 2006: pp 175).

This was more evident in India than anywhere else, where irrigation expansion through large storages had contributed nearly 47 million tons of additional cereals to India's bread basket (Perry, 2001: pp 104). Shah and Kumar (2007) made a rough estimate of the positive externality it created in terms of lowering food prices for the consumers in India as US $ 20 per ton of cereals. One could also argue that rich countries could afford to import food. But, what is important is that water had played a big role for these countries to achieve a certain level of economic growth and prosperity, by virtue of which they can now afford to import food instead of resorting to domestic production. The exceptions are some of the oil rich countries of the Middle East, which do not have an agrarian base, but are economically prosperous.

Contrary to what is found in the case of these 22 countries, there are countries which have large storages, but have very high GHI. They are Zambia and Zimbabwe. They were not included in our analysis. These countries use their water storages for creating hydro-power, which is sold to the South Africa, and they earn revenue out of it. Most of it comes from just one hydropower dam, named, Kariba built in 1955-59 in Zambezi river basin. Hence, storage development does not lead to increased agricultural production in these countries. The GHI values are very high for these countries, which is 31.77 for Zambia, and 23.2 for Zimbabwe (Wiesmann, 2006). In such a situation, the impacts on food security would generally be seen only after many years. But in the case of these Sub-Saharan African countries, three decades of droughts and rainfall reduction had significantly affected the hydropower generation as well (McCully and Wong, 2004).

8. SUMMARY OF FINDINGS

We first analyzed the nature of impact the water situation of a country has on its economic growth by doing regression between: SWUI and GHI; SWUI and per capita GDP; SWUI and HDI; and per capita GDP and HDI for 145 countries. In order to illustrate how creating water storages supports economic growth of countries which fall in hot and arid, tropical climates index, data on per capita dam storage and per capita GDP were analyzed for 22 countries, which fall in that category. The summary results of regression analyses are presented in Table 2. Based on these results, the findings can be summarized as follows.

Improving the water situation, vis-à-vis improved access to and use of water, institutional capabilities in water sector and improved water environment, through investments in water infrastructure, creation of institutions and introduction of policy reforms, can trigger economic condition in a nation. This occurs through the human development route, as shown by the consistent improvement in human development indicators with increase in values of SWUI. This strong linkage can be partly explained by the reduction in malnutrition and infant mortality, with improvement in water situation as indicated by the strong inverse relationship between SWUI and GHI for 117 countries.

Further, progress in human development has very little to do with their economic growth, and that they could achieve good indicators of development even at low levels of economic growth, through investment in water infrastructure and welfare-oriented policies. Many countries of the erstwhile Soviet Union, and communist countries of Latin America, which have low income, spend a significant portion of public funds in health and education, against many poor countries of Sub-Saharan Africa, which spend much less for health and education and more for military.

Table 2: Results of Regressions Analysis of Various Water, Human Development and Economic Growth-Related Variables

Dependent Variable	Independent Variable				Adj-R2	F-Stat	Degree of Freedom
	Constant	LNSWUI	SWUI	LNPCSTR			
HDI	-2.459 * (-17.627)	0.822 * (22.655)			0.781	513.24	(1, 143)
LNPCGDP	3.313 * (11.201)		0.111 * (18.132)		0.695	328.76	(1,143)
GHI	180.792 * (14.985)	-44.057 * (-14.012)			0.593	196.33	(1, 133)
GHI	43.722 * (6.971)			-5.027 * (-5.401)	0.573	29.17	(1, 20)
LNPCGDP	5.031 * (6.919)			0.534 * (4.948)	0.528	24.49	(1, 20)

Note: Value in the parenthesis shows the t-stat for the corresponding estimated coefficient
LNPCSTR –Logarithmic value of per capita storage in dams
LNSWUI-Logarithmic value of Sustainable Water Use Index
LNPCGDP-Logarithmic value of per capita GDP PPP adjusted
* implies that the coefficient is significant at one per cent level

Countries which fall in tropical semi arid and arid climate, can improve their economic conditions through enhancing the reservoir storage. This potential impact be explained by increased water security that comes with greater water storage. This reduces the risks associated with natural calamities such as droughts and floods. Such natural calamities, which cause huge economic losses, are characteristic of these countries. For such large surface water development, the negative impacts agricultural growth would have induced on groundwater resources in such regions would have been far more serious. Nevertheless, the impact of storage could depend on the nature of uses for which the resources are developed, the effectiveness of the institutions that are created to allocate the resource and the nature of institutional and policy regimes that govern the use of the resource. Those countries having high per capita water storage also have very few people living in hunger.

9. CONCLUSIONS

The debate on the linkage between water, economic growth and human development is characterized by divergent views. They can be summarized as: 1] increased investment in water projects would act as engines of growth in the economy, while supporting progress in human development; 2] standard approaches to water management in terms of policies and institutions work when water economies become formal, which are found at an advanced stage of economic development; and 3] ability of a country to sustain its economic growth depends on the extent to which natural resources, including water, are put to efficient use through technologies and institutions, thereby reducing the stresses on environmental resources.

Scholars have provided robust evidences to the effect that water security catalyses human development and economic growth. But, number of regions for which these evidences are available is too limited for evolving a global consensus on this complex issue. Water poverty index, conceived and developed by C. Sullivan (2002), and the international comparisons now available from Laurence, Meigh and Sullivan (2003) for 147 countries enable us to provide an empirical basis for the argument. A new index called SWUI was derived from WPI using four of its five sub-indices to assess the water situation of a country, vis-à-vis access and use of water, water environment and institutional capabilities in the water sector. Analysis was carried out using data on SWUI, GHI, HDI, per capita GDP and per capita water storage in dams to understand the nature of linkage between water situation of a country and its economic growth.

Findings show that economically poor countries, which also show very poor indicators of human development, need not wait till the economic conditions improve to address water sector problems. Instead, they should start investing in building water infrastructure, create institutions and introduce policy reforms in water sector that could lead to improved water situation vis-à-vis access to and use of water, water environment and institutional capabilities. Only, this can support progress in human development, and sustain economic growth, through poverty reduction; food security, improved livelihoods and nutrition, with positive effects on productive workforce; and domestic water security with positive effects on health, environmental sanitation, with spin off effects on livelihoods and nutrition, school drop out rates and productive workforce. But, a pre-requisite for hot and arid tropical countries is that they invest in large water resource systems to raise the per capita available storage. This will help them fight hunger and poverty, malnutrition, infant mortality, and reduce the incidence of water-related disasters. Finally, the study also provides a methodology for analyzing the linkage between water situation in a region and its economic growth.

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GROWTH IMPACTS OF DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

R. P. S. Malik[1]

Abstract

The paper presents the hypothesis that investments in development and management of water resources impacts all round growth - not only in the sectors and regions impacted directly by the availability of water but also in sectors and regions impacted indirectly by the availability of water. The indirect economic impacts can be as large as the direct economic impacts and therefore evaluating growth impacts of water resources projects based solely on the direct impacts can seriously underestimate the true growth impacts. The author supports the hypothesis by analyzing the Bhakara Nangal Project in terms of the direct and indirect economic and developmental impacts it has on the economy at large, including all sections of society, including the poor.

1. NATURE OF WATER GROWTH INTER-RELATIONSHIP

Water impacts growth and is impacted by growth. Water has both been an important driver of and a contributor to the process of growth. Investment in water resources has often formed the basis of investment in other growth inducing activities and programs. To illustrate, provision of water, such as in the case of irrigation water, fundamentally alters the agricultural environment permitting agricultural response along a more productive and intuitively more elastic production function. Availability of irrigation is not only accompanied by technological and other changes at the farm level, state level and district level but also by development of other infrastructure such as road, credit, marketing, electrification, schooling etc. Productivity improvements and related changes brought about by irrigation translate into income improvement per unit of land, influencing income levels and poverty. Investments in water resources has often formed the basis of broad regional and national development as witnessed in many OECD countries (Japan, the Netherlands, Norway, Spain, the western United States) and developing countries (among them Brazil, Egypt, Mexico, India, Pakistan, South Africa and Thailand) and benefits of growth of such investments in water resources have been shared by all sections of the economy and society.

Water impacts growth in a myriad of ways and in all its dimensions. Water impacts growth both positively and negatively, directly and indirectly, locally and regionally, independently and conjunctively, tangentially and substantially, at the level of an individual sector and at the multi sectoral level. The intended growth impacts of water use in a specific sector or in a specific geographical location are generally not restricted to that sector or that geographical region alone but these impacts reverberate through inter-sectoral and inter-regional linkages to other sectors of the economy and over a much larger spatial scale. All forms of water resource development – single or multipurpose, large or small, targeted or untargeted, surface water or groundwater based – and its use have impacted the growth of different sectors of the economy.

Apart from the apparent contribution of water to growth, water has also impacted growth through its linkages with energy. Water-energy linkages and interdependencies have contributed to the growth both through generation of energy and also through use of energy for making groundwater available. Water is required not only for generating hydropower, water is an essential input for generation of thermal and nuclear power as well. About one-third of total electricity in India is used for pumping groundwater for irrigation as well as for domestic water supply in urban and rural areas. The presence of strong inter linkages between water and growth, water

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and energy, and energy and growth have to be harnessed and translated into mutually reinforcing and much stronger and forceful inter-linkages between water, energy and growth.

Water, impacts growth not only through the investments in water resource development, but also investments in more efficient management of water resources. The changes in the policies governing the use of water and its allocation, in isolation and/or in conjunction with investments in water resources, can have substantial impacts on the economic growth and poverty. The empirical evidence linking the 2 is however scarce and sketchy.

Concurrent with growth contributing impacts of water, water has also sometimes been responsible for retarding growth. Floods year after year cause widespread loss to life and property, severely affecting the poor. The use of fertilizers and other chemicals in irrigated agriculture have both on and off site impacts on water quality. The excessive withdrawals of ground water, beyond their sustainable yield levels, have implication for water availability, water quality and agricultural sustainability. The larger industrialization has implications for water quality deterioration through effluent discharge in streams and rivers. The development of large-scale surface water infrastructure has implications for forest submergence, displacement of people, in causing water logging and soil salinity and in spread of water borne diseases. Some of these negatively impacting effects of development and use of water on growth can, however, often be minimized through adoption of appropriate policy, management and technological interventions.

2. OBJECTIVES AND SCOPE

While there is enough theoretical, commonsensical and circumstantial reasoning to substantiate and empirical support to demonstrate that investments in development and management of water triggers growth in multifarious ways, because of the complex interactions water induces in isolation and in combination with other policies and development investments, there are methodological issues relating to quantifying and isolating the contribution of water on various growth variables. An attempt has been made in the present paper to demonstrate how the diverse growth inducing economic impacts of water can be quantified with a reasonable degree of precision. The paper briefly presents results in respect of growth inducing impacts of investments in development and management of water resources from three recent case studies with which the author was associated. To demonstrate how the growth impacts of large scale multipurpose water resources development projects may differ from small scale projects, we analyze the growth implications of both types of projects. We estimate the regional growth impacts of a large project - Bhakra multipurpose dam located in the North-West India. We also estimate the growth impacts of a small check dam constructed in Village Bunga in the Shivalik hills region in the state of Haryana. For demonstrating the growth implications of management of water resources, we have selected Tamil Nadu, a state which is in the grips of acute water scarcity.

Before presenting evidence to demonstrate the growth implications of development and management of water resources, it is important to briefly elaborate on the meaning of growth in the present context and how this has been measured in the present paper. In general growth is a multi dimensional variable and encompasses economic, social and environmental concerns. Water impacts growth in all its constituents. The multifarious nature of impacts of water traverse through a mesh of processes and pathways culminating in to multi dimensional growth impacts of water. While for measuring growth, several indicators of growth can be employed depending upon the purpose at hand, for the present paper we measure the economic growth impacts of water in terms of increase in regional value added.

3. GROWTH IMPLICATIONS OF WATER RESOURCES DEVELOPMENT : LARGE PROJECTS

The Bhakra dam system is a large multipurpose water resource project in north-west India producing several benefits including water for irrigation, domestic and industrial sectors; hydro power for industries, agriculture and households; flood control; recharge of groundwater, tourism, fisheries and other non-irrigation benefits of canals. The availability of irrigation water through the dam-canal network of Bhakra dam system and the groundwater pumping facilitated by recharge from the system over the last 50 years or so has helped in bringing large tracts of cultivated area in the region under irrigation. The availability of surface irrigation water from the Bhakra dam system and from groundwater pumping in the area provided impetus to the adoption of high yielding varieties of rice, wheat and cotton and in promoting use of chemical fertilizers. Adoption of this technological package transformed the agricultural production scenario in the region leading to higher crop yields. This has contributed significantly to the increases in output of agricultural commodities. In addition, the hydro power stations installed in the Bhakra system have a combined generating capacity of 2880 MW, which currently generate about 14000 million units (kWh) of electricity in a year.

The direct economic impacts, in terms of additional agricultural output and hydro power, generated by the availability of water, in turn have led to generation of both inter-industry linkage impacts and consumption-induced impacts on the regional and national economy. These impacts, often referred to as indirect economic impacts, operate as follows : water released from the multipurpose dam provides irrigation that results in the increased output of agricultural commodities. Changes in the output of these commodities require inputs from other sectors such as seeds, fertilizers, pump-sets, diesel engines, electric motors, tractors, fuels and electricity. Further, increased output of some agricultural commodities encourages setting up of food processing (sugar factories, oil mills, rice mills, bakeries) and other industrial units. Similarly, hydropower produced from a multipurpose dam provides electricity for households in urban and rural areas and for raising of industrial outputs (e.g., fertilizers, chemicals, machinery). Changes in the output of these industrial commodities require inputs from other sectors such as steel, energy, chemicals, among others. Thus, both increased output of electricity and irrigation from the dam results in significant backward linkages (i.e., demand for higher input supplies) and forward linkages (i.e., providing inputs for further processing).

Increased outputs of industrial and agricultural commodities generate additional wages and incomes for households. Higher incomes result in higher consumption of goods and services that, in turn, encourage production of various agricultural and industrial commodities. Changes in wages and prices have both income and substitution effects on expenditure and saving decisions of different owners of factors of production, which further impacts the demand for outputs both within the region and throughout the economy. Induced impacts reflect the feedbacks associated with these income and expenditure effects, and also include any impacts of changes in government revenues and expenditures that resulted from the project. The level of indirect impacts of a dam on the regional economic and value-addition however depends upon the strength of linkages among various sectors of the economy.

These direct, indirect and induced growth impacts of any large multipurpose water resources project are evident to any keen observer of the situation prevailing before and after the construction of the dam. However while evaluating the growth impact of such projects only the direct impacts are generally considered and these indirect and induced impacts are almost never taken into account. While fully appreciating and recognizing the existence of such indirect and induced economic impacts, one of the main reasons for not taking in to account these impacts of dams has often been the lack of data and an appropriate methodological framework for quantifying them.

The analytical tools that can be used to assess indirect and induced impacts of exogenous changes – be these demand shocks, policy changes, or the introduction of large projects with potential for such "spillover" effects – fall into the broad category of multi-sector models. A continuum of such models exist, differing primarily with respect to (i) their assumptions regarding quantity vs. price-responsiveness to exogenous shocks, (ii) the focus on income levels vs. the inclusion of distributive considerations, (iii) their capacity to incorporate factor and import substitution possibilities, and (iv) their capacity to accommodate policy distortions, specific factor and output market structures, and other peculiarities.

A number of analytical tools for estimating these multiplier effects have been suggested in the literature (Bell *et al., 1*982; Hazell and Ramasamy, 1991; Haggblade *et al.*,1991; Hoffman *et al.*,1996; and Aylward *et al.*,2000). These tools, which are essentially in the nature of multi-sector models, include: (i) Input-Output (I/O) Models; (ii) Social Accounting Matrices (SAM) based models; and (iii) Computable General Equilibrium (CGE) models.

From the point of view of the analysis of indirect and induced impacts of dam projects, the choice of an appropriate analytical tool need not always favor the most sophisticated tool, but rather be driven by the assumptions regarding the mechanisms through which impacts are transmitted in the specific region of interest – particularly factor mobility. When prices are assumed fixed, as in I/O or SAM-based multiplier analysis, all adjustments occur through quantity changes. In the absence of supply constraints, adjustments occur via impacts on labor or capital employment and inter-regional factor migration. The presence of idle labor or capacity in the system – either locally or in other regions, if the model is inter-regional – is thus crucial for the existence of quantity-driven multiplier impacts as estimated by these models.

On the other hand, a variable-price model, such as a standard[2] CGE, implies the presence of supply constraints, so that for at least one factor, the aggregate levels of factor employment are fixed. In this case, a change in sectoral demand results in relative price changes, determining substitution effects among inputs and among outputs, with factor reallocation across sectors in the regional economy. If available, a CGE could also be used to compute SAM-based, fixed price multipliers analysis, making it possible to highlight the differential impacts that can be seen when considering changes in relative prices, factor mobility and wage differentiation.

Often the selection of a suitable analytical tool for multiplier analysis of a dam critically depends on the availability of I/O tables or SAM databases and models for a region. Based on the above considerations, for estimation of the indirect and induced impacts, we have employed a SAM based fixed price multiplier models in conjunction with mathematical programming models.

Thus combining an analytical framework of optimizing models with a Social Accounting Matrix (SAM) based fixed price multiplier model, the present study on Bhakra dam system has attempted to quantify the direct and indirect aggregate economic impacts of the Bhakra dam[3] for the state of Punjab[4] (Bhatia and Malik, 2008). The SAM framework provides a consistent, comprehensive, and detailed picture of the transactions in the economy and provides a basis for the construction of a model of the regional economy that is used to estimate the direct and indirect effects of a project. Production activities, government and households are considered and the pattern in which incomes are distributed takes its place alongside the sources of its generation.

The aspects of the dam that have been analyzed include: changes in the area irrigated; changes in the supplies of electric power; changes in yields and production technology (primarily changes in fertilizer consumption and the use of High Yielding Variety seeds). The model has been used to compute the values of relevant variables in the 'with project' situation with their counterparts in the hypothetical case that the project had not been undertaken. This set of variables comprises all the elements of a SAM for the region in each situation, assuming fixed prices. This analysis captures the main effects of the dam during a typical year during its lifetime, say 1979-80, approximately 20 years after the construction was completed. The choice of year for analysis in large part has been dictated by the availability of requisite data which was available from a detailed study (Bhalla et al., 1990). In measuring the impact of the project, an attempt is made to assess the situation in the region (the Punjab state) for the hypothetical case of 1979-80 in the absence of the project. This has been done by assuming that all autonomous changes in the region would have taken place except the effects of changes due to major outputs of the project, namely irrigation and hydro-electricity. This hypothetical case in the absence of the project is termed as 'without project' scenario for 1979-80.

3.1 Differences in aggregate value - added under 'Without Project' and 'With Project'

The results obtained show that, in 1979-80, the aggregate gross output in the region under the 'with project' situation was larger by Indian Rupees 19 billion[5] (27%) than it would have been had the project not been constructed. As expected, the project had its biggest impact on the output of agricultural commodities, specially

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[2]A Social Accounting Matrix (SAM) can feed into a standard CGE model .

[3]The benefits of water from the Bhakra dam systems extend over Punjab, Haryana, Rajasthan and Delhi while the benefits from hydropower generated by the dam extend over a much larger area. For the purpose of estimating the direct and indirect economic impacts in this paper we have however restricted the analysis to the state of Punjab alone. If these estimates were to be generated for the entire project benefited area, these impacts would be much larger..

[4] The Punjab state accounts for 41%of the total irrigated area in the Bhakra command and for 38% of the total electricity generated in the Bhakra system

[5] This is roughly equivalent of US $ 2 billion at the prevailing exchange rate in 1979-80. The current (2005) exchange rate is Rs. 45/ US dollar.

the output of wheat, paddy, cotton and oilseeds. The output of agricultural commodities was larger by Rs. 7 billion (61%) under ‘with project’ situation than it would have been had the project not been undertaken. The output of electricity was estimated (for 1979-80) to be higher by 6033 million kWh or Rs. 1442 million.

Further, the results on value added obtained from an analysis of the model show that in 1979-80, the aggregate value added in the Punjab economy under ‘with project’ scenario at Rs. 42.4 billion was higher than the value added under ‘without project’ scenario by Rs. 9.5 billion or by about 29% (Table 1). Of this, the value added from sectors affected directly by the project (agriculture and hydro power) at Rs. 15.3 billion was higher than the corresponding value added under ‘without wroject’ scenario by Rs 5.0 billion. This shows that the value added in sectors directly affected by the dam (agriculture and hydro power) was almost 49% higher under ‘with project’ situation than ‘without project’ situation. The value added by sectors indirectly impacted by the dam was higher by Rs. 4.5 billion (about 20%) in the with project scenario as compared to without project scenario. Thus in absolute terms the increase in value added by sectors indirectly impacted by the construction of dam was almost as large as that by the directly impacted sectors.

Table 1: Growth Impact of Large Water Resources Project: Differences in Regional Value Added under ‘With Project’ and ‘Without Project’ Situations for Bhakra dam system in Punjab 1979-80 (in Rupees Billion)

Sectors/Total	With Project	Without Project	Difference (With Project over Without Project)
Sectors directly affected by the Bhakra dam system (Irrigation and hydropower)	15.3	10.3	5.0 (48.9%)
Sectors indirectly affected by the dam system	27.1	22.6	4.5(19.9%)
Total	42.4	32.9	9.5(28.9%)

3.2 Distribution of Gains : Income Distribution Impacts

The SAM model employed for estimating the direct and indirect economic impacts of Bhakra dam distinguishes five categories of households – self employed farming households, agricultural labour households, rural non-agricultural households, rural other households and urban households. The results of the analysis enable us to assess the differential impacts of changes the construction of the dam had brought about on different categories of households. The income distribution impacts of the Bhakra dam have been analyzed by comparing the differences in aggregate income levels of various household categories under with and without project scenarios and by assessing direct and indirect components of income differences under the two situations. Figures 1 and 2 summarize the results obtained.

The results obtained signify that:

a. The construction of Bhakra dam system provided income gains to all the categories of households, including the urban households and the percentage increase in income of agricultural labor households is higher than that of landed households. This poorest group (agricultural labor) gained a 65% increase in income as compared to a rural average increase of 38% (under the ‘with project’ scenario as compared to the hypothetical ‘without project’) scenario.

b. The gains from the dam to different categories of households emanate from different sources. While landed households, agricultural labor and rural non agricultural labor households derive larger gains from the sectors directly affected by the project, the other rural households and urban households derive larger gains from indirectly impacted sectors.

Figure 1: Income of Different Types of Households With and Without Bhakra Dam, India

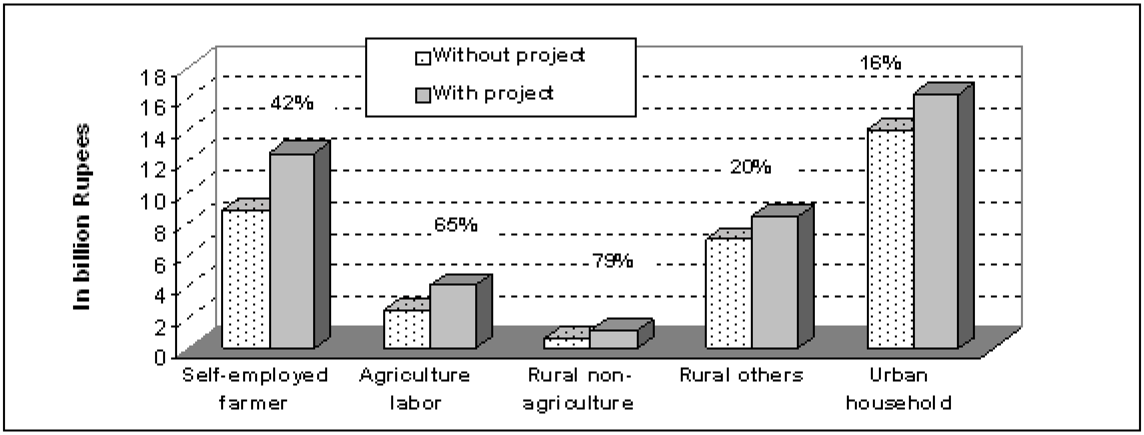
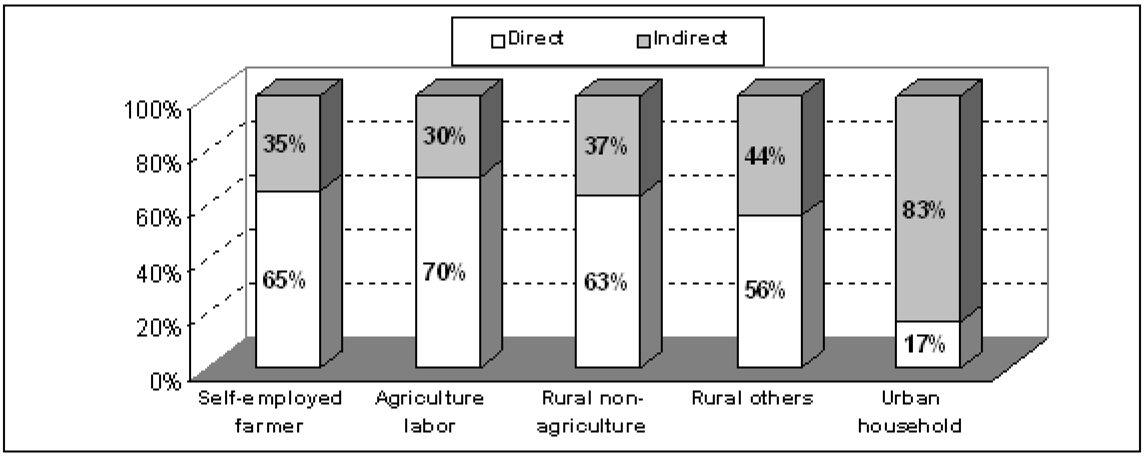


Figure 2: Income Gains to Households by Sectors Affected Directly and Indirectly by the Bhakra Dam, India



3.3 Indirect Economic Impacts in Other Regions

Apart from direct and indirect economic impacts accruing to both rural and urban households as also to landed and labor households within punjab, the water made available by the construction of the dam also impacted other regions of the country. The huge production of food-grains in the region created vast quantities of marketed surplus of these grains. The procurement agencies of the Central government every year purchase huge amounts of this marketed surplus of food-grains for maintaining the national buffer stock of food-grains and running the Public Distribution System (PDS) of the country through a distribution network of hundreds of ration shops spread all over the country. For example, during the year 2004-05 the states of Punjab and Haryana contributed 12.4 million ton of wheat out of a total of 16.8 million ton procured by these agencies from all over the country. Similarly, during the year 2004-05 out of a total procurement of 24 million ton of rice from the entire country, Punjab contributed 9 million ton while Haryana contributed 1.7 million ton. Thus, huge marketed surpluses generated by the Bhakra dam command provided food-grains to the urban poor, at prices they could afford, in other regions of the country.

The shifts in the cropping pattern and attendant changes in crop production brought about by the availability of irrigation water in the region created employment opportunities in the agriculture and related sectors. The huge employment opportunities available on a continuing basis for hired labor every year lures thousands of labourers from far off poor regions of the country (Bihar, Uttar Pradesh) where wage rates are low and unemployment is very high, to migrate to this region in search of employment and better wages. While some of these labourers have settled down permanently in the region itself, others migrate every year. For example, in a study carried out by Punjab Agricultural University, it has been estimated that during the lean period of agricultural operations the number of migrant labors employed in Punjab was 387 thousand and this number increases to about 774 thousand in the peak period. About 93% of the migrants belonged to the poor states of Bihar and Uttar Pradesh while about 5% also came from Nepal. It has further been estimated that the number of migrant labourers have increased by about 35% in 1995-96 as compared to 1983-84 and the Punjab agriculture managers almost one tenths of its total labor requirement from migrant workers.

The wage rates which these migrant laborers were getting in their native villages were lower as compared to what they got in Punjab. Thus, for example, about 46% of the migrant labor were getting less than Rs. 300 per month for being employed on a permanent basis in their native villages while in Punjab they were getting almost 200% higher wages.

It has been estimated that total earnings of the entire migrant labor force in crop production in Punjab during 1995-96 was Rs 5344 million (US$ 114 million) out of which they remitted Rs 3548 million (US$ 75 million or 66%) back to their native places while the remaining Rs 1796 (US$ 39 million) were spent by them in Punjab itself. About 18% of the migrant labor utilized their savings for creation of assets in their native places (Sidhu et al., 1997).

4. GROWTH IMPLICATIONS OF WATER RESOURCE DEVELOPMENT : SMALL PROJECTS

Concurrent with development of large water resources projects, such as Bhakra dam system discussed above, a greater emphasis is now being placed in encouraging development of community-managed small check dams. As a result, a large number of such dams have been constructed during the last two decades. These check dams provide water for irrigation, livestock and human beings and have contributed significantly to the increase in income of villagers and others around these villages.

In a small village Bunga, located in the Shivalik hills region near Chandigarh, 2 such check dams were built – the first in 1984 and the second in 1996. These dams have been providing irrigation to about 276 hectares of land in this small village with a population of 178 families (1100 persons). In addition to the direct increases in the gross irrigated area, output of food-grains and fodder, the check dams have created some indirect economic impacts (milk production and sale; shops and trading in the village, sale of grass etc) that has increased the income levels of almost all the households in the village.

Adopting an analytical framework somewhat similar to that discussed above in the case of Bhakra dam, a Social Accounting Matrix (SAM) based analytical model was developed to estimate the direct and indirect economic growth impacts of making irrigation water available in the village through these check dams (Malik and Bhatia, 2008).

4.1 Differences in aggregate value- added under 'Without Project' and 'With Project' in Bunga village

The results show that in 2001-02, the aggregate value added in the village economy under 'with project' scenario at Rs 10.24 million was larger than the value added under 'without project' scenario by Rs. 3.48 million or by 52% (Table 2). out of this, the value added from sectors affected directly by the project at Rs. 4.71 million was larger than the corresponding value added under 'without project' scenario by Rs. 2.48 million. This shows that the value added in sectors directly affected by the dam (food crops, fodder and income from sale of water) was more than double (higher by 110%) under 'with project' situation than 'without project' situation. The value added by sectors indirectly impacted by the dams was about 22% higher in the with project scenario as compared to without project scenario. In the aggregate, the project induced an increase of Rs. 3.48 million in regional value added. Of this, Rs. 2.48 million (or 71%) was due to increase in the outputs of sectors directly affected by the Bunga dam and the remaining Rs. 1 million (or 29%) was due to sectors indirectly impacted by the construction of these check dams.

Table 2: Growth Impact of Small Water Resources Project : Differences in Regional Value Added under 'With Project' and 'Without Project' Situations for Bunga in 2001-02 (in Rupees Million)

Sectors/Total	With Project	Without Project	Difference (With Project over Without Project)
Sectors directly affected by the check dam (Agriculture and fodder)	4.71	2.23	2.48 (110%)
Sectors affected indirectly by the dam (Milk production, other incomes from trade etc.)	5.53	4.53	1.00 (22%)
Total Value Added (Direct and Indirect)	10.24	6.76	3.48 (52%)

Source: Simulations using SAM for Bunga. See Malik and Bhatia (2008).

5. GROWTH IMPLICATIONS OF MANAGEMENT OF WATER RESOURCES

It is not the development of water resources alone that can and has contributed to growth, both directly and indirectly. Investments in management of water resources in isolation or in combination with development of water resources can be equally effective in contributing to the process of growth. The empirical evidence linking the two is however very sketchy and scarce. In a recent study in Tamil Nadu we have attempted to demonstrate how management of water resources can help not only added to but accelerating the process of growth. The study analyses the growth implications of a switch in water management practices from a system of command-and-control water allocation policies to a more flexible allocation policies, which facilitates the re-allocation of the limited quantity of available water from low- to high-value uses (Bhatia et.al., 2006).

The state of Tamil Nadu has a population of about 62 million people, of which 55% is urbanized. The state is in the grips of a water crisis. Even though total water resource potential of the state is about 46540 million cubic meters (MCM), the water availability per capita is less than 500 cubic meters per year, well below the 1000 cubic meter figure generally considered to signal water scarcity. The current level of water availability and usage clearly shows that Tamil Nadu has been using up almost all its available water and there is no water available to support larger demands from any of the sectors without harming the interests of the other sectors from where the water is diverted. However, the current pattern of availability and use of water should not be construed to imply that the different sectors are able to meet their required demand for water or that water availability to different sectors is reliable, timely and of desired quality. In fact the current demand for water from all the sectors put togather far exceeds the available supply. In many ways, the state is well on the road to a situation that other states in India could face in the coming years. These implicit quantitative and qualitative shortages have resulted in huge hidden costs and production, efficiency and income losses, the extent and magnitude of which are unknown and have never been quantified.

The response of the State to this growing water scarcity has primarily been one of attempts at supply-side augmentation coupled with some demand side management interventions. The various supply side measures attempted to augment available water include – attempt to capture a larger proportion of rainfall, by creating large and small dams and rainwater harvesting structures; try to bring more water into the state from both inter-state rivers such as Cauvery, or from other peninsular rivers such as the Krishna through the Telugu Ganga project; augment supplies for cities and industry by desalination and treating and re-use of wastewater, and through rehabilitation and modernization of tanks through external and internal funding. These primarily supply side augmentation (large and small) from sources within and beyond the state, have, in recent years been complemented with coping mechanisms on the demand side. Recent repeated droughts have forced the state to advise farmers to adopt less water intensive cropping patterns and more efficient irrigation systems. Tamil Nadu has set national precedents in mandating rainwater harvesting in cities and towns to recharge groundwater. The impact of these supply side and demand side interventions has been mixed but minimal in overcoming the water scarcity problems in Tamil Nadu. While these supply side and demand side interventions will need to continue to cope with water scarcity, these interventions will have to be supplemented by more efficient allocation and management of the available water.

As per the Tamil Nadu Water Policy (1994), "water allocation priorities in the planning and operation of systems should be broadly as follows: (i) Drinking Water, (ii) Irrigation, (iii) Hydropower, (iv) Industry and other uses. However, these priorities might be modified, if necessary, in particular tracts with reference to area-specific considerations." This official prioritization of water use has, however, seldom been effective in practice. As in any other state in India, effective institutional mechanism and the political will to enforce the sectoral prioritization envisaged in the policy do not exist. While the state policy gives priority to water for drinking, in practice the drinking water availability in Tamil Nadu is woefully inadequate. Probably the worst drinking water availability situation exists in the State's capital city of Chennai.

5.1 The Increasing Demand for Water in Tamil Nadu and the Likely Supply Scenario in 2020

It is estimated that by 2020 the population of the state will increase to 77.8 million, the rate of urbanization will increase substantially, the economy will continue to grow at the rate of at least 7% per year, and the per capita incomes will increase considerably. These changes in population and economic scenarios will have implications for water demand: the demand for water is also expected to increase correspondingly over this period. In the absence of any new known sources for supply of fresh water, the availability of water is unlikely to undergo any significant change during this period. It is estimated that the availability of surface water supplies are likely to reduce over time due to sedimentation of reservoirs and catchments related issues. Over a 20 year period, a 5% reduction in supply of reservoir water and a 10% reduction in the supply of tank water is likely to occur on account of these factors. However, given the likelihood of future inter-basin water transfers, it is estimated that by 2020, 1600 MCM of additional water is likely to be made available from the Godavari-Cauvery link and about 634 MCM through the Pamba-Vaippar link as per the estimates given by the National Water Development Agency (NWDA). Given the gap between current withdrawals and the estimated groundwater potential in 2020, estimated at 19800 MCM, the availability of groundwater is likely to increase. The other supply side augmentation options such as through rainwater harvesting, through improvement in basin wide water use efficiency, through adoption of high cost solutions such as desalinization of sea water, possibility for additional water through inter-linking of inter-state rivers etc are likely to be either very slow to come by due to economic, administrative and financial considerations or are likely to be masked to a great deal by politics and impasse over water transfers. As a result, in aggregate terms these options are unlikely to add any substantial quantities to the water supply available from traditional sources during the envisaged period. As such any possible addition to water availability from such options, though likely and welcome, has not been considered in the present assessment. The estimated total water availability during 2000 and 2020 from different sources in Tamil Nadu is given in Table 4 and Figure 3. Thus, while the total water availability during this period is likely to increase by about 23%, mainly on account of increased groundwater withdrawals, the water availability from surface water sources is likely to decline substantially.

5.2 Towards Some Management Solutions

Given the estimated availability of water in 2020 and the impacts the changing economic and population scenarios in Tamil Nadu are likely to have on the demand for water, will the command and control approach to water management as envisaged in the State Water Policy be able to ensure a rational allocation of water between the competing water using sectors without seriously hampering the economic growth and adversely affecting the interests of the vulnerable sections of the society? What is the trade-off involved in adopting a more forward looking approach to water allocation and use? To evaluate the likely implication of adopting a more flexible water allocation on the Tamil Nadu economy, we formulate the following alternative scenarios:

2.2.3 Fixed water allocation

This assumes continuation of current priorities in water allocation to year 2020. The future allocation and use is based on maintaining the shares of water in agriculture, domestic, industry at the ratios prevailing in the base year of 2000. Additional supplies of sustainable groundwater are allocated amongst the different water using sectors in the same proportion as in 2000.

2.2.2 Flexible Water Allocation

This scenario is based on reallocation of available water amongst agriculture, domestic and industry based on economic value of water in these sectors. The overall volume of water available in the base-case scenario remains the same as in 2000 but water is allocated (by the optimization model) to all sectors based on the estimated economic value of water in each sector (as defined by the willingness to Pay (WTP) for water in each sector). It is assumed that control structures for water redistribution amongst various users are in place and incentives to transfer water from one use to another will be present. However, due to considerations of livelihood and food security at the local level, basin-wise lower bounds have been put for area under food crops at a level equivalent to 50% of the area under these crops in the year 2000. Similarly, for industry, lower bounds for output have been placed at 2000 level at the basin level. Both agricultural and industrial outputs are constrained, through upper bounds, at a level equivalent to their exogenously projected output level in 2020 at the State level.

The estimated direct and indirect economic impacts of shifting from a fixed water allocation scenario to a more flexible water allocation scenario were estimated in terms of

(i) Comparison of total gross value of output in the two scenarios

(ii) Comparison of value added or state income in the two scenarios

To assess the direct impact of water allocation amongst different water users and to assess the economic value of additional water, basin-specific optimization models were developed. For each of the 17 basins[6], a single-period Linear Programming Model was developed which (a) takes into account exogenously-set water allocations for ecological, environmental and in-stream uses (which are varied in different scenarios) and (b) then determines the economically-optimal allocation of water amongst alternative water using sectors (agriculture, industry and domestic) and amongst alternative choice variables (different crops, levels of service and industries) within the individual water using sectors. The Social Accounting Matrix (SAM)- based multiplier model (that incorporates the input-output model) takes the results of the optimization models as inputs, and then determines the aggregate (direct plus indirect) impacts of different scenarios.

5.3 Comparison of Gross Value of Output in the Two Scenarios

If one were to adopt more flexible water allocation policies, the gross value of output (GVO) in Tamil Nadu in 2020 is likely to be higher by about 40% (from Rs 9925 billion to Rs 13878 billion at 1999-00 prices) in comparison to the policies of rigid allocation of water (Table 3). A closer examination of the changes in the sectoral GVO suggests that as a result of adoption of such water using policies while the GVO of agriculture is likely to go down by about 27%. But that of industry and electricity and gas are likely to increase substantially. The GVO of industry is likely to go up by about 119%. The tertiary sector output is likely to increase by about 14%.

5.4 Comparison of Value-Added[7] or State Income in the Two Scenarios: 2020

Due to differences in the ratio of gross value added (GVA) to GVO across and within different sectors, the magnitude of changes in GVA in the flexible scenario are likely to be somewhat different from those of GVO.

[6] The model does not consider the possibility of inter-basin transfer of water since inclusion of such an option would require making assumptions about the availability of institutions and physical infrastructure to undertake these transfers. Though such a transfer is possible in the long run for the present exercise this option has not been included.

[7] For the purpose of this study, the sum Gross Value Added in all sectors is taken as equal to the state income

As a result, in contrast to 40% increase in GVO, the GVA in 2020 is likely to increase by 21% (from Rs. 5969 billion to Rs. 7233 billion) if more flexible water allocation policies were to be adopted (Table 4, Figure 3). While the GVA from agriculture between the two scenarios in 2020 is likely to decline by about 29%, that of industry and electricity and gas is likely to rise substantially.

Table 3 : Comparison of Gross Value of Output by Major Sectors in Tamil Nadu under the Two Scenarios: 2020 (Rs Billion)

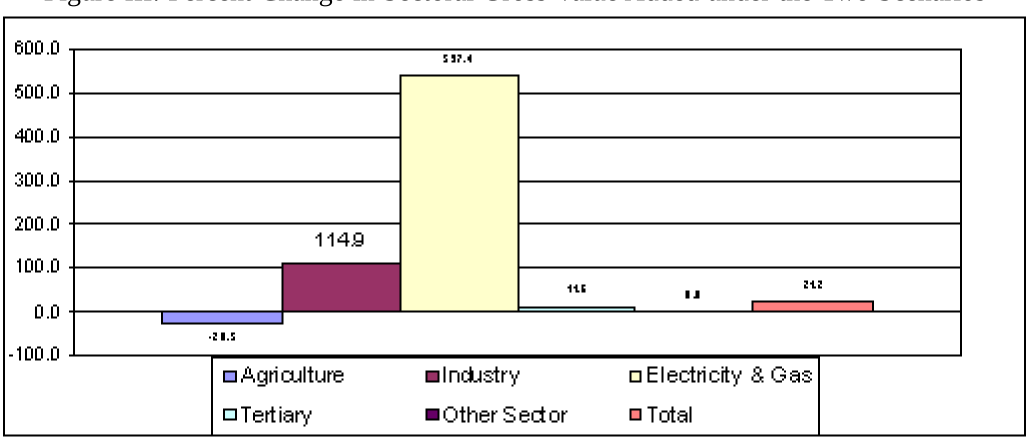
Sector	Water Using Scenarios		Percent Change
	Fixed	Flexible	
Agriculture	158	116	-26.5
Industry	1760	3851	118.8
Electricity & Gas	158	1010	537.4
Tertiary	7611	8663	13.8
Other Sector	238	238	0.0
Total	9925	13878	39.8

The value added in tertiary sector is likely to be higher by Rs. 610 Billion (by about 12%) showing the effects of indirect impacts of additional value added in industry, electricity and gas sectors. Hence, the reduction in value added or income in the agricultural sector is more than compensated for by the increases in the value added in industry, electricity and tertiary sectors.

Table 4: Comparison of Gross Value Added by Major Sectors in Tamil Nadu under the 2 Scenarios: 2020 (Rupees Billion)

Sector	Water Using Scenarios		Percent Change
	Fixed	Flexible	
Agriculture	107	76	-28.5
Industry	360	773	114.9
Electricity & Gas	51	322	537.4
Tertiary	5281	5891	11.6
Other Sector	171	171	0.0
Total	5969	7233	21.2

Figure III: Percent Change in Sectoral Gross Value Added under the Two Scenarios



6. CONCLUSIONS

The evidence presented above demonstrates that investments in development and management of water resources impacts all round growth - not only in the sectors and regions impacted directly by the availability of water but also in sectors and regions impacted indirectly by the availability of water. The indirect economic impacts can be as large as the direct economic impacts and therefore evaluating growth impacts of water resources projects based solely on the direct impacts can seriously underestimate the true growth impacts. The results on income distribution impacts of Bhakra presented above also suggest that economic gains from investment in development of water resources are not iniquitous and the economic benefits flowing there from are shared by all sections of the society including people living in the urban areas and the distribution of these benefits are such which do not leave the poor out.

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ECONOMIC VALUE OF WATER IN AGRICULTURE: COMPARATIVE ANALYSIS OF A WATER-SCARCE AND A WATER-RICH REGION IN INDIA

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Abstract

If the balance between availability and requirement drives the value, then the economic value of water in agriculture should be remarkably higher in water-scarce regions when compared to water-rich regions. Similarly, in water-abundant regions, if the land is scarce, then the incremental return per unit of land should be higher than that in land-rich region that are water-scarce. These hypotheses are tested by comparing the situation in western Punjab, which is land-rich and naturally water scarce and eastern Uttar Pradesh which is land-scarce and water-rich. The methodology used for assessing the economic value of water considered estimating the incremental value of output for a composite farming system from a unit of irrigation water used. The incremental value of farm output was estimated on the basis of the volume-based weighted average of the water productivity values (Rs./m^3) in various agricultural crops and milk production. The total effective volume of water used for various crops and milk production were estimated using physical productivity of water in various crops and milk production (kg/m^3), and the weight of outputs in the respective crops and milk.

The regression analysis shows that every extra unit of water diverted for agriculture generates more economic surplus in western Punjab. Regression of land against economic surplus shows that every extra unit of land put under cultivation generates more economic surplus in eastern Uttar Pradesh when compared to western Punjab. The total economic value of agricultural output generated from a unit of water in western Punjab (Rs.14.85/m^3) is higher than that of eastern Uttar Pradesh (Rs.11/m^3). The farmers in western Punjab allocate a larger share of their water for growing crops and dairying activities that have high water-productivity thereby maximizing the return per unit of water, whereas in eastern Uttar Pradesh, land productivity is an important consideration in deciding the cropping patterns. The livelihood impact of irrigated agriculture in western Punjab, with a livelihood index of 0.928 is higher than that of eastern Uttar Pradesh with a livelihood index of 0.87, meaning greater dependence of Punjab farmers on agriculture for livelihoods. Hence, transfer of water from a water-rich, land scarce region to a water-scarce, land rich region for agriculture might result in realization of higher economic value.

1. INTRODUCTION

In recent years, global discussions on water scarcity have been dominated by considerable amount of debate on the true value of water (Turner et al., 2004). The price that users are willing to pay for use of the resource reflects its marginal value (Young, 1996). Since markets often do not exist for many uses of water and even when exist are often imperfect, estimating the total as well as marginal value of water is difficult. This problem in valuation is true for India also. In India, groundwater lies in the open access regime with the absence of well-defined property rights (Singh, 1995). Though it is traded extensively for agricultural purpose, no tax is to be paid by users for groundwater. More over, agricultural users are not confronted with full marginal cost of abstraction due to heavily subsidized electricity in the farm sector (Kumar et al., 2005a). In the case of public canals for irrigation, there are no entitlements for the water supplied. Irrigation charges are highly-subsidized, and are not based on volumetric allocation (Brewer et al., 1999). In such situations, the incremental economic output that could be realized from its use per unit volume can be treated as its total economic value (Young, 1996).

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Agriculture is the principal 'user' of raw water globally accounting for nearly 70% of the water withdrawn and 93% of water consumed annually (FAO, 2004). In developing countries that are facing water scarcity, as water demand for urban domestic and industrial uses is likely to double from 1995 to 2025 (Rosegrant et al., 2002), irrigation water supplies are likely to be threatened, given the fact that it is the most inefficient and largest user of supplied water in economic terms (Turner et al., 2004). Agriculture accounts for a major share of the total consumptive use of the diverted water in India (GoI, 1999). But, with many regions in the country running short of water and with increasing competition from other high priority sectors, there is a need to raise the incremental value product or the economic surplus of water in agriculture. Enhancing productivity of water is the key to raising the economic surplus from its use in agriculture, thereby it value.

Both the marginal and the total value of irrigation water is determined by the water deficit experienced by the crops at any point of time, which is a function of the agro climate, and the type of crop grown. Hence, the total and marginal value of water in irrigation can be enhanced through efficient use of water and other inputs, or through adoption of more water-efficient crops with intensive cropping. Therefore, when demand for irrigation water exceeds its supplies, farmers should divert it for high valued uses, or use it more efficiently in the field through on-farm water management, farm management and better crop technologies.

But, in India, due to the inefficient pricing of canal water and electricity, the influence of market forces in ensuring transfer of water to high valued uses is almost absent. These low water charges can have adverse impact on the effectiveness of irrigation systems, and efficiency of water use at the farm level (De Moor and Calamai, 1997). Much socio-economic improvement through water use can also be secured through water transfer from surplus to deficit regions (Molden et al., 2001) and using water in regions where its economic value is high. But, water being a "bulky" resource, its economic value (total) tends to be relatively low. Therefore its conveyance over long distances will be economically viable, only if high incremental value is realized by water transfers (Young, 1996).

Going by Malin Falkenmark's physical water scarcity indicator, which is based on per capita total renewable water resources of a region, western Punjab is "water scare". Though the region's ecology is fragile and not favourable for irrigated agriculture, it practices intensive farming with green revolution technologies, with the limited supplies of canal water. Nevertheless, the farmers here are increasingly allocating the water for more economically efficient crops, thereby raising the total value of water.

On the other hand, eastern Uttar Pradesh is relatively water-abundant with rich alluvial aquifers and abundant rainfall in the plains of alluvial Gangetic belt (Shah, 2001). The access to arable land is limited. The farmers of the region, by and large, enjoy sufficient access to water for irrigation in both physical and economic terms due to free boring schemes, subsidized pump sets and groundwater markets (Pant, 2004). The region grows low risk crops such as paddy, wheat and maize, and some high valued vegetables. The cost per unit volume of canal water is low for highly water-intensive crops such as paddy. Water from public tube wells is also highly subsidized. The farmers take three crops, thereby raising the value of land (Pant, 2004).

Punjab's agricultural sector has been under attack for the intensive external-input based rice-wheat farming system costing heavily to its resource and economy in the form of groundwater depletion, and free electricity for farm sector (Singh and Kalra, 2002). But, what is less appreciated is the high productivity potential of irrigation water in this arid region and the value realized from use of imported water. Also, its unique positioning in terms of access to large arable land and arid to semi-arid climate increases the marginal as well as total value of water. India as a whole is characterized by significant mismatch between distribution of water resources and the requirement for water, major share of which comes from agriculture (Kumar et al., 2006). The intensity of use of water for agriculture is high in semi-arid and arid regions, which have poor water endowments. They produce surplus food for water-rich regions that face food deficits (Amarasinghe et al., 2005).

2. RESEARCH OBJECTIVES, HYPOTHESIS

2.1 The Objectives

Though water management involves many trade offs, much socio-economic improvement can be secured without the imposition of excessive costs or loss of environment integrity, through transfer of water to alternative crops and uses; water transfer from surplus to water-deficit regions; and use of water in regions where its economic value is high. The ultimate objective of this paper is to examine whether it makes economic sense to transfer water from water-rich region to water-scarce region, as a strategy to manage growing water demands. It is realized through a comparative analysis of the total use value of irrigation water in agriculture in regions with differential water endowments. While doing that, it does not try to address the complex political and hydrological issues inherent in water transfer project.

The specific objectives of the study are: to carry out a comparative analysis of economic value of water in agriculture in water-scarce western Punjab and water-rich eastern Uttar Pradesh (U.P.); to analyze the response of economic surplus generated from water use in agriculture to change in irrigation water use in the two regions; to analyze the response of economic surplus generated from water use in agriculture to change in land use in these regions; and to examine how livelihood impact of irrigated agriculture in an average farm household differs between the two regions?

2.2 Hypotheses and Assumptions

In line with the main objective, the main hypothesis postulated in this paper is that in water scarce regions, higher economic value is realized from use of water in agriculture as compared to water rich regions. The economic value of water is assessed in terms of surplus value product from a unit volume of water used in irrigation. The hypothesis is further divided into the following three sub-hypotheses. 1. The economic surplus generated from marginal increase in the use of water in agriculture is higher in water scarce regions as compared to water rich regions as farmers in these regions put water to comparatively more productive uses. 2. The economic surplus from marginal increase in land use in agriculture is higher in water-rich regions as compared to water scarce regions as farmers in these regions use their scarce land resources more intensively. They also use it more productively, selecting crops that give high returns, without much consideration to water needs. 3. The livelihood impact of irrigated agriculture in an average farm household is higher in water scarce region as compared to water rich region.

But these hypotheses are based on some assumptions. First, the “user cost” of water is higher in water scarce region as compared to a water-rich region because of higher direct cost of water abstraction or higher “opportunity costs”. Such high direct cost can be due to higher cost of pumping groundwater, owing to higher depth to water table. High opportunity cost can come from either increased irrigation water requirement per unit of land owing to low precipitation and high evapo-transpiration, or poor availability of good quality groundwater for irrigation, or relatively restricted allocation of canal water for irrigation when compared to the amount of land available for cultivation, or a combination of all or some of them. Hence, farmers would allocate water to crops and farming systems that give higher income return per cubic metre of water and that are low water intensive, but involve high risks.

Second, the water-rich regions generally have limited arable land. This is applicable to regions such as eastern Uttar Pradesh, most parts of Bihar and most parts of Kerala. This makes water a “surplus commodity” with negligible user cost. This means, they would have the comparative advantage of selecting crops that are highly water intensive, but give potentially high income per unit of land cultivated. Third, at the regional level, dairy farmers have to depend heavily on endogenous resources to be used as inputs such as fodder, though at the micro level some might be able to depend on markets to access dry and green fodder. This is because, if every farmer starts depending on imported fodder, then the price of fodder itself can shoot up in the market, thereby reducing the net return from dairy farming.

3. METHODOLOGY

3.1 Study Areas, Types and Sources of Data

Two regions viz., Bathinda district of South-Western Punjab and Varanasi district of Eastern Uttar Pradesh were selected for the study. The first is water-scarce and the other is water rich. Two villages from each region were selected for primary data collection. Data pertaining to a normal agricultural year (2003-04) were collected for the two selected regions with the help of a structured questionnaire, using a recall survey. A well structured and a pre-tested questionnaire was used for the interviews. The types of primary data included crop inputs and outputs viz., cropped area, irrigated area, crop-wise labour inputs, irrigation, fertilizer and pesticide use, yield of main crop and byproducts; dairy inputs such as feed and fodder, drinking water, average daily milk production in different seasons, market value of crop produce and milk, and household income from sources other than cropping and dairying. A sample of 160 farmers (40 from each village) belonging to different holding sizes was covered and it included well owners, water buyers and water sellers.

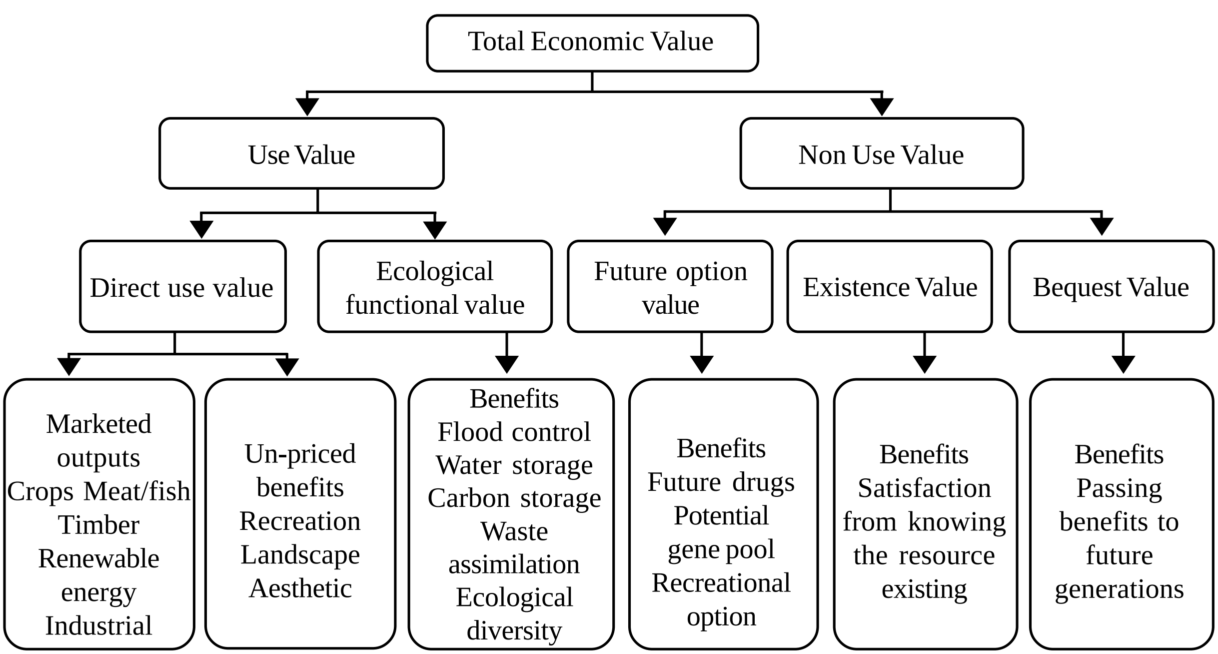
3.2 Estimation Procedure

The methodology used for assessing the value of water involved estimation of the incremental value of output for a composite farming system for a unit volume of water. The incremental value of farm output was estimated on the basis of the volume-based weighted average of the water productivity (Rupees per cubic metre of water) of applied water in various crops and milk production. The economic surplus from irrigated agriculture was estimated for individual farmers by taking into account the net income from crops and dairying. The livelihood impact of irrigation was estimated for individual farmers as the ratio of net annual income from crops and dairying and sale of irrigation water and the total income of the farmers' family from all sources including petty trade and employment.

3.2.1 Economic Value of Water in Agriculture

From an economist's point of view there are two important scientific approaches in valuing all natural resources including water. The first asks individuals, what they would be willing to pay for a given amount of

Figure 1: Total Economic Value



Source: Hodge and Dunn (1992)

resource. The second approach, estimates value by identifying the amount an individual is willing to pay for goods and services that use that resource. The marginal value refers to the price of the resource or good generated from the resource use for meeting a certain level of demand, where as the total value refers to the total price against the total use. Determining the value of water using the second approach is extremely difficult unless we understand the different values individuals attach to water. The classification of different values begins with the concept of Total Economic Value (TEV) of water (see Figure 1 based from Hodge and Dunn, 1992).

Identifying different uses of water is necessary to assess its value. Out of the many values of water, the present study considers the direct use value, i.e., the value of the marketed output (goods) produced with irrigation water, after deducting the production costs. This is same as the incremental value of the outputs generated from its use, which according to Young (1996) can be treated as the value of the resource, provided the market price of the produce reflects its true value that also takes into account the cost of production. Also, estimating the value of water realistically through such methods in non-market situation demands that the actual contribution of irrigation water supplies to generating farm surplus is segregated. Here, the total volume of water used by a farmer for producing all farm outputs and the net value of the product were estimated, and therefore, the value of water, being referred to, is the total value of water

$$Economic\ value\ of\ water\ in\ agriculture = \left[\sum(IWP_i * V_i) + \sum(IWP_j * V_j)\right] / \left[\sum V_i + \sum V_j\right]$$

Here, IWP_i is the net value product per unit of irrigation water used in crops "i" or the combined physical and economic productivity of irrigation water in crop production. IWP_j is the irrigation water productivity of milk production from cattle "j". V_i is the volume of water used to produce main product of crop "i" and V_j is the volume of water used for producing milk from cattle type "j" in the study location.

3.2.2 Physical Productivity of Water in Crop and Milk Production

The physical productivity (Kg/m^3) of the main product of crop "i" was estimated by taking the ratio of the yield (Kg/ha) of the crop grain (main product) of crop "i" and the volume of water allocated (m^3/ha) to the crop grain (vi), and that of the crop by-product (Kg/m^3) was estimated by taking the ratio of the yield (Kg/ha) of the byproduct of crop 'i' and the volume of water (m^3/ha.) allocated to the byproduct. The physical productivity of water in milk production (l/m^3) was estimated as the ratio of the daily average of the quantity of milk produced (litres) by a cow or buffalo in its entire life cycle (Pd) and the daily average of the volume of water (m^3) used by a cow or buffalo over its entire life cycle, both as direct consumption (drinking water) as well as embedded water in all cattle inputs produced using the region's local water resources. The volume of water embedded in cattle input (V_d) was estimated using the formula

$$V_d = \{(W_{df} / AE_{df}) + (W_{gf} / AE_{gf}) + (W_{cf} / AE_{cf}) + V_{dw}\}$$

W_{df}, W_{gf}, W_{cf} and V_{dw} are the daily average weight of the cattle inputs such as dry fodder, green fodder, cattle feed and drinking water, respectively. AE is the physical productivity of water and the subscripts df, gf and cf stand for dry fodder, green fodder and cattle feed.

3.2.3 Combined Physical and Economic Productivity of Water in Crop and Milk Production

The combined physical and economic productivity of water in crop and milk production were estimated using the same procedure as that employed for estimating physical productivity of water, but instead of the yield figures, the figures of net returns are used.

4. RESULTS AND DISCUSSIONS

4.1 Characteristic Features of the Study Areas

Various agro-ecological parameters of the study areas are presented in the Table 1. The major determining factors of agriculture like soil, temperature, rainfall, and relative humidity and irrigation facilities show a great deal of variation. In western Punjab the soil is saline with higher daily average temperature as comparison to eastern U.P. Again, the region has lower rainfall and relative humidity as compared to eastern U.P.

Western Punjab faces problems of inferior quality groundwater as compared to eastern U.P. But in eastern U.P., farmers are having more assured irrigation facility. These factors, in turn, influence the cropping pattern and the cropping intensity of the areas. Comparison of some of the socio-economic parameters of the study area clearly shows that the population pressure on land is higher in eastern U.P. (614 person/ sq. Km) as compared to western Punjab (350 persons/sq. Km).

The per capita holding size is lower in eastern U.P. (0.45 ha against 1.70 ha in western Punjab), meaning low investment capacity. The credit deposit ratio and the number of commercial banks per one lac population are higher in western Punjab (55) than that in eastern U.P. (22). Western Punjab faces labour shortage along with higher incidence of in-migration. Higher number of marketing co-operative societies in case of western Punjab (0.54 against 0.11 for lac population) facilitates better marketing of the produce and provides remunerative price to the farmers as compared to eastern U.P. Besides the above factors, the land consolidation and tractorisation helped in modernization and commercialization of agriculture in western Punjab (source: statistical abstract of Punjab and U.P.; Hira and Khera, 2000).

4.2 Cropping Pattern

In western Punjab, the cropping pattern is mainly determined by access to well water, as there are no major reliable sources of surface irrigation. Eastern U.P. experiences a warm and moist climate with adequate amount of water round the year, and has a good network of canals supported by various ground water-based lift irrigation schemes.

In western Punjab farmers mostly grow Kharif and Rabi crops. In water-rich eastern U.P., farmers take three crops in a year namely Kharif, Rabi and Zaid (summer). The major Kharif crops of western Punjab are cotton (54%), paddy (43%) and bajra, where as in U.P. the major Kharif crops are paddy (87%), brinjal (10%) and bajra (3%). In Rabi wheat accounts for 77.6%; grams 15.4% and jowar 3.7% of the cropped area in western Punjab, whereas in eastern U.P., wheat occupies 87%; cauliflower occupies 7.8% and potato occupies 5% of the area. During Zaid most the land in western Punjab remains fallow due to non-availability of water, where as in eastern U.P. farmers grow maize (33.6%); bitter gourd (17.4%) and okra-a vegetable crop (15.3%). There are major differences in crop yield as well owing to agro ecological factors and socioeconomic conditions such as availability of water and crop technologies and inputs. Paddy yields are far higher in western Punjab villages (18.6 quintal/acre) against eastern U.P. villages (13.18 quintal/acre). Most of the farmers in western Punjab keep some part of their land for producing fodder. In U.P., it was found that crops such as bajra and jowar are grown for dual purposes of fodder and grain production.

4.3 Irrigation Scenario

The percentage of irrigated land in the villages surveyed in western Punjab and eastern U.P. are 95% and 83% respectively. Farmers depend on both tube wells and canals for irrigation in both the areas. The share of other sources of irrigation like tank is very negligible.

In Bathinda district of western Punjab, the ground water and soils are alkaline in nature. But the depth to water table is only 45-50 ft. In the study villages, farmers use ground water and canal water in conjunction for applying to crops. Sometimes, they are blended before applying to the crops. Around 28% of the sample farmers solely depended on tube well for irrigation, where as 72% of the farmers depend both on tube well and canal for irrigation.

In eastern U.P. villages, both ground water and soils are free from salinity. The depth to water table is only 15-20 ft. But, due to poor financial conditions, instead of investing in wells, farmers rely on canal water. But the state government has undertaken several lift irrigation schemes which lift water either from canals or tube well. Around 41% of the sample farmers depended solely on tube well water and 59% depend on both tube-wells and canals. But, in eastern U.P., the canal network is more developed as compared to western Punjab.

While most of the farmers have their own irrigation sources (tube wells), some well-owning farmers also purchase water for some parcels of land. Out of the total number of farmers surveyed in the villages of Bathinda district (western Punjab) 47% irrigate their field with their own tube wells. The percentage of farmers who use only their own wells for irrigation is only 11.25 in the villages of Varanasi district. On the other hand, 11.25% and 75% of the farmers in western Punjab and eastern U.P., respectively, purchase water. The extent of water purchase is high in U.P. Because of the state-owned tube wells and low affordability of the farmers, one reason for this being the low average land holding size (three acres against 9.4 acres in western Punjab).

There are two different type of access to well water. Accordingly, the cost of irrigation water can be worked out. The first is for well owners, based on the costs actually incurred for irrigation. The second is for water buyers, based on the purchase price of water. Private cost has been calculated by taking all the fixed and variable costs involved.[2] Considering the life of the tube well as 20 years, the depreciation cost was worked out and added to the variable cost to derive the hourly cost of the irrigation.

For estimating the private costs, all costs were considered at the current market rate, including that for family labour. Table 2 presents the private costs and selling rate of water for both electric and diesel tube wells. The little variation in private cost of water between the study regions is due to the difference in cost of labour and pumping depths. Again the price of water (selling rate), which includes a profit margin for the water seller, is determined by the balance between demand for irrigation water in that market, and access to supplies. In U.P, government charges a flat rate of Rs. 20 per hour for irrigation services provided by the state-run tube well schemes, for all crops, which seem to be subsidized.

4.4 Livestock Rearing

Livestock rearing is common in both the regions because of its complementarity with farming. In western Punjab farmers keep cattle mostly to meet their domestic needs, where as in eastern U.P. cattle rearing has been taken by some farmers as an alternative source of income due to lack of adequate land resources. The sample livestock population of the study area is divided into three categories, viz., buffalo, indigenous cow and crossbred cow. In western Punjab the type of buffalo breed found was Murrah where as in U.P., Murrah as well as Bhadawari type of buffalo are reared. Generally Sahiwal, Red Sindhi and Jersey are the common crossbred cows found in both the regions. Comparison of livestock composition in the two locations shows that buffaloes account for 84% of the livestock holding in western Punjab, against 52.5% in eastern U.P. But, the percentage of crossbred cow to total cattle population was higher in eastern UP than western Punjab.

4.5 Cost of Cultivation and Returns from Different Crops

Table 3 and Table 4 provide weighted average of various costs incurred in crop production in western Punjab and eastern U.P. villages, respectively. The costs include: cost of irrigation; and cost of various other inputs such as seed, fertilizers, organic manure, pesticides and labour. The tables also show the output (main and byproducts) and the net economic return from crop production. The cost of inputs including irrigation varies across the two regions. The differences in crop yields observed between the regions, is due to a number of factors such as climate, levels of inputs, and selected crop technologies. Cotton is the most profitable crop (Rs. 15,630/acre) in western Punjab where as vegetables such as cauliflower (Rs. 13271/acre), potato (Rs.18186/

[2] Fixed costs included cost of land, cost of installation, cost of the motor, cost of digging the well or drilling the bore well, cost of pipe and digging of field channels. Variable cost included labour, electricity/diesel charges and other maintenance costs.

acre), brinjal (Rs. 13823/acre), okra (Rs. 8448/acre) and bitter gourd (Rs. 16099/acre) are the profitable crops in case of eastern U.P.

4.6 Cost and Returns of Livestock Rearing

The private returns from dairying in both the districts were estimated using estimates of average cost of cattle inputs and income gained from milk output per cattle unit. For estimation for input costs and outputs, the entire animal life cycle and different seasons was considered with four stages, viz., calving stage, pregnancy stage, lactating stage and dry stage. To get data on quantum of inputs, season-wise data on feed and fodder use of livestock were collected for different stages of animal life cycle. The estimated values of daily average feed and fodder consumption for milch animal are presented in Table 5. It shows that in eastern U.P. the amount of feed and fodder consumption level is generally higher than that in western Punjab. The reason is that the small and marginal farmers undertake dairy as an alternative source of livelihood in eastern U.P., owing to limited land resources. Based on the data collected on daily milk yields of animals and its variations with age, the average daily milk production was worked out for different livestock types. The estimated average daily milk production for the entire animal life cycle for western Punjab and eastern U.P. are 3.25 litres and 3.95 litres for buffaloes; 2.98 and 3.45 litres for indigenous cows, and 4.46 litres and 4.69 litres for cross bred cows, respectively. The costs of all inputs such as green fodder, dry fodder and concentrate were estimated on the basis of the actual cost of production or market price whichever is applicable. Table 6 presents the cost, revenue and the net return per day per animal.

4.7 Water Productivity in Crop and Milk Production

Water productivity in crop production (Rs./m^3) was estimated for all the crops grown in both the regions and the mean values are presented in Table 7. In western Punjab, cotton has highest water productivity (Rs. 40.4/m^3), whereas in eastern U.P., brinjal has highest water productivity. The figures also show that many crops grown in eastern U.P. (brinjal, vegetables such as potato, bitter gourd, okhra and cauliflower), have higher water productivity as compared to the crops grown in western Punjab such as jowar and gram grown in western Punjab. Wheat in eastern U.P. has slightly higher water productivity than that for the same crop in Punjab. But, paddy in western Punjab has higher water productivity as compared to that in eastern U.P. Over and above, cotton, which has high water productivity, is not grown in eastern U.P.

Nevertheless, the overall net water productivity depends on how much area is dedicated to each crop and the water productivity of that particular crop. As a matter of fact, farmers in western Punjab allocate a significantly large share of their land to Kharif cotton, whereas farmers in eastern UP allocate a small percentage of their land under crops that are highly water efficient, mostly in this case, vegetables.

In the case of milk production, water productivity figures are extremely higher in case of western Punjab (see Table 8). In case of buffaloes, water productivity in milk production was Rs.7.06/m^3 in western Punjab against Rs. 2.62/m^3 in eastern U.P. In the case of indigenous cows, water productivity was Rs. 16.41/m^3 for western Punjab against Rs. 2.5/m^3 for eastern U.P. The higher water productivity was due to higher values of physical productivity for green and dry fodder, and the much smaller quantum of green and dry fodder used for feeding the livestock, which reduces the value of denominator, i.e., the volume of water used for producing the milk (by reducing the water equivalent of all the green and dry fodder used for feeding the cattle) in the estimation of water productivity, though the net return from milk production are higher for all the livestock types in eastern U.P. As a matter of fact, physical productivity of water in dry fodder in western Punjab is 70.48 Kg/m^3 against 29.32 Kg/m^3 to 46.75 kg/m^3 in eastern U.P. Similar trend was found for green fodder.

4.8 Economic Surplus from Irrigated Agriculture

Based on the values of total economic surplus generated from agriculture available for individual farmers, an attempt was made to know the response of the economic surplus to the volume of water used and the acreage of land under cultivation in both the water scarce and water surplus areas. For this different regression models such as linear, quadratic, exponential, logarithmic and power functions were run. Among these six models the best fit model was selected on the basis of higher R^2 value and was used for the further estimation of economic surplus.

4.8.1 How the economic surplus from agriculture changes with volume of water diverted?

For this, regressions were run taking economic surplus for individual farmers from each location as the dependent variable and volume of water diverted by the farmers as the independent variable.

Six regression models were run for establishing the relationship between "economic surplus" and "volumetric water application", and a linear function having an R^2 value of 0.582 was chosen for further study (Y = 61790.6 + 12.59 X). Hence, linear function is the best fit line describing the response of economic surplus to volume of water used in western Punjab. While general economic theory suggests diminishing marginal returns with increasing level of use of a resource (here water), we must keep in mind that the increasing volumetric use of water occurs with proportional increase in the use of land and therefore what appears as marginal surplus here is not actually marginal for a unit of land, but increase in total farm surplus with some changes in farm size, and consequent change in water use. Further, the relatively scarcity of water for large farm holders is more than that of small holders, again forcing the farmers to increase the productivity of their water.

Similar regression results were obtained in case of eastern U.P. Among them, a linear regression model having an R^2 value of 0.794 was found to be the best fit (Y = 22875.1 + 8.8620X). Figure 2 and Figure 3 show how the economic surplus generated from agriculture vary with changing water diversion for agriculture among the sample farmers in western Punjab and eastern U.P., respectively.

To compare and contrast the trend in economic surplus generated from every unit of water diverted for irrigation between the two regions, the values of economic surpluses were estimated for each farmer by imputing values for "volume of irrigation water diverted" in the best fit regression model. The trend lines obtained for both the regions are presented in Figure 5. From Figure 4, it is clear that the slope of the trend line for western Punjab is steeper than that of eastern U.P. The estimated value of average increment in economic surplus per cubic metre of water used are Rs 12.59 and Rs 8.86 for western Punjab (water scarce) and eastern U.P. (water surplus) respectively, indicating that in western Punjab, water is used more efficiently for crop production in rupee terms, owing to allocation of larger share of land under low water-intensive and high-valued crops such as cotton and gram. It further implies that in western Punjab the criticality of applied irrigation water in generating economic surplus from agriculture is more as compared to the eastern U.P.

4.8.2 How Economic Surplus from Agriculture Responds to Increasing Land Use?

For this, regression was run taking economic surplus as the dependent variable, and acreage of land used in agriculture as the independent variable. From the six regression models run, power function having an R square value of 0.651 for western Punjab ($Y = 32846.8\ X^{0.6806}$), and R^2 value of 0.519 for eastern U.P ($Y = 33128{*}\ X^{0.7092}$), were selected as the best fit models. The reason for choosing this function is that ideally, the net economic surplus from agriculture production should become zero when the land availability becomes zero, and that happens only in the case of the power functions. Figure 5 and Figure 6 show trends in the economic surplus generated from agriculture vary with changing levels of land use among the sample farmers in western Punjab and eastern U.P., respectively.

But, it can be seen that with increase in area under cultivation, the increase in economic surplus with a marginal increase in land size is smaller at higher holding sizes. This could be explained by the lower intensity of use of land by large farmers, due to several constraints, such as labour, water (at least in western Punjab), and farm inputs which require capital.

To examine the differences in the trend in economic surplus generated from every acre of land used in agriculture, estimated values of economic surpluses were obtained for the power function. The trend lines obtained for both the regions are presented in the Figure 7. From Figure 6, it is clear that the slope of the line for eastern U.P. is steeper than that of western Punjab. The estimated values of average increment in economic surplus per acre of land used are Rs. 10774 and Rs. 9528 for eastern U.P. and western Punjab, respectively.

This means every additional area of land put to cultivation gives higher returns in eastern U.P. as compared to western Punjab, perhaps due to the fact that farmers allocate more area under high-valued crops (in terms of returns per unit of land) in eastern U.P. This implies that the criticality land in generating economic surplus is more in eastern U.P. as compared to western Punjab.

4.9 Economic Value of Water in Agriculture

The estimation of economic value of water use in agriculture considers the average incremental value of the economic output generated with every unit volume (m^3) of water diverted/used in agriculture. It is important to remember here that the volume of water diverted at the level of individual farmer is not the same as the amount of water directly used by the farmer for irrigating the crops and feeding the livestock. It includes all the water embedded in the feed and fodder used for livestock, which might be available from the farmers' own farm or through purchase, but excludes the water embedded in the fodder etc. not used by the farmer. The economic value of water from agriculture is higher in western Punjab (Rs.14.852 per m^3 of water) as compared to eastern U.P. (Rs.11 per m^3 of water). This means that a unit volume of water used in agriculture generates more economic value in western Punjab than in eastern U.P.

4.10 Livelihood Impact of Irrigated Agriculture

Analyzing livelihood impacts of irrigation is important because many believe that sustaining irrigated agriculture is not a wise decision for naturally water-scarce regions from the point of view of ecological sustainability. Their point of contention is that such regions had evolved livelihood systems that are less dependent on human-managed water, and need for water transfers is not very compelling.

In Punjab, farmers have access to water from canals. Reliability of canal water is high. The power supply is good and comes with heavy subsidy. The diverted water is used to maximize area under irrigated production with more area under wealth-creating water efficient crops. Larger size of holding and land consolidation makes mechanized farming operations easy. The dry fodder in the form of byproducts of cropping are fed to a high cattle population instead of producing fodder in the farms. Thus, farmers resort to comparatively low input-based, but efficient production methods. Larger quantities of biomass and mechanization of farming allows farmers to keep good number of livestock for dairying.

On the contrary, water-richness enables farmers to keep the land use intensity at high levels in the land-scarce eastern U.P. with cultivation of water-intensive vegetable and paddy. Availability of green and dry fodder throughout the year from irrigated crops such as paddy, wheat bajra and maize enable them take up input-intensive dairy farming. But since farmers are engaged in crop cultivation in all seasons, the cattle-holding is kept low as livestock keeping is labour intensive. The landless get to work in farms throughout the year for key agricultural operations as wage labourers. It is to be noted here that the level of mechanization of farming is low due to lack of land consolidation, which inhibits the use of tractors.

In western Punjab, higher per capita land under irrigated crops and livestock holding demands more labour throughout the year. Labour has to be brought in from Bihar in view of the large labour shortage within the region. Though the labour absorption in main agricultural crops had declined over the past decade due to over-mechanization in Punjab with extensive use of combine harvesters for harvesting and threshing, and weedicides (Sidhu and Singh, 2004: pp2), mechanization generates its own micro economies in rural areas with creation of new employment opportunities for operation of farm equipments and their maintenance. Analysis shows that the livelihood index based on irrigated agriculture in western Punjab (0.928) is higher than eastern U.P. (0.878). This implies that irrigation plays a greater role in the earnings as well as day to day life of the people of western Punjab as compared to eastern U.P. (Table 9).

Table 9 also shows that the average household earnings from crop production and dairying are much higher in western Punjab when compared to eastern U.P. Also other sources of earnings directly or indirectly dependent on irrigation are higher in western Punjab. The major reason of larger impact of irrigation in western Punjab is the greater availability of land resources for cultivation, while farmers manage their cropping with less water intensive and highly water efficient crops such as gram and cotton. It is important to remember that though average increase in farm surplus from every additional acre of land used is lower in western Punjab as compared to eastern U.P., the average net returns are higher there due to larger land area under cultivation. On the other hand, in eastern U.P., due to low per capita arable land, the surplus water resources could not be put to beneficial use. This forces the farmers to take to non-farm enterprises/activities. Also irrigated agriculture supports livestock rearing by supplying adequate amount of feed and fodder. This not only reduces the risk and uncertainty in farming but also improves the disposable income of the farmers.

5. MAJOR FINDINGS

The findings emerging from the analyses can be summarized into those pertaining to: water productivity in crop and dairy production; incremental economic surplus with a unit increase in land and water use; the economic value of water in farming; and the livelihood impact of irrigation. As regards water productivity, many vegetables grown in eastern U.P. namely okhra, potato, bitter gourd and brinjal have higher water productivity, where as only two of the crops grown in western Punjab, namely, cotton and gram have high water productivity. However, Punjab farmers allocate a significantly large portion of their land to cotton and gram unlike farmers in eastern U.P. who allocate a small portion of their land for vegetable growing. As regards dairying, farmers in western Punjab get higher water productivity compared to eastern U.P. Also, 63% of the farmers surveyed in western Punjab were found to be keeping buffaloes against 36% in eastern U.P.

In terms of economic surplus generated against the volume of water used in irrigated agriculture, water-scare and water-rich regions show different trajectories. The estimated value of average marginal increase in economic surplus per metre cube of water used are Rs. 12.59 and Rs.8.86 for western Punjab and eastern U.P., respectively. This implies that in western Punjab the criticality of irrigation water in generating farm surplus is more as compared to the eastern U.P.

The marginal increment in the economic surplus generated per acre of land use is higher in eastern U.P. as compared to western Punjab, though, as the model suggests, the incremental return would decline at higher levels of land use in both the regions. This implies that in eastern U.P., farmers make efforts to maximize the return from every unit of land, and highest consideration is given to the productivity of crops chosen per unit of land.

The economic value of water in agriculture is higher in water-scarce western Punjab as compared to water-rich eastern U.P. owing to judicious allocation of water. Though certain crops grown in eastern U.P. give very high returns per unit of water used, a larger share of the land is allocated to crops such as paddy and wheat which have low water productivity. Over and above, farmers in western Punjab secures higher water productivity in dairying as compared to their counterparts, and they do it much more intensively, and this component of farming has slightly higher water productivity as compared to paddy and wheat if we consider different types of livestock. Hence, the incremental value realized from every unit of water in western Punjab over eastern U.P. is Rs. 3.65/m^3.

The livelihood impact of irrigated agriculture assessed in terms of a livelihood index based on irrigated agriculture in higher in western Punjab (0.928) than eastern U.P. (0.878). This implies that irrigation plays a greater role in income earnings as well as day to day life of the people of western Punjab as compared to eastern U.P. The major reason of larger impact of irrigation in western Punjab is the greater availability of land resources, which enable them to put all the available water resources to productive use, and keep larger number of livestock. On the other hand, in eastern U.P. given the constraint of limited arable land, surplus water resources cannot be put to economically beneficial uses. This forces the people to take other sources of non-farm enterprises/activities as their mainstay of life.

The findings discussed above provide strong empirical support for the economic and social argument behind transferring water from water surplus regions to water-deficit regions. As seen from the analyses, water transfer would not only increase the effective utilization of water with the removal of land constraint in expanding crop production, but would also boost the economic surplus from agriculture, raise the overall productivity and value of water and create better impact on the livelihoods of farmers. The higher economic value of water realized in deficit regions would demand more than the real "volumetric surplus" available within the water-rich region to many water-scarce region that exist in the country, that are also agriculturally prosperous, if cost of transfer of water is less than the incremental economic value realized and mechanisms exist for compensating for the economic and livelihood losses suffered by the water-rich region.

6. CONCLUSIONS AND POLICY RECOMMENDATIONS

The most important findings from the key analysis presented in the paper support the hypotheses set out in the beginning that the impact of irrigation water on generation of economic surplus is much higher in a water-scarce region, when compared to a water-rich region; and impact of land in generating economic surplus in "water-surplus, land-scarce" region is more when compared to a "water-scarce, land-rich" region; higher economic value is realized in the use of irrigation water in a water-scarce region as compared to a water-rich region; and it creates greater impacts on livelihoods in water-scarce regions as compared to water-rich regions. That said, the following points also deserve merit. For estimating the economic value of water, the productivity of applied water was considered for different crops and dairying. The actual water depleted by the crop including fodder could be much higher than the applied water, given the fact that there could be significant amount of soil moisture depletion during the cropping seasons of kharif and winter. But the soil moisture component in the total water used by the crops in a unit of crop land would be higher in a rainfall rich region like eastern U.P., than a scanty rainfall area like western Punjab. Hence, the over-estimation possible due to the use of "applied water" instead of evapo-transpirative use as the denominator in estimating crop water productivity function would be of a much higher order in eastern U.P. than in western Punjab. Hence, it could be argued that the incremental value of water in a water-scarce region would be much higher than what is estimated using the current methodology.

The contribution of modern agricultural technologies alone would be less effective in generating economic surplus in areas facing water scarcity. Higher economic surplus would be generated in those areas with the allocation of more water for agriculture than through any other measure. This is because, in water-scarce areas farmers are already growing crops that are inherently highly water-efficient, choosing right crop technologies, and economizing on the use of all other inputs. This is in spite of the fact that the scarcity value of the resource is not reflected in the prices farmers pay for canal water or the prices electricity they use for pumping groundwater. Higher economic surplus can also be generated in land-scarce regions by putting every unit of land under cultivation into crops that are "high-valued", adopting modern crop technologies, and increasing the intensity of cropping.

Hence, in the ultimate analysis, it appears that the water-scarce regions would be able to boost agricultural production only with increased allocation of water for irrigation. But, this can cause many negative environmental effects if such regions start using its own internal water resources for boosting agricultural production. There are increasing evidences to suggest that these regions have already used up more than what is ecologically sustainable. Many agriculturally prosperous regions in India, especially in the Peninsular and western parts, that are naturally water scarce, are hit by groundwater depletion due to over-draft for irrigation. This has put a break on the agricultural growth in these regions. A recent study by Aggarwal and others (2005) showed that water availability is a major constraint in ensuring agricultural growth and sustained food production even in the relatively water rich Haryana (Aggarwal et al., 2001).

As analysis presented in this paper suggests, there is incremental economic value realized from the use of every cubic metre of water in water-scarce and land-rich region as compared to the use of the same quantum of water in a water-rich, but land-scarce region. This has major policy implications for the allocation and use of water in agriculture across regions that are characterized by mismatch endowment of land and water resources. Many water-rich regions, be it eastern UP or Bihar are at a natural disadvantage of being land-poor. In Bihar, the per capita cultivable land is less than 0.092 ha (Kumar, 2003), while cropping intensities are already high (GoI, 1999). The total factor productivity growth in this region, which falls partly in hot subtropical climate, and partly in tropical cool winter climate, has been on the decline over three decades from 1958-1987

(Evenson et al., 1999: Table 22) in spite of reasonably high irrigation intensities. At the same time, the TFP growth in Punjab, Haryana and western UP falling in “subtropical monsoon” climate was on the rise (Evenson et al., 1999: Table 22).

As has already been noted in the case of Varanasi, farmers take three crops, viz., rain-fed Kharif, and irrigated winter and summer crops. Thus the ability of these regions to enhance crop yields or agricultural productivity per unit of arable land through increased allocation of water is extremely limited. This combined with low TFP growth keeps the value of irrigation water low. While transfer of surplus water from water-rich regions to water scarce regions does not need a better economic rationale than increasing the productive use of the un-utilized water, the notable fact is that such transfers for agriculture lead to realization of greater economic value. The fact that there is a significant incremental value realized from water transfer might demand reallocation of more than the real “volumetric surplus” available within the water surplus region to a water-scarce region. But such transfers have to satisfy two conditions. First: the incremental value realized exceeds the cost of such transfer. Second: mechanisms exist for compensating for the economic and livelihood losses suffered by the water-rich region.

Finally, there are complex ecological, hydrological and engineering considerations involved in water transfer projects other than those which are economic. In the Indian context, regional water transfer is also a major political issue. The proposals for water transfer are under severe scrutiny not only on political grounds (Goel, 2005), but also on economic (Bandyopadhyay and Perveen, 2003; Goel, 2005), ecological (Bandyopadhyay and Perveen, 2003; Khalequzzaman et al., undated), environmental (Vaidyanathan, 2003a), hydrologic (Khalequzzaman et al., undated), financial (Rath, 2003), and scientific grounds. Often, the very methodology for assessing “water surplus” and “water-deficit” nature of some basins has been contested by scholars (Vaidyanathan, 2003b). But healthy debates of such issues are often plagued by lack of sufficient empirical, scientific data on many of these dimensions of water transfers, including those on economics. This is a major hindrance to the process of facilitating informed and scientific debate on regional water transfers, often leading to situations where political interests over-ride other regional interests. So from that perspective, the present analysis would be useful for academicians, policy makers and practitioners to have an informed debate.

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Table 1: Agro-ecological Parameters of the Study Areas

Sr. No.	Parameters	Punjab (Bathinda)	Uttar Pradesh (Varanasi)
1.	Climate	Hot and semi arid	Dry sub-humid to moist sub-humid
2.	Soil	Black soil with alkalinity	Alluvial soil with free from salts
3.	Temperature	Max: 42-45 ^{0}C Min: 2-6 ^{0}C	Max. 38-40 ^{0}C Min. 4-6 ^{0}C
4.	Rainfall	360mm	1025 mm
5.	Humidity	80%	90-95%
6.	Major crops grown*	Rice, Wheat, Cotton, Pulses and Fodder	Rice, Wheat, Vegetables and Pulses
7.	Cropping intensity*	200%	250%-300%
8.	Sources of irrigation	Tube well (59.7%), canal (40.1%)	Tube well (85%), canal (12.5%)
9.	Percentage of irrigated land	95	83

Sources: Statistical abstracts of Punjab and Uttar Pradesh
* Indicates the primary data.

Table 2: Private Cost and Actual Selling Price for Well Irrigation in Sample Villages

District	Private Tube well with				Government Tube well with Electric Pump
	Electric Pump		Diesel Pump		
	Private Cost/hour	Selling Rate/hour	Private Cost/hour	Selling Rate/hour	
Bathinda	18.51	40	43.6	70	-
Varanasi	15.5	20	40.5	60	20

Source: Authors' own estimates based on analysis of sample survey data

Table 3: Cost of Cultivation and Net Economic Return per acre from different crops of Villages Kotsameer and Tungwala of Bhatinda District of Western Punjab

Season	Crops (Rs)	Irrigation cost (Rs)	Total cost (Rs)	OUTPUT				Gross output (Rs)	Net Economic Surplus (Rs/Acre)
				Main product		By product			
				Q	R	Q	R		
Kharif	Cotton	1150	10678	13.3	1833	17.5	100	26241	15630
	Rice	1280	7645	18.6	596	12.5	100	11720	4075
	Fodder Bajra	300	1883	41.3	50	4.8	400	3985	2102
Rabi	Wheat	750	6158	12.3	717	11	50	9429	3271
	Fodder Jowar	250	1539	50	50	5.4	362	4829	2907
	Gram	80	1488	1.9	2753	-	-	5251	3764

Q=Quantity in quintal per acre, R=Rate in Rupees per quintal and V=Value in rupees

Table 4: Cost of Cultivation and Net Returns per acre from different Crops of Bachhao & Dindaspur villages of Varanasi district of Eastern Uttar Pradesh

Season	Crops (Rs)	Irrigation cost (Rs)	Total cost (Rs)	OUTPUT				Gross output (Rs)	Net Economic Surplus (Rs/Acre)
				Main product		By product			
				Q	R	Q	R		
Kharif	Paddy	450	5483	13.2	567	12.2	50	8088	3164
	Fodder Bajra	350	1680	67	50	4.4	250	4450	2894
Rabi	Brinjal	803	6407	40.3	502	-	-	20230	13823
	Wheat	514	4700	12.4	658	17	100	9445	4921
	Potato	981	10714	64.8	446	-	-	28900	18186
	Cauliflower	1035	14180	60.2	456	-	-	27451	13271
Zaid	Bitter Gourd	948	7621	40	593	-	-	23720	16099
	Okra	827	6638	38	397	-	-	15086	8448
	Maize	286	3566	46.7	510	4.1	60	7294	3728

Q=Quantity in quintal per acre R=Rate in Rupees per quintal

Table 5: Daily Average Feed & Fodder Consumption per Milch Animal

Feed/Fodder	Animal Type	Bathinda	Varanasi
Green Fodder(Kg/day)	Buffalo	19.46	23.2
	Indigenous Cow	12.92	16.35
	Crossbred Cow	14.41	24.37
Dry Fodder(Kg/day)	Buffalo	7.94	6.68
	Indigenous Cow	5.07	3.82
	Crossbred Cow	4.33	4.62
Concentrate(Kg/day)	Buffalo	2.28	3.2
	Indigenous Cow	1.2	2
	Crossbred Cow	1.4	2.75
Drinking Water(Litres/day)	Buffalo	55.8	62.5
	Indigenous Cow	52.6	61.8
	Crossbred Cow	60.2	66.4

*Green fodder, Dry Fodder & Concentrates are in Kg/day/animal. Water is in litres

Table 6: Net Return from Livestock (per Milch Animal per Day)

Study Areas	Gross Income (Rs)			Expenses (Rs)			Net Return (Rs)		
	B	C	CB	B	C	CB	B	C	CB
Bathinda	38.94	33.4	48.5	26.4	16.5	27.3	12.5	16.9	21.2
Varanasi	45.8	38.4	56.2	30.1	20.2	32.3	15.8	18.2	24.5

* B: Buffalo; C: Indigenous Cow; CB: Cross bred Cow

Table 7: Water Productivity of Different Crops in Western Punjab and Eastern Uttar Pradesh

Name of Season	Name of Crop	Water Productivity (Rs/m³)	
		Wastern Punjab	Eastern Uttar Pradesh
Kharif	Cotton	40.40	
	Kharif Paddy	7.75	4.51
	Fodder Bajra	2.93	4.78
	Brinjal		45.58
Rabi	Wheat	8.05	9.11
	Fodder Jowar	6.32	
	Gram	24.48	
	Potato		33.02
	Cauliflower		28.97
Zaid	Bitter Gourd		30.14
	Okra		30.11
	Maize		8.91

Source: Sample Survey
* Figures in the bracket indicate the % of the total cultivated area

Table 8: Water Productivity in Milk Production for Different Types of Livestock in Western Punjab and Eastern Uttar Pradesh

	Name of Livestock	Water Productivity in Milk Production (Rs/m³)	
		Western Punjab	Eastern Uttar Pradesh
1	Buffalo	7.06 (50)	2.62 (29)
2	Cross breed Cow	17.44 (5)	1.28 (3)
3	Indigenous Cow	16.41 (13)	2.52 (17)

Note: the figures in parenthesis shows the number of farmers who rear the livestock

Table 9: Livelihood Index of Irrigated Agriculture in the two Regions

Study areas	Annual household income from various sources (Rs)								Livelihood Index (LI)
	Agriculture	Dairy	Selling Water	Working in others farm	NFWL (Non Farm Wage Labour)	Services	Petty trade	Any other	
Bathinda	257845	15364	3566	1450	826	12907	4721	3560	0.92
Varanasi	100242	53514	5038	1000	1858.7	17940	6673	4893	0.87

* Figures in the table are in Rs; LI is the livelihood index.

Figure 2: Response of Economic Surplus to Irrigation Water in Western Punjab

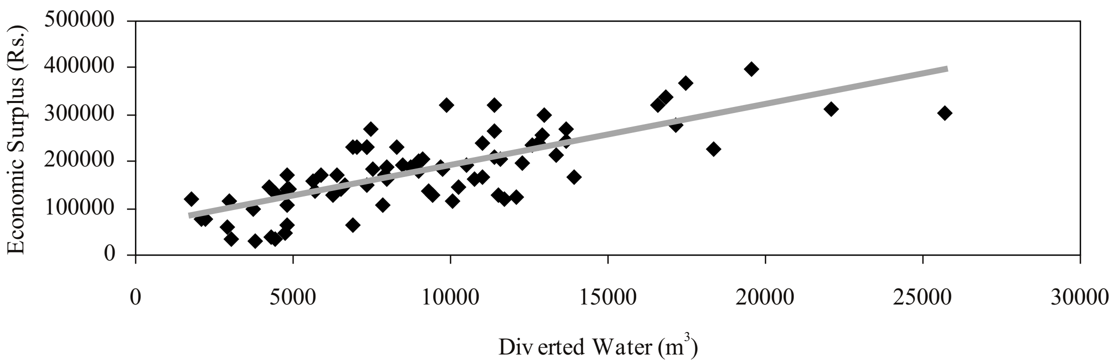


Figure 3: Diverted Water Vs. Economic Surplus in Estern Uttar Pradesh

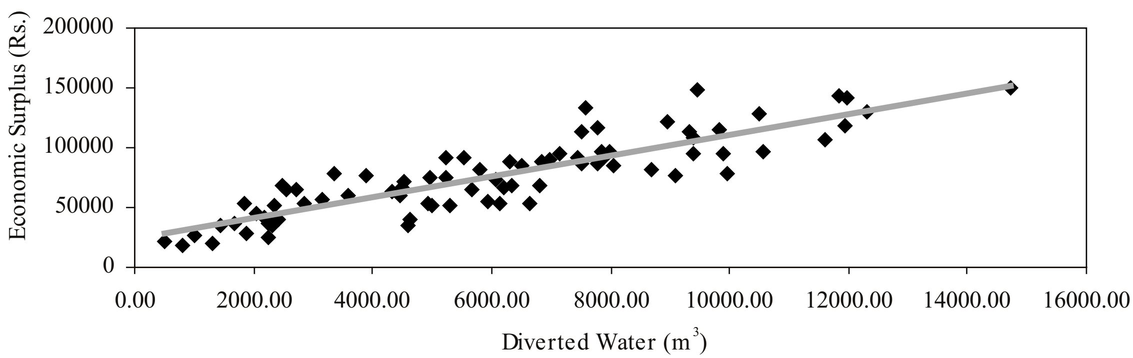


Figure 4: Estimated Values of Economic Surplus for Different Levels of Irrigation in the Two Regions

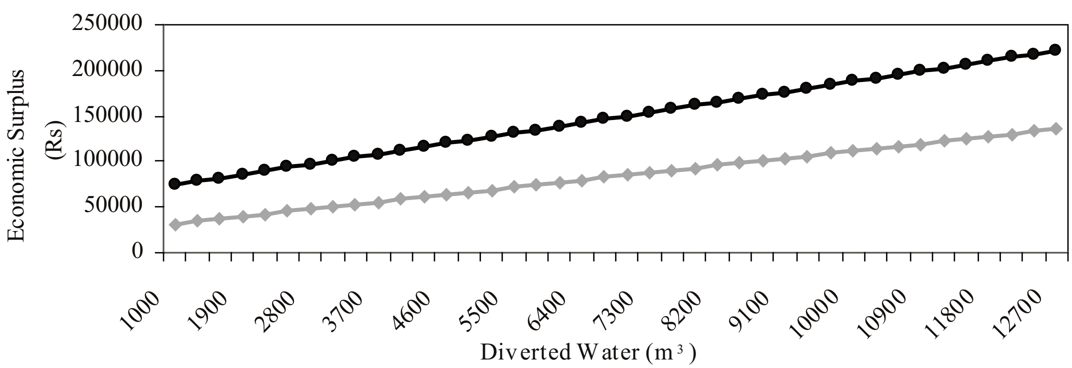


Figure 5: Land use vs Economic Surplus in Western Punjab

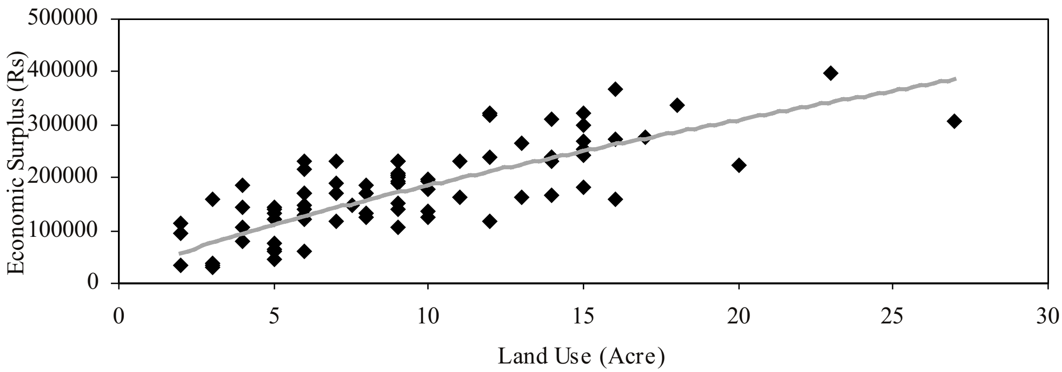


Figure 6: Land use vs Economic Surplus in Estern Uttar Pradesh

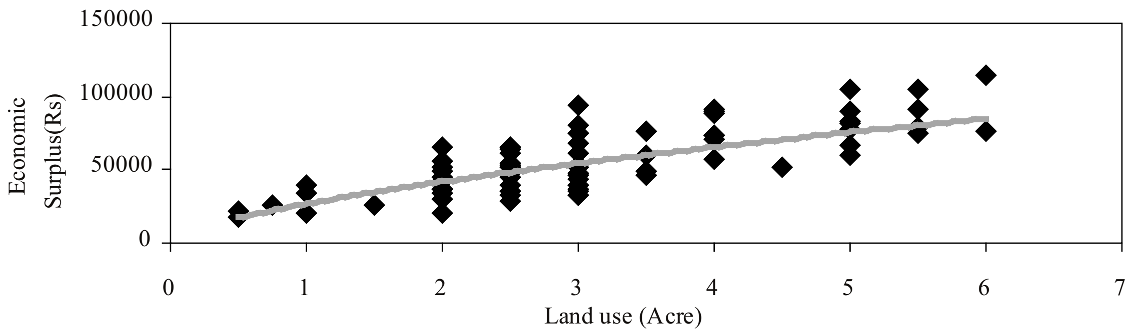
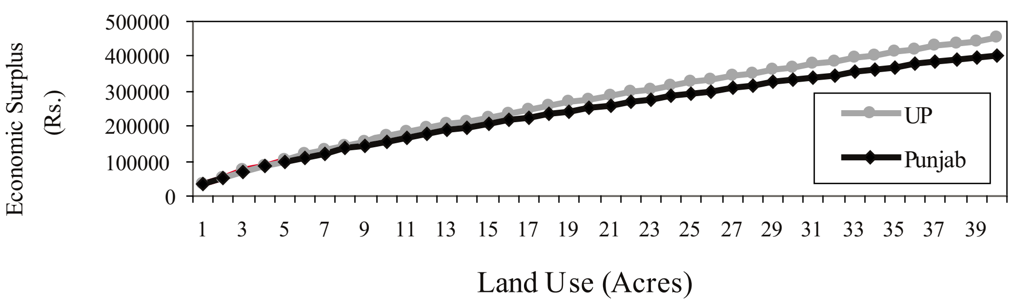


Figure 7: Estimated Values of Economic Surplus for Different Levels of Land use in the Two Regions



IN THE MIDST OF THE LARGE DAM CONTROVERSY: OBJECTIVES, CRITERIA FOR ASSESSING LARGE WATER STORAGES IN THE DEVELOPING WORLD

Zankhana Shah[1] and M. Dinesh Kumar[2]

Abstract

By some estimates, there are 47,000 large dams in the world. India had 4,635 "large dams" as per ICOLD definition. Only technical criteria such as height and storage volume are used for this classification. Large dam projects increasingly face opposition from the environmental lobby from around the world for their negative social and environmental impacts, while their role in development was largely ignored. There are two issues being investigated in this paper. First: what should be the best criterion for classifying dams in a way that they truly reflect the engineering, social and environmental challenges posed by dams? Second: what new objectives and criteria, and variables need to be incorporated in the cost-benefit analysis of dams so as to make it comprehensive?

The analysis based on data of 13,631 large dams across the world shows that the height of the dam does not have any bearing on the volume of water stored, a strong indicator of the safety hazard posed by dams. Further analysis using data of 9,878 large dams shows that the height has no bearing on the area of land submerged, again an indicator of the negative social and environmental effects. The regression using data on 156 large dams across India shows that normative relationship exists between the area of submergence and numbers of people displaced by dams. Therefore, a combination of criteria such as height, storage volume and the area under submergence needs to be considered for assessing the negative social and environmental consequences of dams. Further analysis shows that the available estimates of dam displacement could be "gross over-estimates" in the order of magnitude of eight.

By illustrating the significant positive impact of large reservoir project on stabilizing national food prices, contributing clean energy, improving recharge to groundwater in semi arid and arid regions, and ensuring social security, the authors argue that economic viability of these projects should be assessed in relation these positive externalities they create. The authors estimate the benefit due to lower food prices attributed to large dams in India as Rs. 42.90 billion annually. At the same time, the negative externality effects of large dams should be built in the cost of dam projects to increase the accountability on the part of water development agencies in less developed countries, towards the communities, which are adversely affected by large dams.

1. INTRODUCTION

The current crisis and urgency of meeting the food water requirements of the burgeoning world population has further aggravated the debate on 'Dams or No Dams'. The greatest opposition which dams builders from around the world face is on environmental (see for instance, D'Souza, 2002 and McCully, 1996), financial, economic, and human rights front (see for instance Dharmadhikary, 2005; Fisher, 2001 and McCully, 1996), whereas the proponents of large dam push their agenda on the grounds of enhanced food and drinking water security, hydropower generation, and flood control (see Braga et al., 1998; Verghese, 2001; Vyas, 2001).

In the later half of 19th century, the move of large dam construction started in the developed countries holding technical know-how and financial resources and later spread to the developing countries. By 1975, when the United States, Canada and the Western European countries had essentially completed their programme of construction of large dams (Biswas and Tortajada, 2001), majority of the developing countries were either

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on their peak of dam construction or were just starting to divert their financial resources towards it. As per the data offered by International Commission on Large Dams (ICOLD) in World Register of Large Dams (2003), at the end of the 20th century, China and India kept the United States far behind in total numbers of dams constructed.

According to the data, there are more than 47,000 large dams constructed all over the world and another 1700 dams were under construction. But, the statistics of large dams presented by ICOLD is based on the widely accepted and uniform definition, which considers dam height as the sole criterion. While it is widely quoted that Asia has largest number of large dams in the world, it is silent on how much water is being stored in these dams, and how much area they submerge. According to a World Commission of Dams (WCD) database, dated 2000, China has the largest number of large dams, followed by rest of Asia, immediately followed by North and Central America. But, global comparisons provided by ICOLD register on large dams dated 1998 on the basis of the volume of storage created by large dams brings out a totally different picture. Nearly 29% of the total storage from large dams (6,464 km^3) is in North America, followed by South America (16%). China (10%) is only 4th in terms of volume of storage. Lack of comprehensive criteria for defining "large dams" makes such statistics misleading. But, the criteria of evaluating dam performance should change with the objectives.

Limitations are also inherent in the methods used for benefit-cost analysis. The methods identify only those costs and benefits which can be assigned a market value. Like many social and environment costs are not considered due to limitations in assigning them economic value, many real benefits are underestimated or un-envisaged at the time of project planning. For example, a water resource planning exercise done in the Indian state of Gujarat has checked the possibilities and recommended the use of water from Sardar Sarovar Project (SSP) for recharge in the regional phreatic aquifers and riverbeds (GOG, 1996 as cited in Ranade and Kumar, 2004). However, this was never considered in the planning of SSP. Moreover, unprecedented costs and benefits are never considered, as revision of the cost-benefit analysis after many years of project completion is not a general practice (see Biswas and Tortajada, 2001).

2. THE BASIC PREMISE

The authors take the position that the criteria used for defining large dams are not true reflections of the socio-economic and environmental concerns prevailing in developing economies, and therefore are not relevant. Food security and water security are extremely important concerns for these economies; submergence of productive land is a big concern, given the poor access to arable land; but not so much the engineering challenges posed by dam height.

The definitions based on such poor criteria often invite unprecedented reactions from environmental lobby worldwide to subject dam building proposal to stringent environmental scrutiny, and to revise benefit–cost (BC) calculations to incorporate the social and environmental costs. The authors argue that while there has been a lot of advancement in the recent past in the BC calculations of dam projects, the methodologies still fail to capture the social and environmental benefits that are likely to be accrued in future. Some such benefits are drinking water security, groundwater recharge, reduced cost of energy for pumping and so on. Often, dam builders inflate certain components of the benefits and under-estimate certain cost components, to pass the scrutiny of national and international environmental agencies. In the process, little attention has been paid to look at alternative ways of designing dams.

3. OBJECTIVES OF THE STUDY

The major objectives of this paper are as follows: 1] to discuss the criteria used by various national and international agencies in defining large dams, and identify their limitations in the context of developing countries; 2] to evolve meaningful criteria for defining large storages, which adequately integrates the growing social and environmental concerns associated with dam building; and, 3] identify the gaps in the current cost-benefit calculations, and set out new objectives and criteria for evaluating impacts of large dams in developing economies.

4. LARGE DAMS: HISTORY, DEFINITIONS AND RECENT TRENDS

4.1 Definitions of Large Dams

Numerous definitions are available of large dams, each serving different purpose and objectives, and thus, based on different criteria. The U.S. Fish and Wild Life Service, under its Dam Safety Programme has adopted following criteria for defining dams as small, intermediate and large dams (www.fws.gov). According to them, small dams are structures that are less than 40 ft high or that impound less than 1,000 acre-ft of water; intermediate dams are structures that are 40 to 100 ft high or that impound 1,000 to 50,000 acre-ft of water; and large dams are structures that are more than 100 ft high or that impound more than 50,000 acre-ft of water.

The Central Water Commission (CWC), India in its guidelines for safety inspection has given different definitions of dams on the basis of means of classification such as size, gross storage and hydraulic head (CWC, 1987). Against this, the Planning Commission of India has categorised all reservoirs as large, medium and small irrigation schemes on the basis of the area irrigated. According to the Planning Commission a large irrigation project is the one designed for irrigating more than 10000 hectares (ha) of land.

The most recent, yet widely accepted definition of large dams is given by the ICOLD. The ICOLD defines a large dam as one having a wall higher than 15m from the lowest general foundation to the crest. However, even dams between 10-15m in height could be classified as large dams if they satisfy at least any one of the following criteria (Rangachari et al., 2000). First: the crest length is more than 500 m. Second: the reservoir capacity is more than one MCM. Third: the maximum flood discharge is more than 2000 m^3/s. Forth: the dam has complicated foundation problems. Fifth: unusual design. The ICOLD definition has dam height as the major criterion for defining a large dam. Since this definition has been widely accepted, all world dams are evaluated on the basis of this definition.

4.2 A brief history of dam construction, ideologies, and investments on dams in India

Right up to the 1970s, large dams were seen as the synonym for development and economic progress. Dam-building reached its peak between 1970 and 1980, when an average of two to three new large dams per day were commissioned. Table 1 provides statistics of large dams in India based on ICOLD data.

Table 1: Large Dams in India

Sr. No.	Period	Number of Large Dams		
		15m and more high	10 to 14m high*	Total
1.	Up to 1900	32	13	45
2.	1901-1947	135	127	262
3.	1948-1970	489	254	743
4.	1971-1990	1564	1066	2630
5.	1991-2001	265	82	347
6.	Data not available	434	174	608
7.	Total	2919	1716	4635

* It includes dams whose height is not known.
Source: Data derived from the World Register of Dams, (2003), ICOLD

These figures of number of large dams in India obtained on the basis of height can be extremely misleading. For instances, the first 2919 dams create a storage space of 296.29 BCM, with a mean storage space per dam to the tune of 101.5 MCM. Whereas, the rest 1716 dams put together create a storage space of 6.29 BCM only, with a mean storage space per dam to the tune of 3.65 MCM. So, these are not really large dams in any sense.

Further, the total storage created by all large dams in India is only 302.58 BCM, with a mean storage capacity of 64.28 MCM/dam. This however, does not mean that these dams actually store and provide that much water. The reasons are many. First: many large dams in India do not get sufficient storage, due to inadequate inflows from their catchments, whereas on the other hand, may reservoirs capture and release more than their storage capacity as inflows are received at the time of release of water. Second: the figures of storage capacity are of gross storage, and not live storage. The current total live storage capacity of reservoirs in India is only 214 BCM, and for many reservoirs, it is reducing due to silting as per recent sedimentation and siltation studies (Thakkar and Bhattacharyya, 2006, based on State Reservoir Survey data)[3].

Now, let us look at the figures for United States. The country has 16,383 dams which are listed in the national dams register, which includes small dams as well, or dams having height much less than 10 m. Of these 16383 dams, only 1735 dams have height more than 15m, and they put together create a storage space of 140.14 BCM, with a mean storage space per dam to the tune of 80.8 MCM. But, interestingly, the rest 14, 648 dams put together can provide a total storage space of 342 BCM, with a mean storage per dam to the tune of 23.3 MCM (source: the authors' own estimates based on US national dams register). This means, the dams having height less than 15m, including those having height much lower than 10m, are very important storage systems for US, as not only the total storage volume exceed that of large dams, but also the mean storage volume per dam is also quite significant.

In Australia, the mean storage provided by a large dam is 176.7 MCM (source: authors' own estimates based on data provided in Natural Heritage Trust, 2000). In nutshell, though India appears to be a champion in terms of building large dams, the actual figures of the water storage potential created by large dams is nowhere near that of countries like United States, which have less number of large dams.

4.3 THE DAM CONTROVERSY: UNDERLYING ASSUMPTIONS AND GENESIS

The 4635 large dams in India are either of height above 15m or fulfil any other criteria set by ICOLD. With the kind of technical excellence achieved in the field of civil engineering and structural design, constructing a dam of 15m height or a dam with unusual design or difficult foundation is not a big challenge any more. Besides, criteria such as unusual design or difficult foundation have not much to contribute towards the environmental problems or achieving the targets of irrigation or economic growth. The arguments of anti-dam activists become forceful when they simply magnify the "negative impacts" of some very controversial dams with this large figure and project that as the cumulative effect of all large dams.

Any average number derived from a select few well-known or controversial dams on attributes such as irrigated area against submerged area, the BC ratio or number of people displaced against the number of people benefited should not be blindly extrapolated to get the cumulative effect of all the dams, classified as "large" by ICOLD. The primary reason for this is the complex factors- physical, climatic, technical/engineering, social, environmental, ecological and political-, which govern the above said attributes of dams, differ from case to case. Braga et al. (1998) points out the danger in using simple indices such as area submerged per MW of electricity generated or number of people displaced per MW of power generated in the context of hydropower dams in Brazil, as according to them they ignore the benefit from multiple use of water. Unless relationships and trends are established on the basis of a large database, it would be difficult and often dangerous to draw inferences on any of those. Establishing such trends between the generally known attributes of dams, and the attributes of social and environmental significance is what we would achieve in the subsequent sections.

[3] According to the data cited by the authors, the average live storage loss for 23 reservoirs surveyed was 0.91% per annum. In nutshell, the actual storage in these dams which can be diverted would be even less.

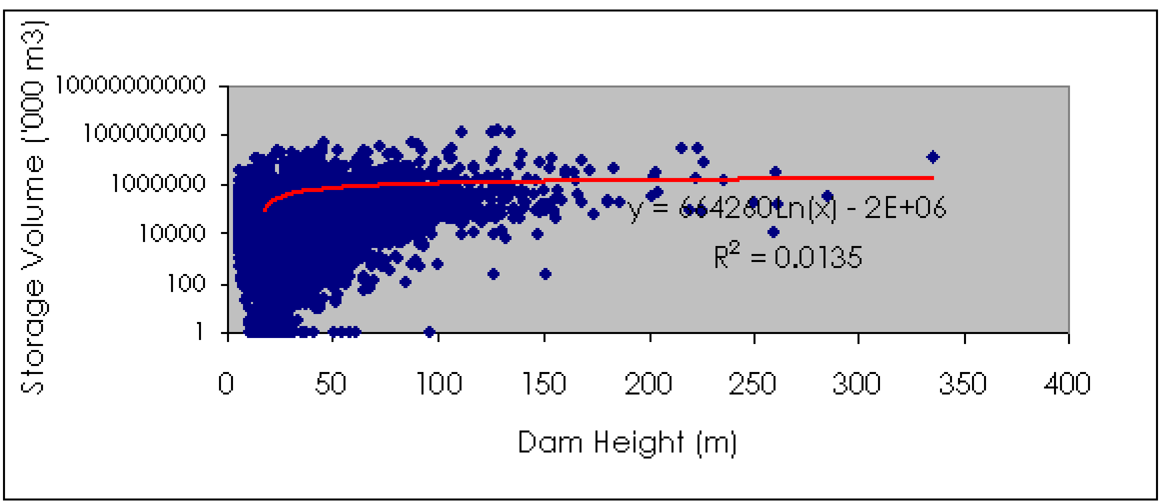
4.4 Analysis of the Defining Criteria for Large Dams

Should the sheer number of large dams really send warning signals on the magnitude of the costs being paid by the society for the negative consequences on communities and the environment? To answer this question, it is crucial to know the relevance of the criteria used for classifying dams as "large". Here it is important to mention that most of the criteria for classifying dams as large or small evolved at times, when large dam building continue to pose major engineering challenges to the humanity[4]. These criteria never tried to capture the social and environmental imperatives of building dams. The driving force behind this analysis is the strong belief that the controversy of environment and mainly of displacement is critically rooted in the way large dams have been defined in the past, and therefore really need a re-look, especially in the wake of growing social and environmental concerns of building "large dams".

None of the definition mentioned above, including that of ICOLD, is universally applicable. The reason is that different physical attributes of a dam, such as height, storage volume, and submergence area have different implications, which again is likely to change with dam location. So, any one component cannot be generalized to measure the various impacts generated by dams. When the impacts of dams are measured on the basis of ICOLD definition, ultimately it is only the dam height which is being considered[5]. But height does not always have direct relationship with the factors like environmental impacts, displacement or even with total storage volume and submergence area.

Normally, dam designers use the storage-elevation-area curve to determine the appropriate height of the dam and spillway capacity etc. Depending on the topography of the location, the storage-elevation-area relationships would change. In a deep gorge, the area under submergence of a high dam having a large storage volume may be very low. For example: Idukki dam, which is a double curvature arch dam, located in a deep gorge in Idukki, Kerala, India having a height of 555 ft, may not have submerged much area. But its storage volume is 2,000 MCM. An analysis of the data of 9,878 dams from ICOLD's World Register of Dams shows that the volume of water stored impounded by a dam is not a function of its height (Figure 1).

Figure 1: Dam Height Vs Storage Volume



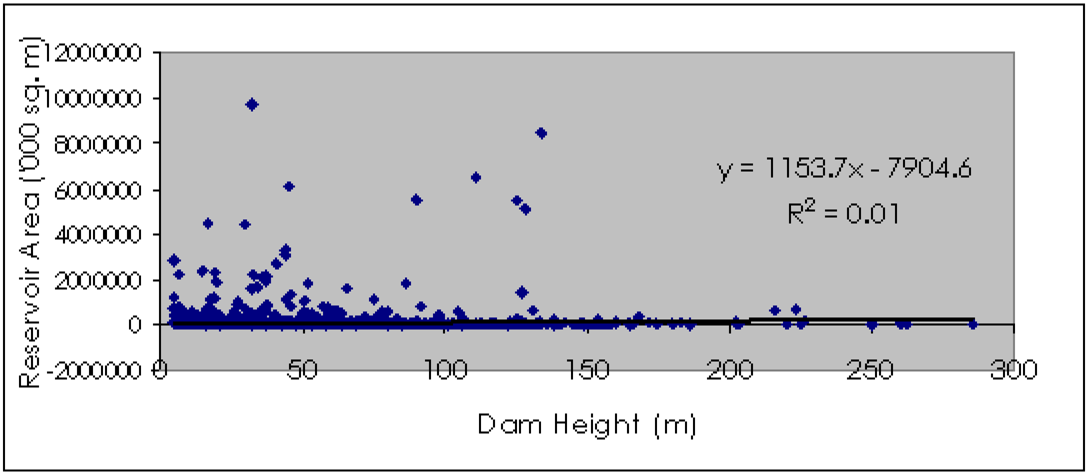
Further analysis with ICOLD data shows that the area of land submerged by the reservoir, which has implications for both environmental and social impacts, such as the number of reservoir affected people and deforestation, and loss of flora and fauna, is not a function of dam height (Figure 2). While it is well known that

[4] Larger height meant greater foundation stresses and forces in the main body of the dam, posing geo-technical challenges. Greater storage meant greater risk for people living in the downstream. Larger spillway discharge meant greater design challenges.

[5] Other secondary criteria such as crest length, dam foundation or unusual design have no bearing on dam impacts in this fast developing world of technology, nor can reservoir capacity or flood discharge capacity logically substitute the dam height criteria.

the dam storage volume varies with elevation (height of the dam), which has to do with the topography or the catchment characteristics, the relevance of the above analysis is that it shows very clearly that they vary drastically from location to location.

Figure 2: Dam height vs Reservoir Area



The results emerging from the foregoing analysis had two major implications. First: the concerns expressed by or protests made by environmental groups, world over, over engagement of poor and developing countries in dam building on the basis of the sheer number of large dams are ill-targeted. Second: the criteria currently being used by dam builders and global agencies dealing with large dams such as height and storage volume are not true reflections of the challenges dam builders pose in an era of growing social and environment concerns.

Of the total 4635 large dams of India, with height more than 15 m or storage volume higher than 1 MCM, 2431 (more than 50%) are built on local streams. Under such circumstances, some of them might be tank systems, with large surface area, whereas some others might be really big dams with large height and storage. Also, it is likely that they are constructed under various small scale irrigation development schemes to achieve benefits at the local level. Thus, one needs to see whether these storages are created by dams or tanks to analyse their environmental impacts. Moreover, locally initiated water harvesting moves or even small scale irrigation schemes are usually not facing the problem of displacement, and so their negative social impacts are also nil or very limited. In that case more than 50% of India’s large dams are socially and economically rewarding with minimum environmental cost bearing. In fact, their presence might have contributed towards growth of vegetation, fisheries and water security.

5. OBJECTIVES AND CRITERIA FOR ASSESSING LARGE DAMS

5.1 Objectives and Criteria for Classifying Large Dams

The second set of questions we are confronted with is: what should be the different criteria and considerations involved in classifying dams as small and large so that they are true reflections of the engineering, social and environmental challenges dams pose? On the first question, we have seen that the height of the dam, a major physical criterion used for classifying dams as large and small, does not have any bearing either on the area that dams submerge, or the storage that dams create. Actually, the area submerged by dams has implications for the environmental consequences of reservoir projects. The storage created by dams has implications for the safety hazards they pose, and the hydrological and socioeconomic impacts.

That takes us to the question of what should be the ideal criteria for classifying large dams. Area submerged by dams is a good indicator of the potential ecological damages dams can cause, though the actual ecological consequences would depend on several factors such as the nature of the eco-region where the dam is located. Such data are easily available for existing reservoirs, or can be generated for the reservoirs that are being planned. But, does that reflect some of the negative social impacts dams can cause? In that regard, one of the biggest challenges developing countries are confronted with today is to minimize the human displacement by dams, thereby minimizing the human sufferings. This is a major issue because of the position taken by anti-dam activists that complete rehabilitation of oustees is impossible (see Fisher, 2001). Hence, choosing a physical criterion which adequately captures the two altogether different dimensions of a complex problem caused by dam building becomes all the more important.

Such a criterion would also help quickly and roughly assess the magnitude of displacement that a reservoir project can cause. The anti-dam activists around the world have been using several different estimates of "displacement" to build their case against dams. The following paragraphs illustrate this problem of how inadequate data create misinformation about an issue as vital as displacement. By identifying the right kind of criterion, which uses measurable indicators, for deriving the statistics of large dams also helps us assess the magnitude of problems large dams pose in any country, using data on such indicators.

Global estimates of the magnitude of impacts show that 40-80 million people were displaced by dams (Bird and Wallace, 2001). In case of India, no authentic figures are available for dam-induced displacement. Whatever numbers are available, are derived largely from some rough calculations using simple norms. Fernandes et al., (1989) claimed that India had 21 million people displaced by dams. Some years ago, the then Secretary, Ministry of Rural Development, Government of India, unofficially stated that the total number of persons displaced by development projects in India are around 50 millions, and around 40 millions of them are displaced only by dams.

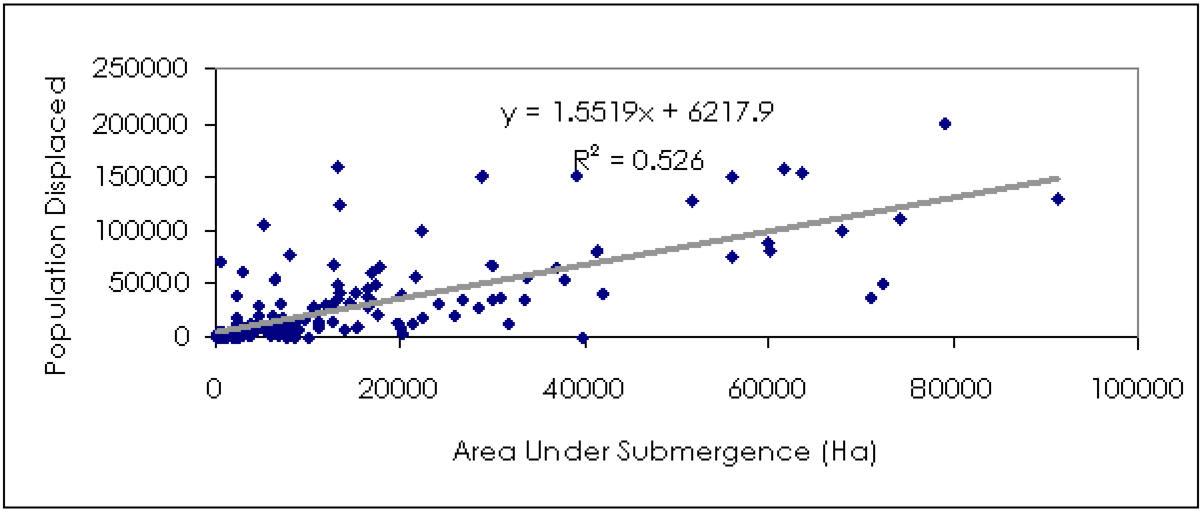
Some other estimates are based on average displacement per dam. After a study of 54 dams, the Indian Institute of Public Administration (IIPA) concluded that the average number of people displaced per dam was 44,182. Roy (1999) multiplied this figure with 3300 dams in India (CWC estimates, as cited in Roy, 1999) and received the figure of 145 million. Since she felt this figure is too large, she took an average of 10,000 persons displaced per dam, and reached to the figure of 33 million people displaced by dams. Singh and Banerji (2002) have compiled the displacement data of 83 dams with the aggregate of 2,054,251. The list covers dams constructed in the year of 1908 as well as many dams under construction. Based on the submergence area of these 83 dams the authors have estimated an average 8,748 ha land under submergence and the average displacement per ha as 1.51. While multiplying these two average figures with the total numbers of dams of 4291 (as given by CBIP, as cited in Singh and Banerji, 2002), the authors derived the astounding figure of 56,681,879 persons displaced by dams. The authors mention this as a clear overestimation.

Let us analyze the flaws in the estimates which form the basis of many of the arguments against dams. As per the National Register of Large Dams in India there are 1529 large dams in the state of Maharashtra (CWC, 1994). The ICOLD figures put a figure of 1700 dams in the state. If we adopt Roy's estimates of 10,000 persons displaced by a large dam, Maharashtra alone should have displaced between 15.3 and 17 million people. It is most unlikely that such a large population in one state has no visibility. Looking at India's poor track record of rehabilitation, majority of these displaced people might be facing poverty and impoverishment. On the contrary, Maharashtra stands next to Kerala, the state which stands at top on human development indicators (Source: UNDP, 2006).

One of the major limitations of these estimates are that majority of them are derived from the average figures of displacement calculated per dam, and are multiplied with the total number of dams. The figures offered by CWC (1994), CBIP (1987, 1998) and World Register of Large Dams (2003) were on the basis of the total number of large dams, based on ICOLD's definition. Thus, all the estimates of displacement have the inbuilt assumption that dam height influences displacement. This is a wrong perception that higher dams cause larger displacement, whereas it is true that the increase in height of a dam at a specific location would increase the area under submergence and displacement.

It is a truism that theoretically, the population displaced would be largely determined by the submergence area and the population density of the region under consideration. But, still it is important to know whether a strong relationship really exists at the operational level between the land area under submergence and population displaced. This is in view of the wide variation in population densities in countries like India from region to region. The following figure supports the argument that it is a good indicator. It is based on our analysis of 156 large dams in India. It shows that the number of people displaced by dams increases linearly with increase in submergence area. Submergence area explains displacement to the tune of 58% (Figure 3). The rest could be explained by variation in population density, and its effect on displaced population. This is a high level of correlation and therefore can be used to project the number of people displaced by dams, if we have data on the total area under submergence of all large dams.

Figure 3: Submergencve Area Vs Population Displaced



The relationship also means that dam height is mainly location specific, and so does not have direct impact on displacement as we have already seen that dam height does not have any bearing on either storage or submergence area. The graph clearly shows that while 100 ha of submergence can cause the displacement of 150 plus people, what is important to note is that many large dams in India have very low level of submergence. It should be noted here that in a country with a much lower population density (for instance United States), the relationship would be different in the sense that the X coefficient would be much lower, meaning the number of people displaced by one sq. km of submergence would be smaller.

Now, the total area submerged by 2933 large dams in India (obtained from The World Register of Dams, 2003) was estimated to be 32,219.25 sq. km. The area submerged by 4635 dams was extrapolated to be 49660 sq. km (32219*4635/2933=49660). Based on this estimated submergence area and the formula given above, the total number of people displaced by dams was estimated to be 7.845 million people. This is far less than the figures of displaced people provided by earlier researchers.

The main utility of this relationship is that once it is established for a given population density range on the basis of existing database, the number of people likely to be affected by dams in any region having that population density range could be estimated with a reasonable degree of accuracy, if area under submergence is known. A direct approach of estimating displacement based on submergence area and population density in each case would be cumbersome, as it is difficult to get population density data for very small areas which form the reservoir catchments.

Now, it is true that height and storage volume together reflect the engineering challenges posed by dams. So, it can be inferred that a combination of parameters such as height, storage volume and submergence area would give a true reflection of the engineering, social and environmental challenges. Hence, the criteria for classifying large dams should be developed by taking into consideration all these three important parameters.

5.2 New Criteria for Evaluating the Performance of Large Dams

The economic impacts of large dams in India are surmised as negative on the bases of construction cost overruns; poor performance of irrigation systems with heavy wastages due to poor conveyance efficiencies in the distribution system; negative downstream ecological impacts; preference for water-intensive and low water-efficient crops; water logging and salinity in command areas; and the problems of overestimation of benefits resulting from shrinking of command areas due to non-availability of water and ecological problems (see Rangachari et al., 2000). Very few studies really exist which comprehensively evaluate the long term economic and social benefits of large dams.

The criteria selected for impact evaluation also suffer from problems. The same criteria, which were followed for evaluating costs and benefits at the time of planning of the project itself, are used to analyze the dam impacts many years after they become functional (Biswas and Tortajada, 2001). In the process, most of the benefit calculations overlooked major benefits like food security from stable food prices, increased rate of employment in agriculture, improved fisheries, increased access to drinking water supplies, development and growth of processing and marketing units etc. Improved groundwater balance due to return flows from canal irrigation is a social benefit. In many parts of Punjab, well irrigation is sustained due to the continuous return flows available from canal irrigation which add to the recharge (Hira and Khera, 2000).

This is not to argue that large dam projects were free from problems. Many of the dams, especially those built in semi arid and arid regions are over-allocating water from their respective basins as shown by case studies from north Gujarat basins in India (Kumar, 2002). The irrigation agency here was often keen to build over-sized dams, taking the flows of low dependability as the design yield, to inflate the design command and economic benefits. This leads to reduced flows or no flows in the downstream parts of the river in most of the years causing ecological problems (Kumar et al., 2000; Kumar, 2002). But, such problems have occurred more due to inadequate governance of water in river basins, characterised by lack of adequate scientific data for hydrological planning; piecemeal approach to water development; and ad hoc governance of irrigation systems (Kumar et al., 2000).

5.2.1 Criteria for Evaluating Environmental Impacts

The arguments against large dams are not founded on scientific assessment of real marginal social costs and benefits. For instance, the long-held position of Narmada Bachao Andolan was that "the social costs of large water development projects cannot be compensated by increased economic benefits accrued from the use of water". They argued that complete rehabilitation of the displaced communities is impossible (Fisher, 2001). They had the deep-rooted belief that cheaper and easier options to large dams exist.

Internationally, such arguments gain a lot of credibility after the concept of virtual water trade was introduced in the early '90s; and later on with small water harvesting options gaining wide acceptance. At least, some of the environmental activists advocate virtual water trade as an alternative to large dams for national food self-reliance. They argue that water-scarce countries should import food grain from water-rich countries. At the same time, the operational level, virtual water flows out of water-scarce regions to water rich regions (Kumar and Singh, 2005). In fact many water-scarce regions in India export agricultural produce worth thousands of million cubic metres of water to regions that are water-rich (Amarasinghe et al., 2004; Singh, 2004). In a similar manner, local water harvesting solutions are found to be having extremely limited scope (Kumar et al., 2006).

This leads us to the point that empirical evaluation of all direct and indirect costs and benefits of dams is inevitable, and the effort should be to minimize the social costs and maximize the returns from large dams, rather than looking at other options. Many international donors have also come out with criteria for evaluating costs and benefits of large dams, which involve stringent environmental criteria. Environmental impact assessment has been made mandatory for all World-Bank assisted dam projects in the world. But, the underlying premise in EIA is that all the environmental impacts associated with large dams are negative. The positive environmental effects of large dam projects such as impact on the local ecology and climate are hardly examined (Kay et al., 1997).

During the past couple of decades, there were significant advancements in the methodologies for evaluating costs and benefits of dam projects that is now capable of evaluating all future costs and benefits, including those which are social and environmental. But, much less have been the advancements at the conceptual level in clarifying what should be considered as positive effect or benefit and what should be considered as negative effect or cost. This has led to very unbalanced and biased assessment of reservoir projects. We will discuss these issues in the following paragraphs.

One of the strongest criticisms against large reservoir projects by environmentalists was water-logging and salinity problems they can cause in command area. Part of the reason is that world-wide, nearly 50% of the reservoir projects serve the purpose of irrigation. This has been an issue in many canal command areas of northern and north-western India and Pakistan Punjab. But, dramatic changes in agriculture in countries like India and Pakistan during the past 2-3 decades had converted some of these challenges into opportunities. With increasing groundwater draft for agriculture, which happened as a result of advancement in pumping technologies, massive rural electrification, and subsidized electricity for well irrigation, water-logging is becoming a non-issue in many canal command areas. In Indian Punjab, which is widely cited in literature as basket case of ill-effects of canal irrigation, the area under water-logging and salinity had actually reduced (Hira and Khera, 2000). One reason for this is increased dependence of farmers on groundwater. In Gujarat, northern region that is to receive Narmada water experiences groundwater mining. Hence, the threat of rising water levels due to induced recharge from canals does not exist (Ranade and Kumar, 2004).

While water-logging and salinity, and downstream ecological damage are much for people to identify, recognize or feel, the un-intended positive impacts such as drought proofing; drinking water security in rural and urban areas; and increased biomass availability in canal command areas through energy plantation; increased inland culture fisheries due to year-round access to water, though felt, were less talked about, and often less attributed to the dam/reservoir construction. Their performance is not evaluated in relation to number of job these dams create in rural areas; or the fishery production or the number of people benefited by drinking water sector, which are in the domain of different agencies.

Let us now examine the unforeseen benefits. Almost all major dams in the world are constructed for hydropower (Altinbilek, 2002). In many regions of the world, especially in Africa and Asia, the hydropower potential is huge and mostly untapped. Whereas globally, nearly 19% of all electric power is generated is from hydropower, which is one of the cleanest powers in the world. That said the greatest environmental benefit of pursuing hydropower as an alternative renewable source of energy to the conventional route of burning fossil fuel had found place in the discussions on multi-purpose dams.

Ideally, the negative externalities created by thermal power on the environment could be treated as the positive externality that hydropower generation creates on the society. So, a kilowatt hour of energy produced from hydropower plant should give an additional benefit equal to the cost of environmental damage which a thermal or nuclear power plant would cause for the same amount of power generation, and at higher levels of generation, the marginal social benefits would be high. The future of the energy economy in India and China, the two fast-growing Asian countries, is very much dependent on how they exploit their renewable energy resources like hydropower. Both the countries have vast untapped hydropower potential. In India, most of it lies in north-eastern mountainous region and Western and Eastern Ghats. It would be quite logical to assume that India would see a lot of dam building for hydropower, where the discussions on negative environmental impacts would be less relevant.

The large dams have important role in replenishing groundwater resources. The return flows from canals had played significant role in sustaining tube well irrigation, and thereby agriculture during the years of scarcity (Dhawan, 1990). A recent analysis by Kumar (2007) showed that nearly 5% of the deep tube wells, 10% of the dug wells and 5% of the shallow tube wells in India are located in canal command areas. Induced recharge from canals control groundwater mining for irrigation in many arid and semi arid areas of India, thereby preventing incidence of well failures. As Ranade and Kumar (2004) notes, such impacts are likely to be significant in semi arid north Gujarat, which is experiencing groundwater mining, and which is to receive Narmada water for irrigation. As Kumar (2007) notes, without the return flows from canals, the extent of groundwater mining in Indian Punjab would have been far more serious.

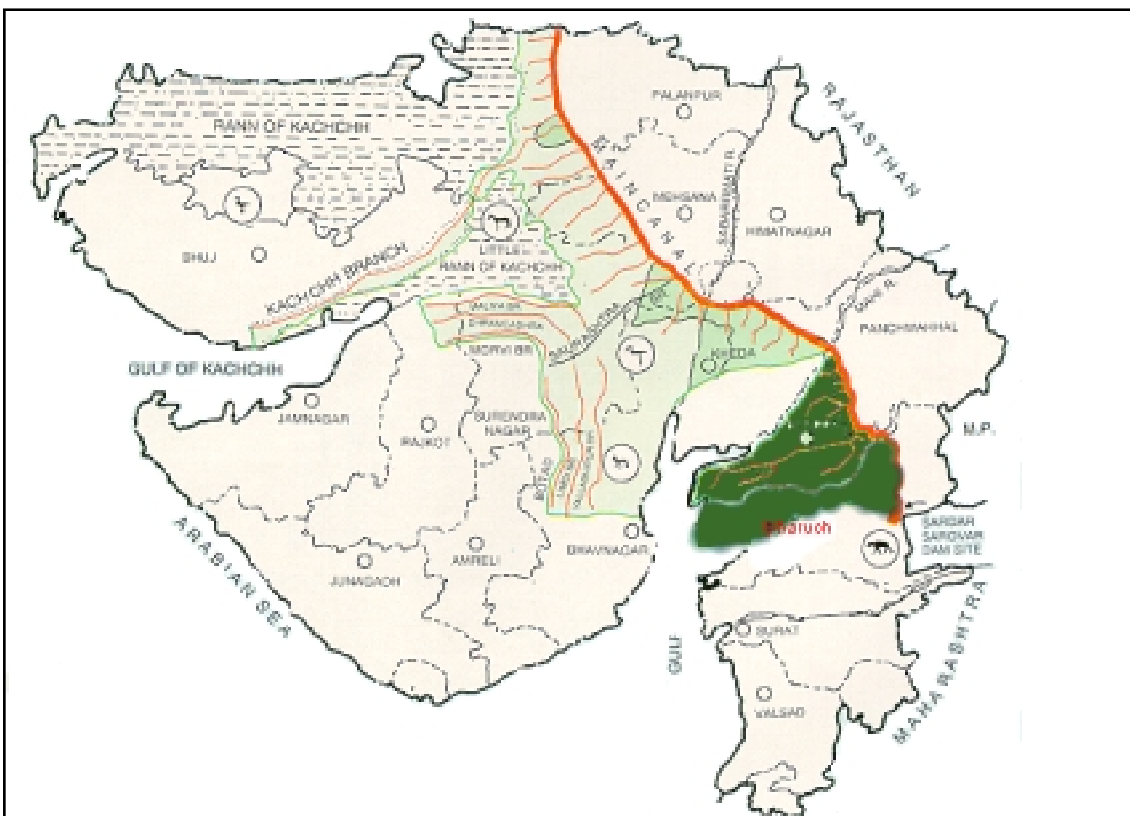
Unlike other parts of the world, where many large reservoirs are earmarked for water supplies, many large reservoirs in India were built primarily for irrigation. But, India's National Water Policy has given first priority for drinking water over irrigation and industrial demand. During droughts, water from irrigation reservoirs gets earmarked for drinking water supply in rural and urban areas. But, the role of large dams in ensuring drinking water supplies and thereby social security in water-scarce regions is less appreciated. Sardar Sarovar Project in Western India, for example, is expected to make a major dent in the rural and urban drinking water needs of 9,663 villages and 137 urban centres. Without the Sardar Sarovar project, the drinking water situation in these drought-prone areas would have been precarious, in the absence of any sustainable source of water to meet the basic requirements (Talati and Kumar, 2005). As many cities and towns are running out of water, due to permanent depletion of local groundwater, many dams originally meant for irrigation are now supplying water for domestic consumption.

While NGOs, which advocate local alternatives in water management, especially in managing drinking water supplies, had fiercely opposed regional water transfer from Narmada to Saurashtra and Kachchh on cost grounds, they failed in setting up demonstration of such alternatives, which are effective in both physical and economic front (Kumar, 2004).

5.2.2 Criteria for Evaluating Ecological Impacts

The arguments about downstream ecological impacts of dams concern potential reduction in lean season flows after impoundment and the environmental stresses they induce (Smakhtin, Revenga and Döll, 2004). But, in practice, regulatory reservoirs could be used to mimic natural flows that are needed for ecosystem health. For instance, in Narmada river basin in central India, large stretches between Indira Sagar dam and Sardar Sarovar dam, the flows are going to be regulated, and as a result lean season flows would be more than in the natural case.

Map 1, Showing the Sardar Sarovar Reservoir, Narmada Main Canal and Rivers of North Gujarat



The more immediate, positive ecological impacts would be accrued in water-starved regions where surplus flows from reservoir can be diverted for ecological uses. The gigantic water transfer project in China involving bulk transfer of water from the water-rich Yangtze river basin to seven provinces in the water-scarce north China plains could benefit more in terms of providing water for ecological flows in Yellow river and meeting drinking water needs of big cities like Beijing. Yellow river had already dried up due to heavy diversion of water for irrigation in the agriculturally productive plains, and no water reaches the end of the river.

In Narmada basin, the Sardar Sarovar reservoir being the terminal reservoir, it can receive all surplus flows from the reservoirs upstream. These surplus flows will be significant so long as upstream dams are not built (Gupta and Kumar, 2006). This water can be diverted through the Narmada Main Canal which runs north, cutting through in rivers in north and central Gujarat viz., Sabarmati, Watrak, Shedhi, Meshwo, Khari, Rupen, Sipu and Banas. Those stretches of the rivers, which the canal intersects, do not carry any flows during lean season even in wet years (see Map 1). They can hence receive the excess flows being diverted from Sardar Sarovar reservoir, which will provide for riverine ecosystems and also recharge the over-exploited alluvial aquifers of north Gujarat (Ranade and Kumar, 2004). This is already being practiced in rivers of Central Gujarat. North Gujarat aquifers have high levels of salinity and fluoride, at many places deteriorating drinking water supply situation, with major public health consequences (Kumar et al., 2001). The induced groundwater recharge can help to improve the quality of water by diluting the mineralized water in the aquifers, along with improving riverine ecology (Kumar and Ranade, 2004).

5.2.3 Criteria for Evaluating Social and Economic Benefits

There are problems in the way performance of dams is being evaluated by global interest groups. For instance, the criteria selected by the WCD report for evaluating dams are completion on time and completion within budget (Perry, 2001). Such technical and financial criteria often provide unfair treatment to large dams. According to Perry (2001), criteria such as food availability, food security, food prices or even resettlement success are the right indicators to measure the economic performance of dams. Food security is an important water management goal for many water-scarce countries including India and China (Kumar, 2003; Kumar and Singh, 2005). Food security is the central goal of constructing around 90% large dams in India and other parts of Asia, and the ratio is of 70% in Africa. As per ICOLD data, worldwide, nearly 48% of all large dams in the world were built for irrigation. Still, the positive externalities induced by improved food security were less articulated.

According to Bhalla and Mookerjee (2001), the total irrigation expenditure on major and medium irrigation schemes since independence in India has totalled Rs. 187,000 crore at 1999 prices. Against this the total agricultural output in 1998-99 was close to Rs. 500,000 crore. After Bhalla and Mookerjee (2001), depending on the assumptions one makes for how much of the total investment is allocated for big dams (whether 100% or 75%) and depreciation rates (3 to 5%), one obtains IRRs in the range of 3 to 9%. This is the direct economic benefit.

The positive externality effects of dam building should be added to it to get the social benefits. The benefits accrued from such positive externalities of increased food security benefits, should be assessed in terms of the opportunity cost of not producing that additional food internally, i.e., the cost of importing food. This is nothing but the import price of food grains minus the price at which it is available in the local market. In order to examine how the Asian giants, China and India influence international food prices under scenarios of rising cereal imports due to increasing meat consumption, a response to income rise and declining domestic production due to degradation of natural resource base, an IFPRI study used IMPACT (International Model for Policy Analysis of Agricultural Commodities and Trade) to simulate a scenario of increased food imports by India to the tune of 24 million ton and China to the tune of 41 million ton in 2020. The model showed an increase in international wheat and maize prices to the tune of 9 % and rice prices to the tune of 26% (Rosegrant et al., 2001).

If we consider that half of the additional food grain production of 94 million ton produced from irrigation in India since 1950s is from large dams (Perry, 2001), and that we decide to compensate the reduced production in the absence of large dams through food imports, and that prices would go up by just US$ 20/ton (nearly 10% of the current price), this would mean a total additional burden of Rs. 42.30 billion rupees annually for the imported portion alone. This is more than 0.l0% of India's GDP. If we assume that the current domestic cereal prices are close to import prices, the lower price consumers pay (say by US$20/ton) is the impact of domestic production of cereals on the food prices or the cost to the consumers, and therefore can be considered as a positive externality effect of large dams. This whooping opportunity of cost importing cereals itself seems to justify the large investment India had made in the irrigations sector. Such benefits should be added to the direct economic benefits to get the real social benefits of dam-building. This amount is the subsidy government provides to the people by avoiding food imports and keeping the cereal prices in the local market under control.

5.2.4 Internalizing the Negative Externalities in Project Costs

The irrigation bureaucracies in poor countries in Asia and Africa show unwillingness to include the negative externalities as part of the project cost as they do not like to transfer those costs to the water users, due to the fear that it would bring down the demand for water, and as a result would make BC ratios very unattractive. Instead, the practice is to bundle all such costs, and come out with a compensation package for the affected people once the project is cleared after the scrutiny for economic viability by the donors.

This myopic tendency can be explained by the fact that the reduction in benefit resulting from the decision to cut down the size of the project to minimize the negative effects on society would be disproportionately higher than the cost reduction. This can adversely affect BC ratios. Hence, in an effort to get donor funds, the size of the project is stretched beyond the point where the net benefit becomes equal to net social costs through exclusion of the negative externalities in cost calculations. This creates social ill-fare due to inequity in distribution of project benefits. In other words, those who get the benefits do not bear the costs. Since the project agencies do not earn sufficient revenue from the services it provides, adequate attention is not paid to compensating those who are adversely affected by the project. Such tendencies have also helped dam builders in inflating the net benefits of the projects.

If the donors make it mandatory for the dam builders to include the economic value of negative externality effects in the project cost, it would have the following desirable consequences. First: the agencies would try and come out with innovative designs to reduce the marginal social cost of water development. Second: they would try and improve the quality of provision of water to raise the marginal value of the water. By doing this even with lower level of development, the net social welfare from large dam projects could be enhanced.

5.2.5 Summary

In nutshell, the criteria for evaluation of costs and benefits of dams need to be made more comprehensive taking into account all possible externalities associated with ecological, environmental, economic and social benefits that dams are expected to accrue. For developing economies, such benefits include: i] environmental benefits due to improved groundwater recharge through canal return flows, particularly in arid and semi arid regions, greater drinking water security in drought-prone areas, and availability of clean energy; ii] economic benefits due to additional well irrigation possible with augmented groundwater and reduced well failures; iii] ecological benefits from increased flows in the downstream areas of highly degraded rivers; and iv] improved regional and national food security that come from lowering of food prices and making it accessible to most people. On the other hand, the negative externalities a large dam project creates should be built in the project cost, and be transferred to those who benefit from large dams in terms of additional price they pay for the services.

6. CONCLUSIONS

We have investigated mainly two issues in this paper. 1. Do the current technical criteria used in classification of dams as “small” and “large” adequately capture the magnitude of likely negative social and environmental impacts they can cause? If not, what should be the criteria for classifying dams for them to be true reflections of the engineering, social and environmental challenges dams pose? 2. Are the objectives, criteria and parameters currently used to evaluate the costs, and benefits of large water impounding and diverting systems, sufficient to make policy choices between conventional dams and other water harvesting systems or groundwater based irrigation systems? Or what new objectives and criteria, and variables need to be incorporated in the cost-benefit analysis of dams so as to make it comprehensive?

The criteria used by ICOLD for classifying large dams, such as height and storage capacity, are not sufficient to capture the potential negative environment and social consequences, for which large dams face opposition from environmental lobby around the world. Analysis of data for 13,631 large dams around the world shows that the height of dam does not determine the storage volume, which, in a way, implies the safety hazards posed by dams. Further analysis using data for 9878 large dams shows that height does not determine the amount of land submerged by reservoirs, which implies the negative social and environmental impacts dams can cause. The use of such criteria results in over-estimation of negative impacts like displacement, leading to over-reaction from environmental lobby against large dams.

While India appears to be a world champion in building large dams in terms of number of large dams built so far, the actual storage being achieved by these dams is nowhere comparable to those in United States and Australia. Therefore, classification based on dam height neither indicates the potential benefits of dams.

Analysis of data for 156 large dams in India shows that the number of people displaced by dams is a linear function of the total area submerged by them. Every one sq. km of area submerged by large dams in India displaces around 154 people. Using the estimate of 49,660 sq. km as the area submerged by large dams, the total population displaced by them was calculated to be 7.845 million people. What might change for other parts of the world is the number of people displaced per unit submergence area according to variation in population density. As shown by our analysis, while the area submerged by dams could be an important criterion for deriving more reliable statistics about displacement, the available estimates of dam related displacement in India are gross over-estimates, in an order of magnitude of eight.

Thus, the criteria for classifying dams should be developed on the basis of the three parameters, namely, dam height, storage volume, and submergence area for them to truly reflect the true engineering, social and environmental challenges posed by them.

It is becoming increasingly clear that local water harvesting and virtual water trade options are non-existent in many countries which need to produce more food. This would compel water professionals to look for ways to minimize the social costs and maximize the returns from large dams. Apart from the economic cost of negative externalities on society in terms of human displacement and ecological degradation, the criteria for evaluating the costs and benefits of dams should involve considerations such as positive externalities associated with larger social and environmental benefits such as stabilizing domestic food prices, reduced carbon emission for energy production, improvement in groundwater replenishment in semi arid and arid areas due to return flows, and social security through improved access to water for drinking. The benefit due to lower food prices from domestic production of 47 million tons of cereals, the approximate contribution of large dams to India's granary, alone would be Rs.42.90 billions.

Water and power development agencies in poor and developing countries are not willing to transfer the additional cost of water provisions due to the negative externalities of dam building, on the beneficiaries of dams. They fear that with increased cost, and therefore with the increased prices users have to pay, the demand for water would come down significantly, making it difficult for them to justify large projects. Such under-estimation helps them show higher demand for water and energy from the system, thereby being able to build projects to such sizes where the marginal social cost far exceeds the marginal social benefits, causing negative welfare effects on the society. If the donors make it mandatory for the dam builders to build in the economic value of negative externality effects of dam building into the project cost, the net social welfare from large dam projects could be enhanced. It is argued that such an approach will also increase the pressure on the dam builders to come out with innovative systems design that minimizes the costs, and raise the marginal value of water, thereby raising the net social welfare.

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LARGE RESERVOIRS: ARE THEY THE LAST OASIS FOR THE SURVIVAL OF CITIES IN INDIA?

Sacchidananda Mukherjee and Zankhana Shah

Abstract

Urban water demand is rapidly growing in India due to high growth in urban population and rapid industrialization. Meeting this growing demand is a big challenge for the urban planners in India. Incidentally, urban areas in arid and semi arid regions of India are experiencing rapid growth. As a result, the supplies from local water resources including aquifers are far less than the high and concentrated water demands in most urban areas. Under such situations, the cities have to rely on large reservoirs. The paper argues that urban growth would be jeopardized in absence of water supplies from large reservoirs. The analysis of 302 urban centres shows that as population of cities grow, their reliance on surface water sources also grows. Also, greater the share of surface water in the city water supplies, better the level of water supply. A multiple regression analysis of 190 class I cities and 240 class II towns further supports this finding. In Class I cities, with every unit increase in population, there is a 1.12 unit increase in quantum of water supplies. Whereas in Class II towns, with every increase in population, there is only a 0.40 unit increase in quantum of water supply. This shows greater capacities of large cities to respond to the growing water demands, induced by population growth and urbanization. The future projections of population growth, economic development and future water demands clearly means that the role of large reservoirs in meeting the demand of urban water supply is going to be more critical.

1. INTRODUCTION

The traditional engineering approach to water management in India largely centered upon building storages and diversions in places which provided hydrological opportunities and taking water to regions that face shortages with the aim of reducing the imbalances in demand and supplies. But, large water resources projects began to face fierce resistance from environmental groups for the potential negative social and environmental consequences they could create (Shah and Kumar, 2008). Though they propose alternative approaches, these alternatives were quite general, and had looked at options for augmenting the aggregate water supplies against the aggregate demands. They missed two important factors that determine the nature of treatments that would be effective in a given situation. The first one is the source of growth in water demands, and thus the nature of water scarcity. The second one is the type of regions which are likely to experience rapid growth in water demands.

To elaborate, most of the solutions to India's water problems have been agriculture centric. The solutions advocated overlook the magnitude of water demands in urban areas; ignore that a significant chunk of the growth in water demand comes from urban areas. Urban water demands are different from agricultural water demands. They are more or less uniform over the year, and are highly concentrated. These characteristic features of urban water problems make it mandatory to have unique approaches and treatments.

Secondly, several of the suggestions on urban water management alternatives advocated[1] are based on the inherent assumption that the regions which are likely to experience water scarcity would have extra water resources availability for harnessing. In contrast to this, most of the regions experiencing urban growth in India are naturally water-scarce regions. These regions have limited water resources endowment. As a result, the

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[1] They include local runoff water harvesting and groundwater recharging, urban storm water harvesting; roof water harvesting. Largely, these interventions would be effective only in high rainfall areas (Kumar et al., 2006).

amount of water that could be managed from small geographical areas in such regions is often too inadequate to cater to the high demands resulting from the population crossing a threshold.

The key propositions in this paper are as follows - i) in semi arid and arid areas, the urban water supply is dependent on local water sources such as wells, ponds and tanks; ii) the rapid growth in urban population and fast industrialization in and around urban centres, which is characteristic of these resource-scarce regions, is threatening the sustainability of local sources; ii) these urban centres will have to depend on exogenous water resources based on large reservoirs for ensuring sustainable water supplies, and as a result, as the city grows, the dependence on surface water resources from large reservoirs is likely to increase consistently; and iv) cities depending on exogenous sources for urban water supplies, particularly large reservoirs, maintain much better supplies as compared to those dependent on local sources.

The next section deals with the objective, hypothesis, methodology and data sets. The third section describes the trend of urbanisation in India and how that changes the pattern of water supply in urban areas. The subsequent sections analyse empirical data on urban population, pattern of water supply, and per capita water supplies in Class I cities and Class II towns, to identify the major determinants of the quality of water supply existing in urban areas. The last two sections offer policy suggestions and concluding remarks.

2. OBJECTIVES AND HYPOTHESIS

The objectives of the study are to: analyze the changing trend in urban water supplies vis-à-vis the dependence of towns and cities on local resources and large reservoirs in accordance with changing size of urban population; and identify the major determinants of water supply condition existing in urban areas.

The main hypothesis being tested in this paper is that beyond a threshold point, the population and economic growth of the city drive the water utilities to shift from groundwater to surface water, in semi arid hard rock regions of India resulting in improved water supplies. The sub-hypotheses to test are: 1] with increase in population, the dependence of cities on surface reservoirs for water supply would increase in both aggregate and percentage terms; and 2] with increase in dependence of cities on large surface reservoirs, the access to water supply would improve.

3. URBANIZATION AND GROWTH IN URBAN WATER DEMAND

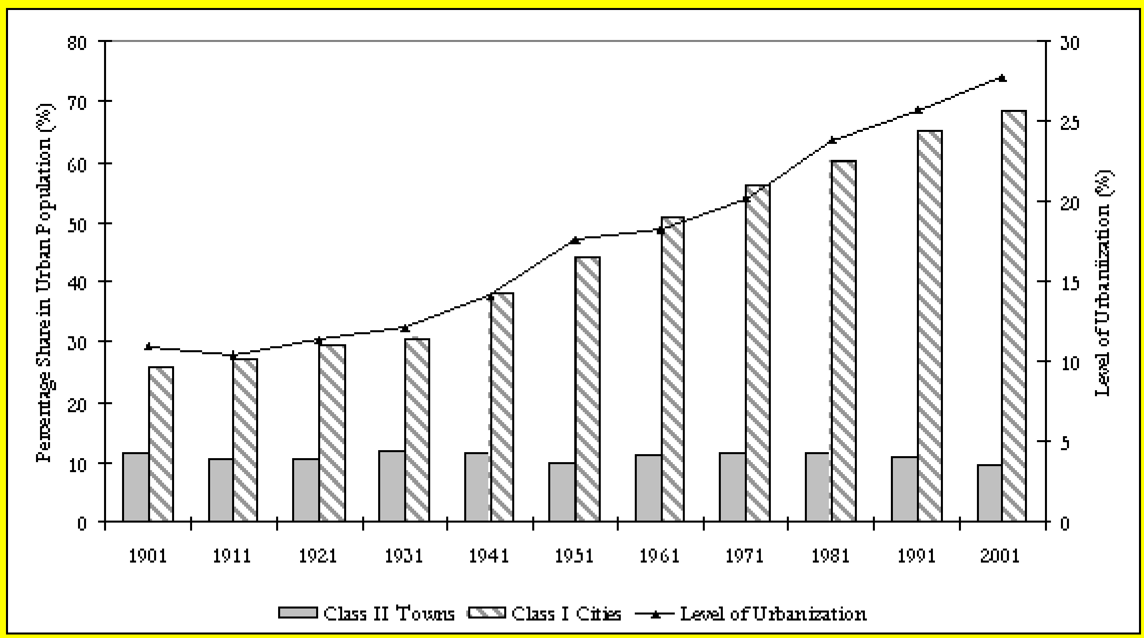
Since independence, the urban population of India has grown exponentially. Total urban population in India increased more than ten times surpassing India's overall population growth, which increased less than five times during 1901 to 2001 (Maiti and Agrawal, 2005). Currently around 27.8 % (285 million in absolute terms) of India's population is living in urban areas (Census of India, 2001), which, as per an estimate will continue to increase up to 40% or 550 million in 2021(Lundquist et al., 2003). The Census of India divides urban agglomerations between Class I and Class VI, based on their population size[2]. Figure 1 describes the share of Class I cities and Class II towns in total urban population and the level of urbanisation (urban population as a percentage of total population).

The magnitude of challenge to India's future water resources planning and management would be largely determined not so much by its population growth, but by the source of this growth, i.e., whether rural or urban, and where this growth is likely to take place, i.e., whether in water-scarce regions, or water-rich regions. The average annual exponential urban population growth rate for last 5 decades is 1.4 times higher than total population growth rate (Census of India, 2001).

Unlike in many developed countries, India's urbanisation is rapid, exponential and uncontrolled. While urbanisation in developed countries accompanied the country's economic growth, which financially supported the infrastructure development in the cities (see Biswas, 2006a). In India, sustaining high urban growth rate

[2] Metropolitan: with a population of more than one million people; the Class I cities are those with a population between one lac and one million. The Class II towns are those having population between 50,000 and one lac people; class III towns have population in the range of 20,000 and 49,999; Class IV towns have population in the range of 10,000 and 19,999; Class V towns: between 5000 and 9,999; and Class VI towns: with population of less than 5000.

Figure 1: Growing Population Pressure on Class I Cities and Class II Towns in India: 1901-2001



Source: Census of India (2001)

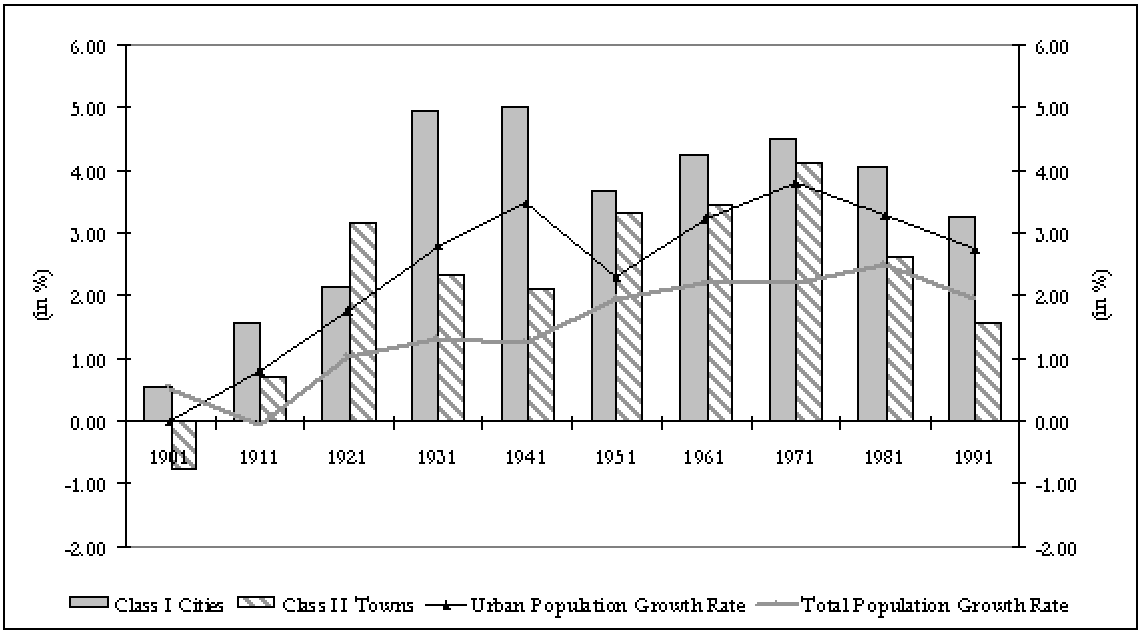
would be crucial for utilizing the future growth potential in the country's economy, which has been experiencing a two-digit growth for the past one decade. Cities are the engines of economic growth. It is estimated that the urban areas of the developing world, which have about 47.2% of the total population in 2000, contribute nearly two-thirds of their total gross national products, and also play an equally important role in terms of social development and cultural enhancement (Biswas, 2006). In case of India the urban population consists of one-third of the country's total population and contributes to more than 50% of the country's total Gross Domestic Product (GDP) (Planning Commission, GoI, 2002). Sustaining high urban growth rate is critical to sustaining the country's overall GDP growth.

Improving urban utilities, including water supply services is the key to sustaining high urban growth rates. As a recent study involving 145 nations around the world shows that the improvement in water security drives economic growth of a nation through the human development route (Kumar et al., 2008). Unlike other infrastructure, water supply needs continuous inputs to ensure high quality of services in terms of the maintaining the daily per capita supplies to the minimum standard, equity in access to water supplies, maintenance of water quality standards, and safe disposal of wastewater. If a city's own sources fall short in meeting the increasing demand for water supply beyond a point, and then it has to look out of its municipal limits to sustain its living condition and economic growth (see McGranahan et al., 2001).

The Nation Water Policy, 2002 (GoI, 2002) prioritised drinking water over agriculture and industrial water demands, and since then a large part of the total water harnessed by reservoirs is kept reserved for supplying to urban and rural households. However, despite the catalytic impact that dam projects have on the formation of modern urban landscapes, these projects have received very little attention in the emerging field of geographical enquiry on the urbanization of nature (Kaika 2006). Sardar Sarovar Project constructed on the Narmada River in Western India, for example, is expected to make a major dent in the rural and urban drinking water needs of 9,663 villages and 137 urban centres (Hirway and Goswami, 2008). Without the Sardar Sarovar project, the drinking water situation in these drought-prone areas would have been precarious to meet even the basic requirements (Talati and Kumar, 2005). As many cities and towns are running short of water, due to permanent depletion of local groundwater, many dams originally meant for irrigation are now supplying water for domestic consumption (Shah and Kumar, 2008).

Figure 2 explains India's exponential urban growth rate. Even now India's urbanisation is more or less uncontrolled and unplanned. The large population base and limited availability of finances for infrastructure development and up-gradation are the further limiting factors of promoting Indian cities at world class level.

Figure 2: Annual Exponential Growth Rate of Population across Urban Agglomeration in India



Source: Census of India (2001)

4. CHANGING URBAN WATER DEMAND AND SUPPLY SCENARIOS

Urban water demand comes both from (a) the concentration of people in cities, who need water to survive; and (b) urban economic activity (Meinzen-Dick and Appasamy 2002). The cities are characterised by concentration of population as well as various kinds of economic activities including industrial units. Against this, the factors that determine its sources of water supply and level of scarcity (physical, financial, political or qualitative) can be classified based on: geo-hydrology; rainfall; technology and management; economic growth potential; and, political influence. At initial stage of expansion the water requirement of a city is met through development of local groundwater resources, and diversion of water from lakes, ponds and tanks. This prove to be limited against the increase in demand, which is an outcome of increasing population pressure (vertical expansion) and expanding city's boundaries (horizontal expansion), growth of its economic activities, and improved standard of living. In this context long-distance transfer of water to the growing urban system is already necessary in many countries (Lundquist et al., 2003). Mexico City, Cairo and Beijing in the developing world and San Diego, Los Angeles, El Paso in USA are some of the examples where the city's water demands have been met through large reservoirs. In India Yamuna River is the major source of water supply for Delhi. Its future panning includes drawing water from Tehri dam. Delhi's hydro-geological characteristics and rainfall pattern cannot sustain its economic and population growth without the external support from far away places. Similarly, the growth of Jodhpur city in the arid regions of Rajasthan can be duly acknowledged to the water supplied through Yamuna canal. The vastly growing city of Hyderabad gets water supply from reservoir on Krishna river and structures built on Godavari river.

4.1 Economics of Urban Water Supply

The investment decisions in the water sector are largely taken on economic and political grounds. The water transfer from large reservoirs to cities is criticized on the grounds that - i) cities take away water from farms (see Lundqvist et al., 2003); ii) the cost of water transfer from far away places is very high (see SANDRP 1999); and iii) the environmental impacts of dam construction and water transfer are always negative and irreversible (see D'Souza 2002; McCully, 1996; Fitzhugh and Richter, 2004). On the other hand, all social, economic and political considerations favour transfer of water from agriculture to domestic sector. Meeting drinking water requirements is the first and foremost priority according to India's Water Policy-2002 (GoI, 2002). In spite of the fact that domestic sector (urban and rural) takes only 3% and less than 5% by industry (Bansil, 2004), this seems to be a daunting challenge, particularly when the domestic water supplies are dependent on groundwater based schemes. The reason is the de jure rights to access groundwater are not clear, whereas de facto, it is attached to land ownership rights.

The direct and indirect social and economic impacts generated by regular water supply in urban areas would justify a city's decisions to obtain supplies often at costs higher than what is necessary, but without significantly compromising their ability to expand and prosper even in the most unhelpful locations (Molle and Berkoff, 2006). When urban areas become large and house large manufacturing units, the opportunity cost of not providing adequate amount of water to maintain minimum supply levels would become prohibitively high in terms of negative consequences for the economic activities that urban areas support, and survival of the communities there, which are often more influential than the farming communities in rural areas. The political economy of growth based on urbanization and industrialization would continue to justify the huge investments in urban water supply infrastructure.

Also from a pure economic perspective, the contribution from agricultural sector to the overall GDP has been decreasing over the years (from 38% in 1980 to 22.7% in 2001), while the contribution from domestic and industrial sectors to the same has been increasing (Ministry of Agriculture 2002, as cited in Amarasinghe et al., 2005). This had forced water resource bureaucracies to reallocate water from agriculture to non-agricultural uses including urban and industrial uses in the past. But, growing water scarcity in rural areas including that for drinking and domestic uses, these agencies would be increasingly under pressure to look for new sources of water. This can lead to planning of new schemes that involve transfer of water from abundant regions to water-scarce regions where urban centres are located[3]. The underlying premise in this new approach is that while the negative environmental impacts of construction of large dams and water transfer can be controlled with good science and technology, the opportunity cost of delaying or stopping dam construction could often be severe (see UNDP 2006, Shah and Kumar, 2008).

5. HOW DOES WATER SUPPLY SCENARIO CHANGE WITH URBAN GROWTH?

In most cases cities exploit their groundwater resource, which is easily accessible since it is within the boundaries of urban centres, and cost effective in terms of initial investment. For a long time since Independence, Chennai city depended on the tanks which are located in the periphery of the city for municipal water supplies. Similarly, Ahmedabad city depended on water from Sabarmati River and the groundwater resources for meeting water supply needs of the city. But urban growth changes it's water demand patterns altogether. The reason for this is that rise in population and growth of economic activities increase the water demands of urban areas exponentially. The cumulative effect of urban economic growth and growth in urban population on urban water demand can be explained this way. The population itself increase per capita water supply needs. Further, economic growth increases the per capita water demand for domestic uses (Rosegrant et al., 1999). Also, urban growth, which comes with heavy industrialization, would increase the water supply needs for commercial activities and manufacturing units. Amarasinghe et al., (2006) shows that economic growth and urbanization influence the per capita water demand in urban centres. Their analysis shows that a 1% increase in per capita gross domestic product would have a 0.17% increase in the per capita domestic water demand. A similar increase in urbanization would result in a 0.68% increase in per capita domestic water demand.

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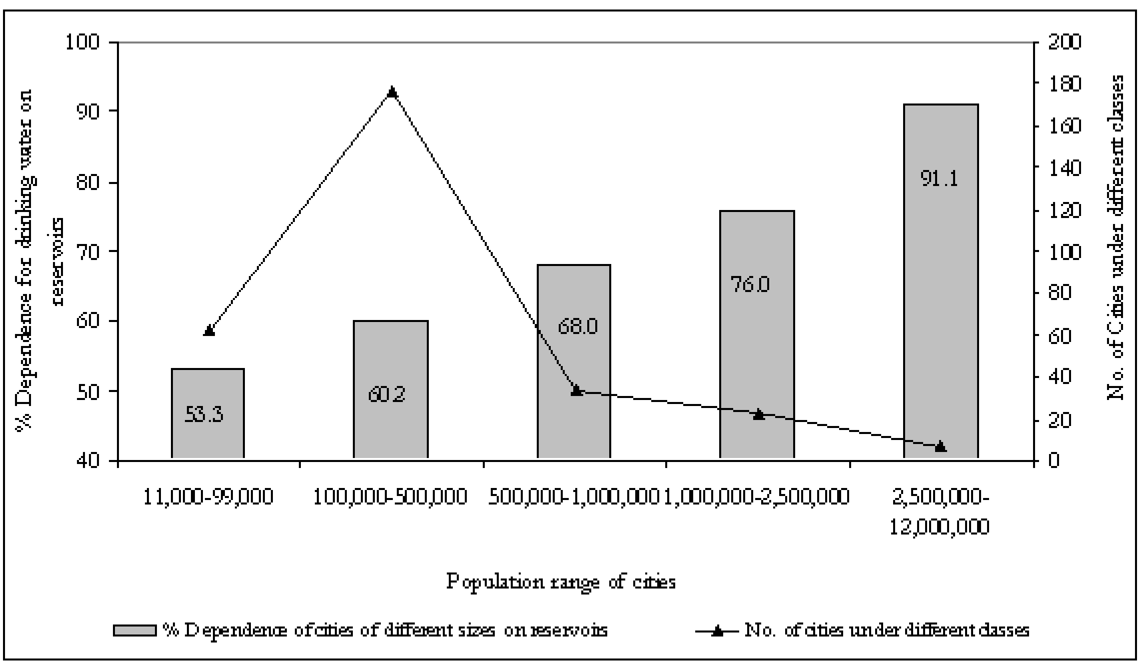
[3] The drinking water supply schemes in large number of cities in Gujarat including Ahmedabad, based on water from Sardar Sarovar reservoir is one of the most recent examples of such an approach. While earlier, Ahmedabad city depended on water from Dharoi reservoir, the increasing pressure on this scheme to get water for rural drinking had reduced its ability to meet Ahmedabad’s annual demands.

Thus when the cities grow, the dependability of local resources would become too low for water utilities to provide adequate supplies to the municipal users on a sustainable basis. More importantly, the fast growing urban centres in India are located in semi arid and arid areas experience high variability in rainfall conditions, making the supplies from local water bodies such as tanks, and ponds and wells unreliable. Examples are Pune, Ahmedabad, Hyderabad, Chennai, Delhi, Rajkot, Hyderabad and Bangalore. There are very few urban areas that are located in water-abundant regions. In a semi arid or arid area, if the urban centre taps water for municipal uses from underground sources, the chances of aquifers getting depleted due to excessive pumping are very high as the pumping takes place within small geographical areas creating "cones of depression". This is a phenomenon found in many urban areas around the world including those located in humid climates. Examples are Beijing, Bangkok and Ahmedabad. On the other hand, the tanks and ponds get dried up fast due to heavy diversions. More over, increasing urbanization leads to encroachment of tank catchments for building activities and peri urban agriculture, adversely affecting the inflows from the catchments.

As on today, when the supplies from the tanks around Chennai are compared against that city's water demands, these sources are not dependable for urban water supplies. Hence, Chennai now depends on water from Nagarjunasagar reservoir in Andhra Pradesh. Over-draft of groundwater for municipal uses had led to mining of aquifers underlying Ahmedabad city; with serious water quality problems in terms of high levels of salinity (as indicated by Total Dissolved Solids) and fluoride in groundwater beyond permissible levels. Whereas, Sabarmati river as a source of water for municipal uses ceased to exist due to excessive diversion of water from the upstream reservoir in Dharoi for rural drinking water supply and irrigation. Hence, Ahmedabad city depends on water from Sardar Sarovar reservoir. A similar phenomenon was found in Hyderabad. Earlier, the city depended on the lakes for its water supply needs. Today, with a population of nearly 4 million people, the Municipal Corporation heavily depends on water from Krishna river to ensure good quality supplies.

An analysis of the water supply sources of 302 urban centres representing various classes of cities shows that the dependence on surface reservoirs for water supplies increases with increase in size of the city (Figure 3).

Figure 3: Percentage Dependence (in Volumetric Terms) of Cities of Different Sizes on Reservoirs



Source: NIUA (2005)

5.1 Urban Water Supply from River Basin perspective

Water availability varies drastically in different parts of the country, and so an analysis based on aggregate number of cities would be highly misleading. To get overcome this limitation, we have analysed the basin wise urban water supply data. Rivers have played a significant role in the history of civilisation, and their role in the social, cultural, economic and spiritual lives of Indian population is equally unquestionable. The total land on India can be largely divided in 19 drainage basins. These basins are the home of millions of Indians and the sources of their basic and economic water requirements. Table 1 describes the area and population served by the river basins.

Table 1: Area and Population Served by the River Basins in India, 1999

	River Basin	Catchment Area (km^2)	Population		
			Total (millions)	Density (No./m.^{2})	Urban (% of total)
Basins of the Westerly Flowing Rivers	Indus	321	48.8	140	29
	Mahi	35	6.7	324	23
	Narmada	99	17.9	160	21
	Sabarmati	22	6	521	46
	Tapi	65	17.9	245	37
	WFR1	56	58.9	425	28
	WFR2	378	51.9	166	43
Basins of the Easterly Flowing Rivers	Brahmani and Baitarani	52	16.7	204	13
	Cauvery	81	32.6	389	30
	EFR1	87	19.2	293	26
	EFR2	100	39	484	40
	Ganga	861	370.2	449	25
	Godavari	313	76.7	186	15
	Krishna	259	68.9	253	32
	Mahanadi	142	27.2	202	20
	Pennar	55	14.3	189	22
	Subarnarekha	29	15	347	24
	Brahmaputra	194	33.2	161	14
	Meghna	42	10	160	18
	All Basins	3191	932	282	26

Source: Figures derived based on data available in table 1, Amarasinghe et al., (2005) originally compiled from various sources.

Notes:

- WFR1 = Westerly flowing rivers-Group 1: the westerly flowing rivers in the Kutch and Saurashtra regions of the state of Gujarat, and the Luni river.
- WFR2 = Westerly flowing rivers-Group 2: the westerly flowing rivers south of the Tapi basin.
- EFR1 = Easterly flowing rivers-Group 1: the easterly flowing small and medium-sized rivers between the Mahanadi and Pennar basins.
- EFR2 = Easterly flowing rivers-Group 2: the easterly flowing small and medium-sized rivers between the Pennar basin and Kanyakumari at the southern tip of India.

The Ganga basin has the largest catchment area, and it is also the most populated basin in absolute terms. However, if we compare the rural-urban composition and density ratio, Sabarmati basin surpasses all other basins in the country. 46% population in the basin is concentrated in its urban areas with a density as high as 521 persons/km^2. Its density ratio is almost one and half times more than the average of the all river basins. No wonder that a large chunk of total water harvested in Dharoi dam on Sabarmati River was supplied to cities including Ahmedabad (which is the largest urban centre in Sabarmati basin) until they started receiving the benefits of Narmada water through SSP. Incidentally, all river basins with high population densities such as Sabarmati, Mahi, WFR2, Cauvery, and EFR2 are also characterised by arid or semi-arid atmosphere, and so their environmental characteristics cannot support their urbanization unless water is drawn from other sources. Tables 2 and Table 3 show basin-wise water supply to Class I cities and Class II towns respectively.

The data shows that Class I cities rely more on surface water sources to meet their demand for water. The trend in Class II towns shows that these urban centres still rely on their groundwater sources to an extent. Meeting some part of the total water requirement in Class II towns can be attributed to its smaller population base, and limited economic and political power to draw water from surface sources located outside their municipal boundaries.

The data shows that Class I cities rely more on surface water sources to meet their demand for water. The trend in Class II towns shows that these urban centres still rely on their groundwater sources to an extent.

Table 2: Basin-wise Water Supply in Class I Cities: 1999-00

Major River Basin	No.of Cities	Population	Surface Source (mld)		Ground Source (mld)		Combined Source (ml)		Total Water Supply (mld)	Per Capita Water Supply (Ipcd)
Brahmani	1	398,864	21.56	(100)					21.56	72
Brahmaputra	7	1,415,601	30.37	(20.9)	10.68	(7.3)	104.42	(71.8)	145.47	222
Cauvery	16	8,212,863	231.96	(25.2)	12.9	(1.4)	675.54	(73.4)	920.4	133
Ganga	103	49,478,976	1343.98	(15.1)	732.93	(8.2)	6809.94	(76.6)	8886.85	199
Godavari	25	6,919,320	623.43	(80.8)			147.93	(19.2)	771.36	120
Indus	15	4,192,909	212.75	(28.1)	282.8	(37.3)	262.3	(34.6)	757.85	229
Krishna	27	12,659,457	864.87	(50.3)	4.8	(0.3)	850.03	(49.4)	1719.7	151
Mahanadi	9	2,476,450	221.84	(56.3)	114.35	(29)	58.16	(14.7)	394.35	184
Mahi	3	1,311,534					206.2	(100)	206.2	196
Narmada	4	1,183,593	13.62	(8.5)			147.04	(91.5)	160.66	145
Pennar	6	971,371	50.9	(63.5)			29.2	(36.5)	80.1	86
Sabarmati	7	3,678,921	24.54	(3.7)	22	(3.3)	613.63	(93)	660.17	181
Subarnarekha	2	1,059,883	358.54	(100)					358.54	364
Tapi	8	3,444,041	180.2	(50.6)			176	(49.4)	356.2	128
Sub Total	233	97,403,783	4178.56	(27.1)	1180.46	(7.6)	10080.39	(65.3)	15439.41	182
Coastal	29	23,275,720	3428.93	(84.2)	62.96	(1.5)	579.39	(14.2)	4071.28	200
Non-Major Basin, Non Coastal	37	7,434,362	528.39	(48.2)	298.8	(27.2)	269.36	(24.6)	1096.55	171
Grand Total	299	128,113,586	8135.88	(39.5)	1542.22	(7.5)	10929.14	(53)	20607.24	183

Source: CPCB (2000a)

Table 3: Basin-wise Per Capita Water Supply in Class II Towns: 1999-2000

Major River Basin	No.of Cities	Population	Surface Source (mld)		Ground Source (mld)		Combined Source (ml)		Total Water Supply (mld)	Per Capita Water Supply (lpcd)
Brahmani	1	41,202			4	(100)			4	162
Brahmaputra	9	611,617			17.5	(33)	35.6	(67)	53.1	132
Cauvery	18	1,155,954	7.6	(14.8)	21.1	(41.1)	22.6	(44.1)	51.3	66
Ganga	119	7,903,938	119.1	(15.4)	331	(42.7)	325.3	(42)	775.4	110
Godavari	37	2,405,618	47.2	(29.7)	13.2	(8.3)	98.3	(61.9)	158.7	74
Indus	20	1,336,496			106.4	(61.3)	67.3	(38.7)	173.7	175
Krishna	22	1,464,861	27.6	(23.2)	22.3	(18.7)	69.3	(58.1)	119.2	96
Mahanadi	9	548,883	19.6	(59)	4.7	(14.2)	8.9	(26.8)	33.2	93
Mahi	4	238,770			4	(15.4)	22	(84.6)	26	111
Narmada	5	330,307	10.7	(31.8)	18.9	(56.3)	4	(11.9)	33.6	108
Pennar	5	338,500	0		0		19.2	(100)	19.2	65
Sabarmati	6	342,993	4.5	(11.4)	35	(88.6)			39.5	120
Subarnarekha	2	133,164	5	(54.9)	4.1	(45.1)			9.1	98
Tapi	5	371,292			23.1	(100)			23.1	67
Sub Total	262	17,223,595	241.3	(15.9)	605.3	(39.8)	672.5	(44.3)	1519.1	104
Coastal	16	966,375	12.5	(23.5)	13.4	(25.2)	27.2	(51.2)	53.1	100
No Major Basin	67	4,185,618	53.5	(14.7)	219.1	(60.2)	91.4	(25.1)	364	1 0 1
Grand Total	345	22,375,588	307.3	(15.9)	837.8	(43.3)	791.1	(40.9)	1936.2	103

Source: CPCB (2000b)

Meeting some part of the total water requirement in Class II towns can be attributed to its smaller population base, and limited economic and political power to draw water from surface sources located outside their municipal boundaries.

5.2 Water Supply Scenario in Class I Cities and Class II Towns

Table 4 shows the factors influencing total water supply for cities and towns of India. It clearly brings out two important facts: 1) the level of dependence of larger cities on surface water is much higher than of smaller cities; and 2) the larger cities have higher average per capita water supplies. Further, over the years, the dependence of class I cities for on surface water sources for municipal water supplies had increased, and some improvements in per capita supplies are also seen. Contrary to this, in the case of Class II towns, the dependence of water utilities on groundwater had increased, and some reduction in per capita supplies is observed.

We have estimated multiple regression models based on the available information on urban water supply for 209 Class I cities and 239 Class II towns in India. The results, presented in Table 5, show that population elasticity of water supply (ep) change with time and space. For example, for Class I cities ep with reference to 1981 population is 1.19 whereas and with respect to 1988 population is 1.13. The results show that - a) water supply grows more than the population growth rate. The results also shows that Class I cities have better water supply as compared to Class II towns. For Class I cities and Class II towns together ep is 1.22 with respect to 1981 population and 1.13 with respect to 1988 population. However, the results show the supply side aspects of

Table 4: Decadal Trend of Water Supply in Class l Cities and Class ll Towns in India (1978-79 to 1994-95)

Parameters	Class I cities			Class II Towns		
	1978-79	1988-89	1994-95	1978-79	1988-89	1994-95
Number of Class I Cities	142	212	299	190	241	345
Population (millions)	60.16	102.85	128.03	12.76	20.7	23.62
Distribution of Class l cities according to catchment area						
Major river basins	112	170	233	135	168	262
Coastal	17	23	29	13	20	16
Non-basin, non coastal	13	19	37	42	53	67
Distribution Population of Class I cities according to catchment area(millions)						
Major river basins	42.7 (71.0%)	74.4 (72.3%)	97.4 (76.1%)	9.2 (72.1%)	14.7 (71.0%)	17.2 (72.8%)
Coastal	12.8 (21.3%)	20.6 (20.0%)	23.2 (18.1%)	0.81 (6.3%)	1.69 (8.2%)	2.23 (9.4%)
Non-basin, non coastal	4.66 (7.7%)	7.85 (7.6%)	7.43 (5.8%)	2.75 (21.6%)	4.31 (20.8%)	4.19 (17.7%)
Total Water Supply (mld)	8638	15191	20607	1533	1622	1936
Ground (mld)	784 [9.1%]	3528 [23.2%]	1542 [7.5%]	499 [31.5%]	700 [43.2%]	838 [43.3%]
Surface (mld)	5261 [61%]	11132 [73.3%]	8136 [39.5%]	1018 [64.3%]	814 [50.2%]	307 [15.9%]
Combined ground and surface source (mld)	2582 [29.9%]	531 [3.5%]	10929 [53%]	66 [4.2%]	108 [6.7%]	791 [40.9%]
Per capita water supply (lpcd)	143	148	161	124	78	82

Source: www.indiastat.com

Note: Figure in the parenthesis shows the percentage share in total population of Class I cities
Figure in the bracket shows the percentage share in total water supply

water supply not the demand. It is known that in most of the urban centres in India water supply is not adequate, therefore actual demand for water is much higher than what is supplied. However, this analysis shows that there is need to augment water supply for urban centres as population pressure is mounting up in urban centres and it is mostly Class I cities which is attracting growing urban population. The results show that better water supply coverage significantly influence total water supply, therefore in order to achieve cent percent coverage water supply needs to be augmented from all possible sources. Water supply in urban centres falling in arid and semi-arid regions is worst hit as their water supply is relatively lower.

In order to understand the factors influencing the water supply coverage, multiple regression models were estimated separately for 190 Class I cities and 240 class II towns. Table 6 and Table 7 show that when the share of surface water in municipal water supplies increases, the water supply coverage improves, and arid and semi-arid regions urban centres are more dependent on surface water sources. The regression analysis shows that with growing population in urban centres, it is necessary to augment the water supply for providing better access and coverage for urban dwellers. Current level of water supply is not enough to achieve cent percent coverage; while access to water supply is also meager in many urban centres. In arid and semi-arid parts of

India, urban water supply is in stress and to cope up with population pressure, there is need to look for surface water source to augment water supply.

As size of the cities increases, it becomes difficult for water supply agencies to meet growing demand

Table 5: Factors influencing Total Water Supply (LNWSTOT) in Cities and Towns of India: 1988-89

LNWSTOT	Class I Cities: 1988		Class II Towns: 1988		Class I Cities and Class II Towns: 1988	
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Constant	-12.864*** (0.664)	-12.402*** (0.821)	-6.289 ** (2.509)	-3.656 * (2.13)	-12.922*** (0.431)	-12.182 * (0.627)
LNPOP1981	1.189*** (0.042)		0.64*** (0.224)		1.218*** (0.036)	
LNPOP1988		1.127*** (0.057)		0.396 ** (0.184)		1.13 ** (0.051)
WSCOV	0.019*** (0.005)	0.019*** (0.005)	0.014*** (0.002)	0.014*** (0.002)	0.016*** (0.003)	0.017*** (0.003)
ARID	-0.158 * (0.094)	-0.124 (0.103)	-0.414*** (0.089)	-0.427*** (0.09)	-0.301*** (0.064)	-0.3*** (0.07)
No. of Obs.	*209*	*209*	*239*	*239*	*447*	*447*
Adj. R2	0.746	0.711	0.205	0.184	0.736	0.704
D-W Stat	1.407	1.548	1.816	1.79	1.61	1.614
F -Stat	204.375	171.255	21.447	18.877	416.413	354.158

Note: Figure in the parenthesis shows the White Heteroskedasticity-Consistent Standard Error for the estimated coefficient

LNPOP1981: Natural Logarithm of 1981 Population

LNPOP1988: Natural Logarithm of 1988 Population (estimated)

WSCOV: Percentage of population covered under organized water supply

ARID: Whether the city/town fall under Arid and Semi-arid zone (1, 0)

***, ** and *-imply estimated coefficient is significant at 0.01, 0.05 and 0.10 level respectively.

for water solely from local sources as a result they tap the water from distant sources which are mostly surface water sources (e.g., large reservoirs and tanks). However, in cities like Chennai and Coimbatore of Tamil Nadu, a large number of water vendors supply water mostly drawn from open wells or deep wells due to demand from urban dwellers as their groundwater quality problematic. Water footprint of urban centres in India is growing up and it is mostly away from the urban centres (Kampman, 2007). However, due to growing dependence on distant sources protection of local sources is often neglected (Mukherjee, 2008), as a result Major challenges that water supply sector in India is facing today are not only to meet the large investment requirement to augment the water supply, but also additional investment burden to tackle the water quality related problems.

Multiple regression analysis has been carried out by considering per capita water supply (lpcd) as dependent variable, and water supply coverage, type of climate and share of surface/ground water in total water supply as independent variables. The results show that per capita water supply (in lpcd) goes up as water supply coverage improves and in arid regions lpcd is low. However, factors like of share of surface water to total water supply or share of groundwater to total water supply do not have significant impact on access to water supply. Regression analysis for Class I cities based on the sample survey carried out by NIUA (2005) shows that as

Table 6: Factors Influencing Share of Surface Water Source(s) in Total Water Supply in Cities/ Towns (SHARESW) (in percentage) in India: 1988-89

LNWSTOT	Class I Cities: 1988		Class II Towns: 1988	Class I Cities and Class II Towns: 1988	
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Constant	-82.71 ** (39.682)	-90.443 ** (39.769)	-205.481 *** (72.54)	-40.92 (27.009)	-60.833 ** (25.493)
LNPOP1981	7.987 ** (3.324)			4.429 * (2.339)	
LNPOP1988		8.486 ** (3.272)	18.913 *** (6.387)		6.077 *** (2.166)
WSCOV	0.42 ** (0.173)	0.411 ** (0.173)	0.416 *** (0.152)	0.43 *** (0.114)	0.42 *** (0.113)
ARID	13.847 ** (6.365)	14.073 ** (6.338)	21.639 *** (6.197)	18.124 *** (4.448)	18.26 *** (4.421)
No. of Obs.	190	190	240	414	415
Adj. R2	0.075	0.079	0.092	0.074	0.084
D-W Stat	1.15	1.156	1.245	1.245	1.235
F -Stat	6.107	6.374	8.556	11.924	13.63

Note: Figure in the parenthesis shows the White Heteroskedasticity-Consistent Standard Error for the estimated coefficient
***, ** and *-imply estimated coefficient is significant at 0.01, 0.05 and 0.10 level respectively.

Table 7: Differences in level of access to public water supplies with changes in sources for Class I cities in 1999

Dependent Variable	SHARESW Coefficient	LNWSTOT Coefficient
Constant	-645.11 ** (321.802)	77.779 ** (37.772)
LNPOP1991	240.673 ** (117.256)	-41.995 ** (20.401)
LNPOP1991^2	-20.661 * (10.536)	7.6 ** (3.649)
LNPOP1991^3		-0.441 ** (0.216)
ARID	23.447 *** (7.426)	
No. of Observations	163	163
Adj. R2	0.101	0.672
D-W Stat	1.29	1.669
F-Stat	7.099	111.472

Note: Figure in the parenthesis shows the White Heteroskedasticity-Consistent Standard Error for the estimated coefficient
***, ** and *-imply estimated coefficient is significant at 0.01, 0.05 and 0.10 level respectively.

distance (dist) between drinking water source and urban centres increases access to water supply (as measured by lpcd) improves.

6. SUMMARY AND FINDINGS

An analysis of sources of water supply across urban agglomerations of different sizes shows that as the population pressure on city grows up, dependence on surface water reservoirs for water supply increases. Dependence of Class I cities on surface water reservoirs for urban water supplies is much more than that of Class II towns. In arid and semi arid regions, urban centres are more dependent on surface water sources for municipal water supplies as compared humid and sub-humid regions. Larger urban centres (Class I cities) have greater capacity to respond to the increasing water demands induced by population growth and urbanization when compared to smaller ones (Class II towns), as reflected in the higher values of population elasticity of water supply in the case of Class I cities.

7. LARGE RESERVOIRS: ARE THEY THE LAST OASIS FOR THE CITIES?

Large dams have played significant role in achieving national food security, rural employment, hydro power generation and flood control. Enactment of National Water Policy-2002 has recognised the importance of large reservoirs in domestic and industrial water supply also. The reason is that earmarking water from aquifers for high priority uses like drinking is still not possible through administrative measures due to the common pool nature of the resource. The future population growth, economic development and urbanisation would demand further increase in the role of large reservoirs in domestic and industrial water supply. The counter effects of these developments would be on higher water demands for food production and hydropower generation. In nutshell, the role of large dams is going to be more critical in the years to come.

As it is projected, by 2050 around 45% of India's total population would be living in urban areas (Kundu, 2006). In India, the current domestic water use (urban and rural both) of about 25 BCM is expected to increase up to 67 BCM by 2050 (MoWR, 1999). Moreover, the water supply coverage in urban areas is steadily improving. In 2000 around 69% of total households were covered under water supply system, which has increased at 2% annually during last two decades (GoI 2004, as cited in Amarasinghe et al., 2007). The authors project that most of the urban population will be covered with drinking water supply by 2050. This would increase per capita water consumption even in poor households. Looking at this increasing demand for domestic water supply, it would not be an exaggeration to say that cities would not be able to cope up with their water demands without relying on large reservoirs.

This view has been counter-argued on the grounds that the local water resources including lakes, ponds as well as groundwater are unrestrictedly exploited in process of urbanisation, which resulted into their depletion, pollution and destruction (SANDRP, 1999). The same paper further argues for various options for augmenting water supply in urban India through rainwater harvesting, groundwater recharge and wastewater recycling. Ironically, such arguments are largely based on the success of some individual cases, not sufficient to take decision about replicating them on larger scale. Kumar (2004) shows that roof water harvesting systems would not only be hydrologically and economically unviable in urban areas in most parts of India[4], but also would lead to inequity in access to urban water supplies, if they are subsidized. It points out the small per capita roof area available for urban dwellers and the pattern of occurrence of rainfall against water demand pattern as the major reasons. Another work by Kumar et al., (2006) shows that rainwater harvesting and groundwater recharge offer extremely limited potential in arid and semi arid regions in terms of hydrological opportunity and economic viability.

Notably, suggestions such as institutional reforms, demand management, wastewater treatment, promoting water efficient technologies in production (see Postel, 1992, Brown, 2008) are most welcome. In fact, they are essential to achieve equity and environmental sustainability in longer terms. These interventions would certainly have positive impacts on total water demands of the cities, but in case of India, they can certainly not

[4] Except high rainfall, hilly and mountainous regions.

guarantee non-reliance of cities on large reservoirs. The reasons are - firstly, India has a wide population base, and so urban population growth would remain high in actual terms even when the percentage growth would be minimal; secondly, not necessarily all Class I cities and Class II towns would have enough financial resources and political abilities to implement such interventions successfully; and lastly but not in the least, the growth of cities in arid and semi-arid regions of the countries would always thrust ahead by importing water from other regions. In other words, the growth of cities located in arid and semi-arid regions cannot sustain without large water reservoirs.

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