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SUBJECT II

POLICIES FOR SUSTAINABLE USE OF WATER

Enhancing Sustainable Management of Water Resource in Agriculture Sector: The Role of Institutions*

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I

Growing water scarcity problems, competition and conflicts among users pose a serious policy and institutional challenges to policy makers, water managers and researchers in India. It is rather ironical and immensely unfortunate that a country so beautifully endowed and with such glorious historical tradition of water management is the epicenter of a deepening global water crisis. Population, economic growth and changes in technology had led to rising demand for water for human and livestock consumption, food production and industrial uses, while opportunities for supply augmentation are becoming prohibitively expressive. One of the common issues in the management of water resources in India is the dominance of agriculture as a water user and the political costs of reallocating water away from this sector to others. Designing institutional structures for governing demand and supply management is increasingly important for coping with increased water scarcity and intersectoral allocation. Institutions can be considered as a social tool for management of water scarcity and uncertainty. Institutions are capable of minimising vulnerability, scarcity and conflict and of enhancing sustainable management of water resources. When resource scarcity is high and the competition for resource use is important there can be social demand for reforming the existing technological and institutional structures in order to increase productivity of a resource and optimise co-ordination for their interdependent uses (Hayami and Ruttan, 1971). A few researchers in India studied these issues considering the ecological- cultural-socio-economic interfaces and the dynamics of the embedded institutions concerned with the management of natural and environmental resources. Economists in India however, have not researched adequately the linkages between vulnerability conflict and changes in the institutions

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concerned with sustainable management of water resources and second order water scarcity. First order water scarcity is a lack of water resource itself, while second order scarcity lack designing institutions to management of resources usefully (Mathieu, 2001). Evolving appropriate institutional arrangements is fundamental to solving the water resource management problem (Vaidyanathan, 1999). Privatisation and market allocation of such a basic common pool resource such as water is neither feasible nor desirable, and therefore the government must play a major role, but one which is very different from its current character. It needs to involve user representatives in system management. While the broad directions of the necessary institutional reform are reasonably clear, working out its details and implementing them is far from easy. The design of appropriate institutions in the face of variations in environment, agrarian structure and other related aspects is complex and engineering the reforms is even more difficult (Vaidyanathan, 1999).

This paper addresses policy problems of institutional choices and hierarchy for enhancing sustainable development of water resource in agriculture sector in India and points to some issues that deserve further research.

II

INSTITUTIONAL DIMENSIONS OF WATER USE GOVERNANCE

The institutional economics offers a framework for analysing the governance structures that are required for water resource management in an interdependent situation. A study of institutions focuses on the laws, conventions and working rules of the society that either directly allocate resources or establish the processes and constraints for resource users in an economy to make allocative decisions (Challen, 2002). Institutional concepts used in this paper to understand the water resource management problems are institutional arrangements, property rights structures, entitlement system, authority systems and transaction costs. Natural resources like water and land are managed and controlled through technical and institutional arrangements. The technical arrangements provide tools and knowledge or technological components which define how land, water or other resources are used as factors of production. The institutional arrangements define who can control the resources and how the techniques are applied. Technological and institutional arrangements must complement each other if resources are to be used efficiently and sustainably (Gibbs and Bromley, 1989). The nature of institutional arrangements defines the extent of property regime over land, water and related resources. A property regime is a system or a set of institutional arrangements or working rules of rights and duties characterizing the relationship of co-users to one another with respect to a specific natural resource (Bromley, 1991).

Property rights in resources exist either under state property regime (where the secure claim rests with government) or private property regime (claim rests with individual or corporation) or common property regime (individuals have claims on collective goods as members of organised group) or open access (or no property regime with no secure claims) (Bromley, 1991). An entitlement system can be conceptualised as a quota system that provides a basis for defining shares or parts of a resource belonging to the state and collective or individual entities holding property rights to that resource (Challen, 2002). The basic requirement for any property regime is an authority system (for example, Central or State Governments/panchayats/ resource development committees/user groups/water users associations) that can guarantee the security of expectations for the rights holders (resource users). When the authority system breaks down, a particular resource regime starts degenerating. Under such a situation, new institutional arrangements are used to define the resource regimes over natural resources and the authority systems protect the interests of those (resource users) holding the rights under a particular regime (Marothia, 1997 a). The mechanisms usually exist for adjusting allocation of water entitlements or re-allocated amongst holders of property rights or users. The static and dynamic transaction costs are important in efficient allocative decision of water and changing institutional structures respectively (Challen, 2002). The producers for altering allocations may be broadly categorised as administrative allocation, user-managed allocation and market allocation (Ballabh, 2001, Meinzen-Dick and Mendoza, 1996). These methods are simplistic and a deeper understanding of the institutional choice and hierarchy is needed to determine allocation and mechanism of water and nature of static and dynamic transaction costs.

In the Indian context most of the agricultural technologies and specifically water intensive technologies are adopted by the individual farmers under private property regime and the incentives in terms of subsidised inputs and diffusion of technological components have also been targeted towards private landowners. Individual cultivators under private property regime may over-exploit water, land and other resources and can potentially create spatial and temporal damages (Marothia, 1997 a). Institutional arrangements play a much greater role in the adaptation of water resource conservation technologies, for example watershed management or rainwater harvesting, where collective actions are required for sustainable development of agriculture and other natural resources oriented programmes. Most agricultural technologies including water resource intensive and water resource conservation technologies have an element of interdependence between (among) farmers or between (among) users (Marothia, 1997 a). In an interdependent situation the third party effects are important, transactions costs are significantly high, human and ecological concerns a serious and relevant unique damage function is difficult to estimate, irreversibilities might be important and markets are generally missing if intergenerational issues are involved (Marothia, 1997 a). With full ownership, the owner can prevent others from using, benefiting from or damaging the resource without making compensation. When such uncompensated benefits or damages occur, these are called spillover effects or externalities or interferences. Whenever property rights are not clearly defined or enforceable, externalities or divergences between private and social costs or third party effects arise (Bromley, 1991). It is these market and policy failures which provide the rationale for improvement of institutional structures, property rights, entitlement and authority system for minimising conflicts and competition between and among multiple use and users of water resources. This also becomes necessary to make sure that the current technical and institutional arrangements are not counter productive for sustainable development of water resources. The concepts discussed herein are used in this paper to examine the opportunities for enchanting sustainable management of water resources in the agriculture sector.

III

STATUS OF WATER RESOURCES, INTERSECTORAL USE AND CONFLICTS

According to one water balance study of India, the country receives 400 million hectare metres (mha.m) of rain and snowfall. Out of the annual precipitation of 400 million hectare metres (mha.m), 215 mha.m enter into the soil and 115 mha.m enter surface flow. Out of the surface water flow of 180 mha.m, only 15 mha.m are captured in reservoir and tank storage structures, and 165 mha.m flow into rivers and streams. Only 25 mha.m are finally used through surface irrigation. This constitutes a mere 6 per cent of the total water available through annual precipitation and 20 mha.m flow in as surface water from outside the country (Majumdar, 2000). The per capita freshwater availability has sharply declined in the last fifty years from 6,008 cubic metres to 2,200 cubic metres and in some of the major river basins has fallen to as low as 1,000 cubic metres (Engelman and Roy, 1993). As far as sector-wise use of water resources is concerned nearly 84 per cent of the country's water is used to irrigate agricultural crops. The industrial sector uses about 12 per cent and about 4 per cent of the water is consumed for domestic needs. The average consumption per person per year for all uses is around 680 cubic metres, but, it is projected to increase. Demand projected for water in all sectors put together would be much in excess of total average utilisable water resource.[1]

In his recent study Ballabh (2001) had analysed inter-sectoral water use competition and conflicts. In the absence of well defined property rights regime in river or stream flow surface water resources are *de-facto* open access regime and as a result the riparian doctrine does not encourage socially optimal use of water (Ballabh and Singh, 1997; Ballabh, 2001). The upstream state or region over appropriates water resources, if a river basin cuts across state boundaries, leading to inter-state conflicts (Ballabh, 2001). Conflicts due to industrial and municipal pollution in water streams, irrigation system and diversion of water to cities and municipalities from reservoirs leading conflicts among different use sectors. Competitive deepening of wells for irrigation also adversely affected quantity and quality of drinking water availability in rural areas (Agrawal and Narain, 1997; Ballabh, 2001). Competitive deepening makes the distribution of access to groundwater increasingly skewed in favour of large, resource rich farmers leaving the small farmers at an increasing disadvantage in sharing the benefits of well irrigation (Vaidyanathan, 1999; Ballabh, 2001). In his analysis Ballabh (2001, 2003) came out forcefully with the observation that the political economy of state generally supports to urban rich domestic users, industrial units and rich farmers. The losers are poor farmers, urban poor and people living in disadvantageous rural areas who are unable to meet their basic needs (Ballabh, 2001). It is imperative to design alternative institutional structures to minimise intersectoral conflicts and competition and to work out the static and dynamic transaction costs emanating from such alternative institutional arrangements.

IV

INSTITUTIONS IN IRRIGATION MANAGEMENT

There is widespread agreement about the need to improve irrigation management to enhance the efficiency of water use and sustainability of irrigated agriculture. Researchers indicate that institutional deficiencies are at the root of the water resource management problems. Innovative institutions and management structures are preconditions for tackling the problems of water management. There is wealth of evident supporting usefulness of institutions in sustainable irrigation management. India's freshwater lakes and streams have been used for irrigation through construction of thousands of village ranks and canals maintained by local communities. During colonial rule and even after independence government involvement led to a collapse of some of the village irrigation systems due to problems such as siltation and poor maintenance (Shankari, 1991). Elsewhere in India, private ownership or operation of surface and groundwater use for irrigation has generally replaced collective action. The result is substantial degradation of water resources (Ballabh and Singh 1997; Vaidyanathan, 1999). To this end we discuss the role of institutions in the case of canal, groundwater and tank irrigation systems management.

Canal Irrigation

Investment in canal and groundwater irrigation development[2] has enhanced the productive capacity of land resources which has in turn enabled the nation to achieve steady agricultural growth. However, the impacts of irrigation systems, particularly of canal irrigation, are besieged with a number of management and environmental problems. Management problems related to the allocation and use of water within the distribution network are exacerbated by poor maintenance and degraded infrastructure. Some of the environmental problems associated with the irrigation systems include waterlogging, salinity and weed infestation. It has been shown that the economic gains from surface irrigation in many projects are not commensurate with the large public investments and subsides given to the farmers (Chambers, 1988; Gulati and Narayanan, 2003; Vaidyanathan, 1994; Marothia, 1997; 2002 a).

The physical and technical attributes of canal irrigation put water resource under the category of common pool resources which is used by numerous farmers under the private property regime. Efficient and equitable water distribution of canal water among different categories of farmers (small or large, powerless or powerful, locationally and economically advantaged or less advantaged, etc.) depend upon technical and institutional arrangements. These include rehabilitation of the existing canal irrigation system in terms of modifying the water delivery system, regular operation and maintenance of the created system, conjunctive use of surface and groundwater, careful design of cropping patterns, optimal allocation and appropriate scheduling of water, and greater enforcement (or changes, if needed) of the rules and regulations governing access to irrigation water by the individual farmers (Chambers, 1988; Vaidyanathan, 1994, Marothia, 1997 a). Until recently, the decision-making environment, and incentives facing farmers and irrigation officials were not dealt with sufficiently. A few State governments, practitioners and scholars involved in irrigation management in India have recently begun to realise the limitation of relying primarily on government bureaucracies to solve development and collective action problems and design complex institutional arrangements linking state agencies with local water users. The failure of many large, medium and small irrigation projects to deliver the projected benefits to the farmers beyond pipe outlets clearly indicates the limitation of state control over canal irrigation water. It is, however, now recognised that these technical solutions are not sufficient, involvement of the farmers is key to improve the management effectiveness (Marothia, 1997 a). Further, it is widely claimed that with involvement of farmers in managing irrigation systems either through Participatory Irrigation Management (PIM) or Irrigation Management Transfer (IMT) can effectively arrest the erosion of huge irrigation capital built at a massive investment in this country. In India the impact of water users' associations under PIM model in terms of implementing the equity-based institutional arrangements are mixed. They are functioning effectively in some areas and have failed in others. The key reason for the successful water users' associations (WUAs) may be attributed to the effective functioning of technical and institutional arrangements at the main canal system, below the outlet and at the community/farm levels and continuous efforts to invest in capacity building of WUAs (Marothia, 1997 a, 2002 a). PIM has recently been introduced in Andhra Pradesh, Madhya Pradesh, Chhattisgarh and Gujarat States to empower WUAs (Jairath, 2001, Marothia, 2002 a, Reddy and Reddy, 2002 and Parthasarthy, 2003). The successful adoption of the PIMS requires a complete change in the mindset, and in several cases the officers of Water Resource Department (WRD), members of the managing committees of WUAs and farmers are still in a learning process. Periodic training for official members (superintendent and executive engineers), and nominated and elected members of the committee and farmers is required to educate them about the importance of institutional arrangements to achieve self-governance in canal irrigation systems. The sustainability of PIMS depends largely on political and bureaucratic will to share power with the farmers and create an apolitical environment for the smooth functioning of WUAs (Marothia, 2002 a). Most of the successful cases of PIM were found under a wide range of conditions, such as small size of the command, small number of irrigators, access of markets, no huge income disparity among the irrigators, and no perpetually disadvantaged section such as pronounced head tail conflicts. We need to look not beyond PIM but towards PIM plus. Capacity building of WUAs at all stages is necessary. Simple enactment of PIM law does not guarantee successful PIM. Probe into other aspects of WUAs, such as equity and water rights issues, management implications for a flow system and a lift system, interlinkages between drinking and irrigation water are important (IWMI-Tata Water Policy Program, 2003).

Successful stories of irrigation co-operatives functioning in the command area of the river Tapi in Maharashtra, Mohini Water Distribution Co-operative Society in the Ukai-Kakrapar project command area in Gujarat, Sri Datta Water Co-operative Water Management Society in the Mula irrigation project in Maharashtra, Lower Bhavani Project - Thindal distributary in Tamil Nadu, water users association in Kerala and Paliganj distributary in Bihar are also available to draw lessons for replications (Mahapatra and Rajput, 2002). In most of these cases the State Department of Irrigation facilitated the formation of co-operatives and is still maintaining the main water courses. However, the internal institutional arrangements related to an equitable and efficient water distribution, recovery of the irrigation fees and maintenance and repairs of the canal system are designed and enforced by the members of the societies. In some cases, water users associations have also promoted group farming to enhance the productivity of tiny farm holdings, for example, in Kerala (Mahapatra and Rajput, 2002).

Groundwater Irrigation

The use of the groundwater accounts for over half of the total irrigated area in India. The expansion of groundwater irrigation was largely due to improved drilling and lifting technologies, lower per unit cost of water pumped, massive rural electricity programme, liberal institutional support like credit for exploring groundwater and subsidised supply of electricity.[3] The productivity of irrigation in conjunction with chemical fertilisers and high-yielding varieties (HYVs) is much higher for groundwater as compared to canal irrigation, mainly due to less wastage of water and flexibility to adjust the timeliness and quantity of water distribution to the crops. Studies also indicate that the poor are better represented in the ownership of groundwater related assets. Hence, groundwater irrigation can play an effective role in poverty alleviation programmes (Mukherji and Shah, 2002). However, with the advent of green revolution and rising demand for food, social and livelihood security in the last five decades, the over-extraction of groundwater has assumed serious dimensions. Until recently the government's policies of supporting and promoting private groundwater development were widely acclaimed time and again.

However, there is now a growing concern that the existing policies, if continued may lead to over-exploitation of groundwater particularly in arid, semi-arid and hardrock regions of peninsular India (Shah, 1993; Dhawan, 1995; Vaidyanathan, 1996, Marothia, 1997 a). Further, under the private property rights regime, water markets have emerged in many parts of the country (Shah, 1993). The individual farmers are more concerned with their private gains and costs, while completely ignoring the social cost of over-exploitation of groundwater resource (Joshi 2002; Dhawan, 1995; Vaidyanathan, 1996). At the aggregate level only 50 per cent of the total utilisable groundwater is currently used. It indicates that considerable potential exists for the expansion of groundwater based agriculture. At the micro level, however over-exploitation of groundwater has been observed in many areas (Dhawan, 1995, Gandhi and Namboodiri, 2002). In some areas even drinking water has become a problem due to the excessive use of groundwater in irrigation (Ballabh and Singh, 1997).

Efficient, equitable and sustainable use of groundwater can be achieved through designing technical arrangements relating to spacing regulations, identification of aquifer size of pumps, control on the overall rates of exploitation and supporting institutional arrangements which include rights to water, land tenure, users' relationship, financial incentives, etc. The traditional property rights structure dominated by private property rights needs serious rethinking for judicious use of groundwater. Ownership of groundwater is tied with the ownership of land in India, and the landowners have the right to extract the groundwater beyond any time until it is available (Singh, 1991). The landowner can use the groundwater and market it to other potential users and locations. Property rights to groundwater are complicated due to the fugitive nature of aquifer, the size of aquifers, the seasonal and secular nature of aquifers and the capability of more than one user to tap the same aquifer. Groundwater is thus neither a true open access resource because the ability to extract groundwater is limited by well ownership, not common property resource because it lacks an identifiable group of users having co-equal use rights (Ciriacy-Wantrup and Bishop, 1975; Veeman, 1978, Vaidyanathan, 1999). This puts pressure on the availability of water for competitive uses in irrigation, industry and domestic consumption. Sustainable ecological balance, inter-sectoral water supply, therefore cannot be assumed without simultaneously addressing the inter-linked issues of water. There seems to be an interlinkage between groundwater regulation and drinking water crisis. Political consensus and willingness to legislate on groundwater comes forth only when drinking water is threatened. Under the existing legislative framework the landowner also retains ownership of water underneath the land and the system of water rights is bequeathed future generations despite the fact that ground-water is a shared resource from common pool aquifers. Secondly, the indiscriminate use of bore well technology for groundwater extraction at phenomenon rates, in excess of recharging capacity, fuelled by the growing emphasis on cash cropping irrespective of water availability. Electric pump owners tend to pump for longer durations without any positive impact on crop yields, mainly because the incremental cost of one additional unit of water pumped is nearly zero, given the very low or flat power tariff rates. In direct contrast, diesel pump owners tend to economize on number of hours of pumping (Mukherji and Shah, 2002). Cropping pattern therefore, needs to be adjusted through out the country in consonance with groundwater availability is a particular region. Research and administrative efforts are urgently needed to carry out exploratory studies on several aspects of water rights systems and their adoptability in different agro-climatic regions. The ecological, economic and equity gains with water rights systems could be much more higher than the investment in institutionalising these (Saleth, 1994). Legislative structures, equally important, to manage groundwater through appropriate local organisations and approaches may also help to minimise environmental and equity problems in the long run (Moench, 1994). Current financial incentives provided for power and electricity, diesel oil and credit need to be critically analysed in addition to developing new technical and institutional arrangements (Shah, 1993; Dhawan, 1995; Vaidyanathan, 1996). The nerve centre of groundwater development is not ground-water corporations, departments or boards, but the State Electricity Boards, since it is the supplying of and charging for power that can have the most important impact. The key problem in India's irrigation sector is of building modern, forward-looking, imaginative organisations institutions with high levels of management capacity (Shah 1993, see also Gulati and Narayanan, 2003 for critical analysis of performance of State Electricity Boards and power subsidy issues).

Declining and rising water table are two distinct problems, which are threatening the sustainability of Indian agriculture and has attracted the attention of researchers and policy makers in recent years (Joshi, 2002). Defective irrigation pricing policy is the main cause of both rise and fall in the ground water table. Pricing of both canal water and power is not decided on the basis of economic and ecological parameters but on political considerations, which has a very high social cost (Joshi, 2002, Vaidyanathan, 1996, Marothia, 1997 a). The implications of groundwater mis-management are increase in the irrigation cost, decline in productivity, and widening income disparities. Technological and policy options are available but they need effective implementation. Among the technological options, subsurface drainage and water-saving irrigation methods (like drip and sprinkler systems) are feasible and cost-effective means to control rise in the water table. To prevent fall in the water table, besides water-saving irrigation systems, crop diversification through low water requirement crops can be introduced. Designing an appropriate irrigation pricing policy, withdrawal of all subsidies from canal water charges, and power tariff and transfer them to water-saving irrigation systems, educate farmers and organise a social movement by creating mass awareness about the beneficial effects of collective action in using groundwater, introduce effective legislative structures to control mis-management of groundwater, strengthen the role of co-operatives or group-oriented system, adoption of river basin approach are the effective ways to control externalities related with groundwater (Joshi, 2002, Rathore, 2002, Shah, 1993, Dhawan, 1995, Vaidyanathan, 1996, Veeman, 1978, Saleth, 1994, Marothia, 1997 a, Kumar, 2001). Institutions like Pani Panchayats should be replicated on a large scale particularly in groundwater scarcity zones for an efficient and equitable distribution of water, promoting a less water intensive cropping pattern and effective enforcement of the rules and regulations by Panchayats (Deshpande and Jyotishi, 2002). Groundwater can be efficiently managed through drip and sprinkler irrigation technologies under common property regimes if supported by use rules for water users. These technologies are being adopted on a large scale by private landowners. It is important to expand the manufacturing capacities of sprinkler and drip irrigation systems to meet the growing demand as well as to keep the prices under check so that the full benefit of the financial incentives could be passed to the farmers (Marothia, 1997 a). We will discuss this issue further in the later part of this paper.

Tank Irrigation

For several centuries, tanks have been central to socio-ecology and irrigated agriculture in the states of Andhra Pradesh, Karnataka, Tamil Nadu and Chhattisgarh. Tanks are, however, disappearing fast, and those that remain have long since fallen into disrepair. Decades of siltation, poor organisation and management, decline of compulsory labour contribution in maintenance work, inadequate operation and maintenance budget from the government, meagre revenue from tank based activities (social forestry, fisheries, duck-and goat-rearing, grazing leases, poor collection of irrigation fees), growth of wells in tank command areas and well owners' reduced interest in tank management, and encroachments have contributed to their decline (Shah *et al.*, 2002, Palanisami and Balasubramaniam, 2002). Most of the tanks in Tamil Nadu (Shah *et al.*, 2002 and Palanisami and Balasubramaniam, 2002) and elsewhere (see, Rao and Chandrakanth, 1984, von Oppen, 1985, Marothia, 1992) have degraded into open access due to weak institutional arrangements, property rights structures and breakdown of the local authority system (see also Marothia, 1992, 1993; Vaidyanathan, 1997). In several parts of India tanks have been used as resource conservation technology for irrigation and domestic activities since centuries.

Irrigation tanks in India before independence were managed and controlled under private property regimes. After Independence ownership rights in private tanks have been abolished and vested with State Governments but the tanks are used by village communities as common pool resources for irrigation and in some cases for aquaculture and domestic activities. These common pool resources degenerated into open access due to evolution of modern irrigation systems, alteration of organic relationship between tanks and tank committees, poor management, non-contribution of labour or capital resources by users, absence of well defined structures of rights and duties with respect to water rules, regulations and acts and the breakdown of village panchayats authority system to protect the water users' rights. In several dryland areas of the country this traditional technology has been promoted for water harvesting through rainwater management. Irrigation tanks have been constructed by the state department of agriculture or soil and water conservation or irrigation department, and have been handed over to the village panchayats for their management to provide supplementary irrigation at the critical crop growth stages. In some cases these tanks were hooked with the canal irrigation system for water refilling (Marothia, 1992). These tanks are degenerating due to weak technical and institutional arrangements and the non-existence of resource users' authority (Marothia, 1992; 2002 b; Singh, 1994; Palanisami and Ramasamy, 1997).

Tank rehabilitation should be a demand-driven programme instead of a donor-driven programme. Donor-driven programmes have only a short timeframe. Thus even well intentioned non-governmental organisations (NGOs), which would like community participation in donor programmes, end up doing nothing but physical rehabilitation (see Shah *et al.*, 2002 for evaluation of tank revival programme implemented by PRADAN - a Madurai based NGO to promote community based management).

Looking at tanks at the watershed level would give a good idea about the extent of resource (water) availability and multiple stakeholder conflicting interests. The watershed approach can effectively replace the open access management regime to common property resource regime. Also to increase the gross tank productivity, entitlement systems need to be worked out with well designed and supported institutional hierarchy[4] as tanks are multiple use common pool resources. Tanks are important not only as sources of irrigation but also in the urban context. In urban areas they help in recharge as well as drainage of rainfall water. But many of the tanks in urban areas have been filled up. The need to look at tanks in the urban context still holds because of the rapid urbanisation (Marothia, 1997 b).

V

TRADITIONAL RAINWATER HARVESTING

India has an enormous amount of water - theoretically as much as 173 mha.m which is lost as evaporation or becomes soil moisture - which can be captured directly as rainwater or as runoff from small catchments in nearby villages or towns. Capturing the flood water of major rivers can further increase the water availability. Local water harvesting and small water structures have been part of Indian rural communities and understanding of property rights over water relates more easily to rainfall then to diverted water. In a study Centre for Science and Environment (CSE) advocates that for drought proofing and ensuring drinking water supply the answer lies in decentralised rainwater harvesting, CSE estimated that the average area for India needed as a whole is 1.14 ha/villager in normal rainfall year and double in a drought year (Agarwal *et al.*, 2002).

Rainwater harvesting and watershed development can meet the people's basic needs as also improve food and livelihood security. The main objectives of the rainwater harvesting or watershed development are to optimise land use patterns, to conserve the soils and water resources through controlling erosion to manage the land and biological resources so as to control land degradation, to recycle run-off water to boost up the production of food and non-food crops, fuel, fodder and timber and to improve the conditions of the resource users as well as village communities (Marothia, 1997 a). To achieve these objectives, the basic problem in effective implementation of watershed management is that its functional area typically consists of land owned and cultivated by the individual farmers largely under private property regimes and to some extent under community lands, from which villagers get fuel, fodder, small timber, which are operated either under common property regime or have resulted into open access due to decay of institutional arrangements. Collective action by resource users is required to adopt the technical components with well designed institutional structures relating to decision-making arrangements and patterns of interactions. The combined effects of these have implications on the outcomes of the programme in terms of efficiency, equity and sustainability (Marothia, 1997 a, Vaidyanathan, 1994, Chopra and Kadekodi, 1991, Singh, 1994).

Community and NGO-based experience of Sukhomajiri, Ralegaon Siddhi, Tarun Bharat Sangh, PRADHAN, Sadguru Water and Development Foundation and other organisations have shown that the transformation process from a state of ecological poverty to a state of sustainable economic growth demands community participation with multi-faceted dimensions and strategies (Agarwal and Narain, 2002, see also Shah, 2003 for natural resource and poverty linkages). The work of the Rajiv Gandhi Watershed Development Mission in Madhya Pradesh also shows that the government agencies can learn from community-based management experiences and replicate on a large scale. In all the three cases of Sukhomajiri, Ralegaon Siddhi and Tarun Bharat Sangh village-level institutions played a crucial role in developing institutional arrangement and applying them for sustainable management of the created water resource and equitable access to the resource generated by the total village population. Multi-layered institutional development structures were created in the villages for decision-making and implementing the applied programme with participatory democracy rather than representative democracy (Agarwal and Narain, 2002). To manage water as common pool resources and to understand poverty water interface it is imperative to design an integrated village ecosystem planning with a high order of democracy in the decision-making for ecological regeneration, create appropriate community-based property rights, provide village institutions directly with financial grants to increase productivity of water and other common pool resources and to induce village institutions to raise substantial funds by organising these resources (Agrawal and Narain, 2002 and Ballabh and Thomas, 2002).

VI

WATER SAVING TECHNOLOGIES

Rationalising water prices, regulating water markets and most of all treating water as an economic resource, hold the key to adopt water saving technologies. Drip and sprinkler irrigation technologies have appealed to large and commercial farmers for cultivating plantation and high value crops. In recent years, attempts have also been made by NGOs to adopt these technologies and promote them as income-livelihood-creators for the poor in water scarce areas of the country (IWMI-Tata Water Policy Program, 2003).

Drip-irrigation technology covered a very small area of the potential 40 million hectares, and that the spread was largely concentrated in high value commercial crops despite being tried and tested for success and high economic benefits in terms of improved yields, moisture retention, cost reduction and labour saving for different crops under varying agricultural conditions (IWMI-Tata Water Policy Program, 2003).

The farmers do not adopt micro irrigation technologies for water saving; rather they adopt them when irrigation becomes difficult owing to water or power scarcity. Better-off farmers are generally not concerned about water saving issues and technologies as they have the money to fulfill their needs through other supply side alternatives while the poor do not have enough investment ability to shift to other water sources. Low cost technologies are suited for those regions where the well yield is low and crops are under moisture stress. Comparative costs and benefits of drip adopters, flood irrigators and Pepsee adopters are locational-specific in nature. Micro irrigation technology need to be linked with on-farm water harvesting schemes as many farmers do not have access to irrigation (IWMI-Tata Water Policy Program, 2003).

Affordability, supply chain, water, credit, power and electricity pricing and availability, awareness, market linkages and income levels are the major issues in scaling up micro-irrigation technology to the masses (IWMI-TATA Water Policy Program, 2003).

VII

INTEGRATED RIVER BASIN MANAGEMENT

In recent years irrigation experts and political leadership have placed a heavy emphasis on transferring of water from one river basin to another with a view to meeting the requirement of water-short areas. Issues in transferring successful river basin management models, evolved over centuries in European nations, U.S.A. and Australia, to India have received serious attention of print and electronic media, concerned citizens, academic circles, NGOs, water activists and economists. In a recent Water Policy Briefing of International Water Management Institutes - (IWMI -

Tata Water Policy Program, Shah (2002) discussed the challenges of Integrated River Basin Management (IRBM) in India. According to Shah (2002) in most of the developing countries these models have failed because they are not designed to deal with the climatic and hydrological conditions, demography, socio-economic and strong community institutions for managing monsoon rains. In India water management centres on rainfall, not managed water. The approaches to water rights in the developed countries, where IRBM has been introduced, depend on concentration of water users along rivers and streams. In India such institutional arrangements are not appropriate as millions of people pumping groundwater and large communities depend on tanks, small rainfed wells and traditional water structures. The informal water sector is central to sustainable and productive use of groundwater and surface water. In most of the developed countries, most users receive their water from organised public and private service providers licensed by the government. The water sector is well supported with water law and water prices (Shah, 2002). In India, on the other hand, most water users get their water directly from community storage tanks or ponds, municipal corporation without any significant interventions from public agencies or organised service providers. These institutions have not been working too well in India. The real issue in India is how to enforce water law and introducing water prices in an informal sector. The high transactions cost of monitoring water use and collecting charges from a large number of small scale users are the central issues. The NGOs and water users association under PIM have to play a significant role to bring users into the formal sector. Shah (2002) further raised the issue of improving the productivity of green water, i.e., harvesting rainwater and maintaining soil moisture and to manage groundwater intertemporally in the given informal sector with low-cost drip irrigation and micro-tubes technologies for groundwater utilisation. According to Shah (2002) it is imperative to understand the local institutional structure and consequences form transformation of institution designed in developed countries to rural village of our country to achieve IRBM.

VIII

ISSUES FOR FUTURE RESEARCH

To ensure sustainable water use it is crucial to conduct good research on frontline issues in water management and translate those research outcomes into actionable policy recommendations and for creating awareness among the water users and managers. In this section we have identified the following important issues for the future research.

1. For the effective operation and maintenance of canal network, higher recovery of irrigation fees, and for the timely and equitable distribution of water to the farmers located in the different zones of command area of water users association participatory irrigation management system (PIMS) or Irrigation Management

Transfer System (IMTS) have been implemented in a few states of India. Both state government and NGOs have initiated PIM and the results of these institutional reforms are mixed in terms of achieving objectives of the farmers participation and collective action. Further analysis is required to design institutional arrangements for 'PIM plus strategies' for vitalising irrigation sector in India.

2. Several aspects of groundwater management including the role and likely impact of pricing of power and electricity subsidy to agriculture, increasing level of cross subsidisation, differential impact of power pricing and supply policies on different sections of the society, over-estimation of power consumption in agriculture, performance of state electricity boards legal and regulatory tools, and alternative governing structures and mechanism, participatory approaches in ensuring efficiency, equity and sustainability need to be understood.
3. Tanks are used by village communities as common pool resources for irrigation and in many cases for aquaculture and domestic activities. Tanks today lie in the state of disrepair due to rapid adoption of pump irrigation technology in the command and catchment areas of tanks which in turn have basically altered the organic relationship between tanks and tank users communities. A few state governments also initiated PIM through water users association to improve the performance of tanks in terms of water allocation and distribution, water fee collection and infrastructural maintenance and repair. However, to improve the gross tank product the existing entitlement systems, possibilities to alter the property rights structures and mechanisms for adjusting tank water among different users (fishermen groups, farmers, domestic users) have to be understood in different agro-climatic and socio-ecological conditions.
4. The community-based water harvesting paradigm still has great relevance to meet the basic water requirements in rural and urban areas. Documentation of success stories of traditional water harvesting practices in different agro-climatic conditions will help to distil or draw lessons for their potential replicability under common property regime or shared resource management system.
5. Micro-irrigation technologies have potential water savings in water scarce areas and for building livelihoods. Research efforts are required to understand the dynamics of parameters which may promote this technology on a large scale for resource poor farmers. Methodological framework is also required to be developed for scaling up micro-irrigation technologies.
6. Significant opportunities to develop small-scale irrigation from small perennial streams exist all over the hilly and undulating regions of India. These regions are the homes of large tribal population. India's irrigation development strategy by and large has not exploited this opportunity to a significant extent. Research efforts are required to understand the appropriate design and strategy for programmatic intervention to develop these regions. There are very few studies available as to why the institutional base in tribal areas is so poor and how this

could be rebuilt and that there is a need to articulate institutional building in the tribal context for irrigation interventions keeping in view their property rights, entitlement and authority systems.

7. Despite growing awareness that effective community based irrigation planning and management approaches require to take into account gender concerns, women water requirements and interests are often not adequately understood either due to land ownership structures and underestimation of their participation in household and other activities. Explicit studies are required on the impact of irrigation on gender role in agriculture in terms of irrigation related conflicts and resolution, women's participation in water users association formed for canal, lift irrigation, watersheds, groundwater based water groups, and equal control of women over water resources and greater participation in decision-making.
8. Very few studies have been conducted to assess the impact of irrigation on rural communities and on how irrigation schemes - minor, medium and major - help to reduce rural poverty in India. Understanding has also to be developed on how the present design and management of irrigation projects can help in reducing poverty. How irrigation can make a significant contribution to poverty alleviation by direct as well as indirect ways through greater labour absorption and by attracting migrant labourers from unirrigated areas? Any impact analysis of irrigation on poverty, should take all three stakeholders landless, land owners and those who lease-in land into analytical framework to probe the interlinkages.
9. River linking for integrated river basin management (IRBM) seems to the top priority for water policy makers and political leadership in India today. Are IRBM models designed in developed countries capable to deal with the hydrogeology, demography, socio-economics and community-based approaches to water management and problems of informal water sector? Economists are required to carry out well informed research for addressing the challenges in transferring IRBM in the Indian context.
10. In a few states of India multinational companies have been assigned rights and control over water resources for domestic water supply and utilising river water for soft drinks and water trading. In World Trade Organistion (WTO) framework water is being placed under trade services. Economists must play a significant role in creating an understanding for socio-economic, cultural, political consequences of trading water as services and privatising water in the Indian context.
11. Even after enactment of Water Acts and water pollution control laws, water quality continues to deteriorate in the rivers, canals, tanks, village ponds, streams and groundwater. The main sources of water pollution are domestic sewage, industrial effluents and agriculture run-off. Arsenic and fluoride contamination have emerged as a big problem in some parts of the country. The efforts should be directed towards understanding the groundwater-drinking water linkages and quantifying the socio-economic impact of arsenic and fluoride contamination of

groundwater. Alternative technologies for wastewater treatment, economic incentive structures to minimise pollution to the prescribed standards, role of Central and State Groundwater Boards and State and Central Pollution Boards, water pollution control laws need a hard look. Despite the enactment of laws, water pollution continues unabated, predicating to a clear failure in policy and legislation in their implementation. Indepth multidisciplinary research efforts are required to design a comprehensive water quality management strategy, which may include input from environmental engineers, agricultural economists, natural resource economists, water technologists, legal experts and development practitioners from NGOs and civil society.

12. Institutional choice can be considered as a cost-effective analysis of alternative institutional arrangements attempting to minimise static transaction cost (cost of making and executing allocation decisions) and dynamic transaction costs (cost of altering institutional structures or transferring property regimes) of water allocation decisions among multi-users and sectors. It is important therefore to address the issues associated with static and dynamic transaction costs that may emerge in different allocations of property rights structures across the multiple levels of institutional hierarchy and decision-making by different parties in different sectors in regard to water use. Institutional choices may also have long-term consequences in terms of sustainable environmental externalities and socio-economic value of water resource.

NOTES

1. As per Ministry of Water Resources, demand for water in increasing rapidly due to agricultural, industrial and population growth. It is predicted that agriculture would probably require 770 billion cubic metres (bcm) of water by the year 2025 to support food demand in India (Chitale, 1992) and the total estimated demand of 1,013 bcm by the year 2025 would be nearly equal to the current available utilisable water resources of India. As per the lower bound on demand projected for water in all sectors put together, it will increase from 644 cu.km in 2010 to 1,214 cu.km in 2050. Similarly, as per the higher bound projected water demand, it will increase from 733 cu.km in 2010 to 1,674 cu.km in 2050. Total water requirement would be much in excess of total average utilisable water resources of 1,086 cu.km (Government of India, 1999). To meet the future demand for drinking water, several programmes have been implemented to cover all rural and urban population during the Ninth plan (Government of India, 2003).

2. See irrigation section of *Economic Survey 2002-03* (Government of India, 2003) for irrigation potential to be created during Tenth plan. Details of financial allocations and proposed restructuring in the irrigation sector are also discussed therein.

3. See Gulati and Narayanan (2003) for details on power subsidy and outcomes of power reform.

4. For example in case of Chandeli Tanks (Satpathy *et al.*, 2002) of Tikamgarh district (Madhya Pradesh) and village irrigation tanks of Chhattisgarh (Marothia, 1990) fishermen's co-operative societies have significantly contributed to the sustainability of irrigation tanks. These two cases suggest for comprehensive tank management authority system which include entitlements system, i.e., right for fishing as well as selling water for irrigation under common property regime.

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