Irrigation Impacts on Income Inequality and Poverty Alleviation

Policy Issues and Options for Improved Management of Irrigation Systems

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Irrigation Impacts on Income Inequality and Poverty Alleviation: Policy Issues and Options for Improved Management of Irrigation Systems

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Contents

Tables

Figures

Summary

This study explores the conceptual and policy issues relating to the impact that irrigation has on crop production, farm income, inequities in income distribution and poverty alleviation. It also focuses, specifically, on poverty issues associated with head-tail water distribution inequity in an irrigation system.

Improved access to irrigation infrastructure will increase crop yield, agricultural production and farm income within a region. However, the nature and scale of feedback effects associated with irrigation access and their impacts on farm income and poverty reduction process are not yet clearly understood or reported in irrigation literature. The literature has focused more on the direct impacts of irrigation (increased crop yield and farm income), but not on indirect impacts like rural employment and economic multipliers associated with the provision of irrigation in a region. Likewise, a little explored topic is how exactly irrigation infrastructure affects inequalities in income distribution and the poverty status of a region (system). Equally, the feedback effects and the nature of secondary benefits associated with this process are also unexplored. In the context of decreasing real world market food prices over the last two decades, the secondary benefits of irrigation provision are increasingly receiving central focus in irrigation investment decision-making. In fact, these secondary benefits are now considered more important than the direct benefits of an irrigation project.

From the synthesis of results presented in contemporary irrigation literature and the evidence provided in this paper, we conclude that improved irrigation access is a powerful instrument for reducing rural poverty in a given region. This is not so much through the direct impact of increased yield and farm returns *per se,* but more through indirect impacts like increased rural employment and the feedback and multiplier effects associated with the provision of irrigation infrastructures. The scale of multiplier effects generated in an irrigated agricultural society depends upon the level of backward and forward linkages operating in the particular regional economy, i.e., the nature and scale of interlinkage within and among rural enterprises and the interlinkage with market infrastructure. In other words, increased crop yield is a necessary condition but not the sufficient condition for poverty alleviation in a region. The impact of irrigation on poverty reduction depends upon the structure of a rural economy and on how the additional farm income generated by improved access to irrigation is actually spent within a rural economy, and its feedback impacts on rural employment and rural wage structures. Therefore, the level of economic multipliers operating in a regional economy is crucial in determining the impact of irrigation on the poverty status and the inequalities in income distribution within that particular economy.

The focus of policy-makers in the irrigation sector has now shifted to issues like irrigation water management, participatory decision-making and institutional reform in the irrigation sector, environment management for system sustainability and more equitable distribution of benefits across irrigation systems and across agro-environments. All these changes are visible in efforts at reducing the level of *governmental failures* and *market failures* associated with managing irrigation commands. The underperformance of canal systems has further aggravated the income gap and the relative poverty level within irrigation systems, leading to an unequal distribution of irrigation benefits across sub-systems. In reality, the wealth creation and trickle down effect aimed at alleviating poverty in irrigated areas is not happening in the originally envisaged manner. Therefore, additional direct public policy interventions and more pro-poor institutional and policy reforms

are required. This will help minimize the differential distribution of benefits across sub-systems and farmers, and increase the social benefits and well-being provided by the provision of irrigation infrastructure. Ultimately, irrigation is a typical public good, either directly provided or largely subsidized by governments for overall social well-being.

The restructuring of irrigation commands could be achieved through reforming of institutional, technical, managerial and operational factors. Some of the institutional reforms are: improved stakeholder participation in resource use decision-making, participatory irrigation management (PIM), irrigation management transfer (IMT), defining clear water rights and water entitlements and self-enforcement of efficient service fee collection mechanisms. Some of the technical factors for improving water allocation across sub-systems are better water control structures, laser leveling, lining of canals, improved water storage systems, conjunctive use of rain, canal and groundwater, etc. Likewise, some of the managerial and operational factors involved here are: better enforcement of existing rules and regulations to minimize the lawlessness seen in irrigation commands, improved operation of systems, tailoring the irrigation operation and maintenance costs based on incremental benefits generated and level of water uses in the system, targeted additional financial and credit interventions in the system considering the need of tail-end farmers for additional irrigation equipment, and improving field structures and water storage.

Introduction

Historically, irrigation originated as a method for improving natural production by increasing the productivity of available land and thereby expanding total agricultural production—especially in the arid and semi-arid regions of the world. Availability and access to irrigation was considered essential for crop production, asset creation and expansion of development frontiers. Rapid expansion of irrigated areas in the recent past, coupled with availability and access to new technology—high yielding varieties (HYV), fertilizers and tubewell and water extraction mechanisms—in the late 1960s and 1970s were major underlying factors for the success of the green revolution in Asia. Better access to irrigation infrastructure facilitated intensification of cropping practices and inputs used, thus paving the way for the "modernization" of the agricultural sector.

Irrigated agriculture is one of the critical components of world food production, which has contributed significantly to maintaining world food security and to the reduction of rural poverty. About 17 percent of global agricultural land is irrigated and contributes about 40 percent of the global production of cereal crops (WCD 2000).[1] The total irrigated area in the world was 266 million hectares in 1997, which is 250 percent more than it was in 1950 (FAO 1998). The per capita per year cereal production in developing countries has increased from 200 kg during the early sixties (1961-65) to more than 260 kg in 1997. This is despite the fact that world population has increased from 3 billion to 6 billion during the same period—close to 5 billion in the developing world alone (FAO 2000). In addition to food security, irrigated agriculture significantly contributes towards generating rural employment and maintaining rural livelihoods, which is particularly important in the context of declining real world market food prices during the last two decades.

Some of the Asian economies have succeeded in increasing agricultural production significantly over a short span of time by accelerated provision of irrigation facilities. Irrigation infrastructure is one of the critical factors for improving agricultural production, farm incomes and rural wealth (capital) accumulation. The massive investments in irrigation infrastructure in India, China and Pakistan in the 1960s and the 1970s and their success in achieving food self-sufficiency were also driven by the same underlying philosophy. These countries have succeeded in reducing the scale of poverty to a large extent. The upliftment of mass populations above the poverty line (in absolute numbers of people as well as in relative terms) in some of these Asian countries, with the overall success of poverty reduction due to irrigated agriculture, is considered one of the significant achievements of the 20th century—unprecedented in the past.

Roughly 60 percent of the rice production and 40 percent of the wheat production in developing countries comes from irrigated land; thus the success of irrigated agriculture and better irrigation access has large implications for poverty reduction and maintenance of food security in a nation. However, the benefits of irrigation have been severely questioned by the World Commission on Dams in its report on "Dams and Development" (WCD 2000). The WCD report spells out the negative performance of multipurpose dams for irrigation and their impacts on irrigated agriculture. The report explicitly says, "dams designed to deliver irrigation services have typically fallen short

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[1]There are no authentic statistics available on the net contribution of irrigated agriculture worldwide, which are acceptable to all. Despite some controversies, the WCD statistics, however, can be considered as the lower margin of benefits of irrigation while the upper margin could be much larger than reported here.

of physical targets, did not recover their costs and have been less profitable in economic terms than expected" (WCD 2000). The underestimation of the total benefits of irrigated agriculture by WCD, particularly failing to account for any of the indirect benefits of irrigation in the face of declining world food prices, has spurred on several debates—both for and against the efficacy of irrigation projects and the use of water resources in irrigation. The actual contribution of irrigated agriculture to global food production, maintenance of food security, rural livelihoods and the overall well-being of society are issues that are debated now.

Irrigation development is not free from controversies. It has been argued that irrigation development in various regions has displaced marginal and poor farmers and have made them landless laborers and ultimately driven them to become urban dwellers (Chambers 1988). Likewise, the social disruption of rural poor due to large-scale irrigation systems and reservoir construction, payment of inadequate compensation to displaced persons and increased incidence of water-borne diseases in irrigation commands are other potential negative impacts associated with irrigation development. Increased waterlogging and soil salinity buildup due to poor provision of drainage facilities in irrigation systems are also often cited as negative environmental impacts of irrigation.

However, the positive impacts of irrigation infrastructures could far outweigh some of these negative impacts, which can be potentially minimized or can be duly compensated through improved planning and management of irrigation systems. The total benefits and distributional impacts of irrigation services depend upon the nature and type of irrigation infrastructure: whether it is a large irrigation command, or a minor tank irrigation scheme or a tubewell irrigation scheme. Some studies conducted in South Asia have shown that the benefits of groundwater are more equitable than large-scale surface irrigation systems (Sampath 1990; Shah 1998, 2001; Chambers 1988). The cost of irrigation water per unit of the land is sometimes nearly 20 times higher in the case of groundwater irrigation than in surface irrigation (Shah 2001). Despite this, farmers are increasingly expanding groundwater use because of its reliability, timely availability, control on demand and due to less transaction costs involved.

The recent institutional and financial sector reforms in pump-set and tubewell marketing in eastern Uttar Pradesh, India, and its success in expanding groundwater irrigation, indicate the importance of transaction costs and the incentive structures involved in farmer's choice of irrigation services (Shah 2001). In other words, the transaction costs of doing business and the underlying institutional structures have a significant role in influencing irrigation impacts, income growth and distribution of incremental benefits across locations and across sectors (large-scale or small-scale farmers). In turn, the underlying institutional structures also shape the relationship between irrigation, income distribution, levels of relative and absolute poverty and the poverty alleviation strategies in a region.

The main objective of this paper is to explore the conceptual and theoretical issues involved in irrigation impacts and their distribution across locations, and their implications for equity and poverty reduction strategies in an irrigation system. The paper also critically reviews some of the selected literature on irrigation and income inequity in relation to water allocation, and explores the opportunities and options for institutional and policy reforms in general, and in relation to improved water allocation and management within an irrigation system in particular. Despite the importance of several social and environmental costs associated with irrigation systems, our discussion in this paper is mostly limited to exploring the relationship between irrigation impacts and income inequality, and its feedback effects on poverty alleviation.

Socioeconomic Impacts of Irrigation

In addition to increasing crop production and farm and family incomes, improved irrigation access significantly contributes to rural poverty reduction through improved employment and livelihoods within a region (Chambers 1988; Barker et al., 2000). Indirect benefits, such as more stable rural employment as well as higher rural wage rates, help landless farm laborers obtain a significant share of the improved agricultural production. In addition to yield improvement and intensive production practices, better irrigation infrastructure and reliable water supply also enhance uses of other inputs like fertilizers and HYV. This intensification of agricultural practices generates additional employment opportunities in the rural sector. The irrigation induced benefits are not limited to farming households but also affect broader sectors of the economy by providing increased opportunities to growing rural service sectors and other off-farm employment activities (Mellor 1966). Examples of such opportunities are, additional employment creation for landless laborers in agro-industries, rural marketing and other off-farm activities like house construction and basic infrastructural building. In turn, this feedback process increases the demand for employment manyfold and generates additional wealth creation and/or capital accumulation in the rural sector. All of these benefit processes create transformation within rural and urban sectors, and their feedback mechanism in an economy has significant importance in designing location-specific poverty reduction strategies.

The total beneficial impacts of irrigation development, both direct and indirect, can be summarized under the following categories:

1. Increased crop production (yield improvement) and increased farm income.

2. Increased cropping intensity and crop diversification opportunities and the feasibility of year-round crop production activities.

3. Increased farm employment—more employment opportunities for farming families as well as for hired laborers in the locality.

4. Increased farm consumption and increased permanent wealth (permanent asset accumulation due to irrigation). This has significant implications for reducing intrinsic food insecurity in a region.

5. Reduced food (crop) prices allowing access to food for all, which is more beneficial to landless and subsistence families and provides better nutrition intake. This is also equally beneficial to urban poor and city dwellers, since they spend more than 50 percent of their daily income on food items.

6. Reduced friction in the rural economy and reduced transaction costs including reduced farm marketing costs due to increased access to farm link roads and to other improved farm and non-farm related services in the region.

7. Multiple uses of water for bathing, washing, livestock and home gardens.

8. Increased recharge of groundwater, easy access to groundwater and less drudgery for women in fetching water for daily household needs.

9. Aesthetic and recreational benefits accrue out of irrigation facilities.

10. Increased farm income (for farmers) and increased farm and off-farm employment opportunities for rural landless laborers result in better school attendance of children of farm laborers and improved social capital in society. This is due to the *income effects* of irrigation, since education is still a luxury compared to other basic needs: foods, clothes, shelter, health, etc.

11. Export tax revenue accruing to government coffers; this is important particularly for the major agricultural (rice) exporting countries like Thailand, Vietnam, USA, etc.

Improved rural infrastructure always coincides with irrigation facilities. This greatly reduces transaction costs and rural marketing costs and other frictions associated with the farming sector. The benefits generated by these activities are also called indirect benefits of irrigation investments. These indirect irrigation benefits, usually intangible, are not fully captured by farming communities alone; rather, they are shared by larger sections of society. For example, lower food grain prices benefit poor urban and rural landless communities more by enabling them to purchase required food items at affordable prices. Keeping food prices at relatively low levels also greatly assists the industrial sector to avoid the pressure of increasing the real wage rate. In this process, improved agriculture indirectly subsidizes the industrial sector of the economy as well.

The full benefits of irrigation are not only captured by farmers, but are also spread to wider sections of society—also called positive externality effects of irrigation access to society. These externality effects are the unintended income (also employment) equivalent of welfare changes brought about by the irrigation project. The extent of such irrigation induced positive externalities, or spillover impacts of irrigation benefits, is much wider in scope in large-scale irrigation projects—contributing significantly to the regional and national development pace of a country. The farming sector alone cannot capture all the benefits of external effects of reduced friction and transaction costs in the rural economy, as they are economy wide impacts. In addition, these reduced transaction costs have other feedback chain effects on the development of new institutions and the emergence of new socio-political orders in the rural economy.

All of these direct and indirect benefits achieved through irrigation access are difficult to quantify and value in monetary terms. Many of them are even harder to pin down and they also depend upon several other underlying institutional and structural factors and the benefits vary from system to system. This creates difficulties in identifying and delineating irrigation costs to the actual project beneficiaries or the service users. This high exclusion cost (costs to exclude members from service use once it is there) is the underlying factor for treating irrigation services as a typical public good type of resource. These indirect and intangible benefits have a large implication for management, and investment and financing decisions in the irrigation system. The level of complexity involved in identifying (and valuing) these intangible impacts of irrigation access and high exclusion costs prohibit private sector provision of the service, which are some of the reasons for societal involvement in provision of irrigation infrastructure almost everywhere in the world throughout history.

Indirect or Secondary Impacts of Irrigation

The decreasing trend in real world market food prices during the last two decades has shifted the focus of public sector irrigation investment focus from the objectives of increased food production and maintaining food security levels to rural employment generation and other indirect impacts. Also, other objectives equally considered in irrigation investment are, non-farm sector growth, regional development and rural poverty reduction. An expansion of off-farm activities (inputs and outputs markets) and related service sectors (rural financing) in the rural economy due to increased demand for goods and services will greatly facilitate the expansion of rural employment and effective demand in newly developed irrigated regions. This also leads to significant wealth creation in the irrigated region compared to the rainfed situation. These secondary level impacts or indirect economic impacts of irrigation in a regional economy are also called the *multiplier* impacts of an irrigation project (system).

There are several kinds of irrigation induced linkage effects in the rural economy, such as forward linkages (in the farm products market), backward linkages (in the farm inputs market) and adjustments for the shadow prices of the inputs and outputs in the economy (feedback effects from foreign exchange rates). The difficulty in quantifying and measuring all these indirect impacts of irrigation is still one of the major limitations in economic impact analysis (or in project analysis). Particularly, issues like reduction in transaction costs and institutional development type of tertiary level linkage effects, improved quality of life and improved livelihoods, etc., are difficult to identify. In the past, analytical techniques like In-put and Out-put (I-O) models and the Social Accounting Matrix (SAM) were used to capture some of these direct and indirect economic impacts and multiplier effects of an irrigation project within a regional context (Bell et al. 1982; Powell et al. 1985). These are however, mostly done in a relatively advanced economy where the market transactions are easy to identify and quantify in monetary terms.

Irrigation Multiplier Impacts

Assessment of multiplier impacts is an important task in (economic) impact analysis. The concept of the multiplier is more useful in assessing the impacts of an irrigation project to capture the project (system) related total effects in a regional context. The multiplier is the ratio of the total impacts of a project to the initial (or direct) impact; hence it is usually more than one in value terms. In that sense, the multiplier estimates for system wide impacts (stimulus) are brought about by an additional induced demand (i.e., outside targeted intervention). In other words, the multiplier captures the total impacts of a project, i.e., the sum of direct effects, indirect effects and induced effects in the region (economy) resulting in change in final demand or a change in final output. In fact, the magnitude of the irrigation multiplier varies from economy to economy based on the characteristics of the underlying system, the existing structure and the level of forward and backward linkages in the economy and landholding patterns (degree of skewness) in the region.

There are several kinds of multipliers based on the type of specific direct impacts. Some of the more relevant ones in the context of an irrigation system are economic multipliers, resource multipliers and environmental multipliers. Economic multipliers are for estimating the linkage effects in relation to economic activities such as assessing total economic activities like

employment, income, population, housing, marketing, etc. Resource multipliers are for estimating linkage effects in total resource uses (water, land, etc.,) in related sectors like agriculture, domestic and industrial over the basic resources used in the production system. Likewise, environmental multipliers are for assessing the linkage effects associated with total resource quality (water pollution, soil degradation, etc.,) related impacts.

The varying nature and magnitude of irrigation multipliers across regions based on the underlying, location-specific, environmental, structural and institutional factors are some of the major reasons for differential irrigation impacts across systems. In turn, this also determines income inequality across systems, and across reaches within a system. Therefore, a proper understanding of the nature and size of these multipliers associated with an irrigation system (project) is an important step in managing irrigation agriculture in a more equitable and desirable way from the societal point of view. At the same time it helps increase system productivity. Therefore, the relative success of an irrigation project in poverty alleviation and the upliftment of rural poor largely depends upon the magnitude of multiplier impacts generated by the project. Employment multiplier effects and interlinkages in different sectors of the rural economy also determine the level of total impacts generated by an irrigation project (system).

There are only a few available studies that measure the total impact on an irrigation system. These studies have found a very large percentage of indirect impacts in relation to direct impacts associated with irrigated agriculture (Bell et al. 1982; Powell et al. 1985). In fact, Powell et al. (1985) estimated an irrigation induced multiplier of more than 6 for irrigated areas in the New South Wales (NSW) region of Australia. This means that, one dollar worth of output generated in irrigated agriculture would create more than five dollars worth of value added to the regional economy of NSW in the form of other related goods and services and employment (i.e., multiplier impacts). Using the Social Accounting Matrix (SAM) and Input-Output (I-O) analytical techniques, they also estimated that employment worth one dollar on irrigated farms in NSW would be complemented by a further 3.75 dollars worth of employment in related activities giving a total employment value of 4.75 dollars. This means that the employment multiplier of irrigated farming is 4.75 in magnitude in the context of the NSW regional economy. Likewise, Bell et al. (1982), in a comprehensive impact analysis in the Muda valley irrigation project in Malaysia, estimated that for every dollar of value added by the irrigation project to the regional economy, another 83 cents were generated in the form of downstream or indirect effects (multiplier of 1.83). The large variation of the magnitude of the irrigation multiplier also indicates the effects of existing forward and backward linkages (degree of market development) on shaping the level of irrigation impacts in the economy.

Comparison of Effects in Irrigated and Unirrigated Agro-environments

The total impact of irrigation can be best assessed by comparing two agro-environments, which are similar in all aspects, including endowment of resources, except in access to irrigation infrastructure. Bhatia (1991) reported the scale of irrigation impacts by comparing the performance of farm financial indicators across irrigated and unirrigated regions in the state of Bihar, India. He showed the extent of variation in gross margin, net farm family income as well as the structures of farm expenditure between the irrigated and unirrigated regions in Bihar (table 1). The data and indicators in table 1 clearly demonstrate the extent of irrigation impacts on the degree of farm intensification and the level of inputs used in farms, and in turn the difference of farm income between the two agro-environments. The level of additional net income or incremental benefits

because of improved irrigation access was Rs 2,511 per hectare. This means that the farm income in irrigated areas was 77 percent higher than the income in unirrigated regions of Bihar. The difference in farm income between these two regions has large implications for farm capital accumulation and wealth creation across the two regions.

Table 1. Gross income (Indian Rs/ha), farm expenditure and net income of irrigated and unirrigated farming areas in Bihar, India: 1985.

Indicator	Irrigated region	Unirrigated region	Additional net income of benefits from irrigation
Gross Income			
Rice (1 ha)	5,217	2,434	2,783
Wheat (0.8 ha)	3,221	2,016	1,205
Total	8,438	4,450	3,988
Farm Expenditure			
Fertilizer	1,646	115	
Irrigation cost	72		
Other materials costs (seeds, fertilizers, etc.)	2,676	7,95	
Total cash expenditure	2,664	1,187	
Net farm income			
Return to farming family	5,774	3,263	2,511

US$1 = Indian Rs 12.5 in 1985/86.
Source: Bhattia 1991.

The differences in economic and management performance of the irrigation sector across the two states of Bihar and Haryana in India, and their implications on the variation of wealth creation and per capita income in these two states are presented in a comparative setting in table 2. The difference in the set of aggregate level farm returns and irrigation management indicators between the two states clearly demonstrates the extent of irrigation impacts in the development of a region. The gross cropped irrigated area as a percentage of the total gross cropped land in Haryana is nearly double that of Bihar, and the per capita income in Haryana is nearly triple that of Bihar. The per capita income reflects the accumulative wealth creation impacts of agriculture and other sectors of the economy in a state (region). Interestingly, the difference in per hectare returns to farm family resources from irrigated land is not so high between the two states (a difference of 6%). In fact, per hectare net family returns from unirrigated land is much higher in Bihar (over 50%) than in Haryana. However, there is a large difference in the average annual per capita income between the two states, largely because of the difference in irrigation access and farm infrastructures and also because of other related institutional management factors between the two states.

Likewise, more than half of the rural population in Bihar was below the poverty line, while it was only about 15 percent in Haryana in the early 1980s (table 2). This also reinforces our hypothesis that the performance of irrigated agriculture and the scale of its access in a region is very crucial to poverty alleviation, as discussed in earlier sections. The table also indicates that

the farmers in Haryana are getting more benefits and also paying more for water service than in Bihar. Improved access to irrigation and better-managed irrigated infrastructures add to additional wealth creation, and has a large impact on poverty alleviation and the improvement of livelihoods in a region.

Table 2. Comparison of irrigation impacts based on variation of irrigation sector related profiles in the states of Bihar and Haryana, India: 1980/81.

Indicators	Unit	Bihar	Haryana	India average
1. Average size of land holding.	Hectare	1.11	3.58	2
2. Net irrigated crop area as % of net sown area	Percent	36	58	28
3. Gross irrigated area as % of irrigated total cropped area	Percent	32	60	29
4. Per capita income	Rs	870	2,331	1,537
5. Annual irrigation charge set by public agency	Rs/ha	72	105	
6. Net returns to farm family resources	Rs/ha			
Irrigated farm		5,774	6,109	
Unirrigated farm		3,263	2,140	
7. Additional net income, or incremental benefits of irrigation	Rs/ha	2,511	3,969	
8. Rural population below poverty line (1983/84)	Percent	51.4	15.2	40.4
Irrigation management indicators				
9. Total of payments (direct and indirect) for irrigation by farmers	Rs/ha	43	98	
10. Estimated benefit recovery ratio in public irrigation services	Ratio	2.9	2.6	
11. Total direct and indirect payments for irrigation by water users as % of net returns to the farm family resources	Ratio	1.2	1.7	

Source: Bhattia 1991 and Narayanamoorthy 2001.
Notes: 1. We have estimated some of these indicators based on data provided in different sections of the papers by Bhatia (1991) and Narayanamoorthy (2001).
2. US$ 1 = Indian Rs 8 in 1980/81.

Similar differences in agricultural production, farm income and socioeconomic factors between irrigated and unirrigated agro-environments are also reported in cross-country analyses based on a number of Asian village studies. Table 3 provides recent evidence of relative performance of irrigated and rainfed agriculture in selected Asian countries (Vietnam, India and Sri Lanka), based on data collected from village-level and household surveys held recently. It is clear from the table that crop yields (t/ha), cropping intensity, gross value of product (GVP) per hectare and gross margins are significantly higher in irrigated agriculture than in rainfed agriculture in all the countries. The difference in cropping intensity between irrigated and unirrigated agro-environments has large implications for secondary benefits of irrigation like rural employment and the poverty status of a region. Because of low cropping intensity, out migration from rainfed agro-environments, or poorly managed irrigated systems, to intensively irrigated zones is common in Asian rural economies. The states of Haryana and Punjab, the hub of the Green Revolution belt in India, have

been attracting hundreds of thousands seasonal farm laborers from as far as West Bengal and Northeast India, more than 2000 km away from Haryana and Punjab, during rice and wheat plantation and harvesting seasons. Some of the secondary benefits of irrigation are indirectly transmitted thousands of kilometers away from the irrigated systems through labor mobility.

Table 3. Relative performance of irrigated and unirrigated agriculture in selected countries in Asia.

	Vietnam (US$)			India-Chattisgarh (Indian Rs)			Sri Lanka (Sri Lankan Rs)		
	Rainfed	Irrigated	% Increase	Rainfed	Irrigated	% Increase	Rainfed	Irrigated	% Increase
Cropping Intensity (%)	63	194	68	102	152	33	95	157	39
GVP per ha.	348	654	47	11,023	15,493	29	10,034	19,403	48
Cash Cost	206	366	44	3,217	5,487	41	10,864	12,895	15
Gross Margins	130	318	59	7,806	10,006	22	-829	6,519	112
Rice Yield (t/ha)	2.78	4.81	42	3	4	25	3.2	4.5	40

Notes: GVP = Gross Value Product.
Figures are derived from the following sources:
Vietnam: Ut, Hossain and Janaiah 2000.
India, Chhattisgarh: Janaiah, Bose and Agarwal 2002.
Sri Lanka: Based on IWMI survey in Ruhuna basin 2000 (in progress).
Primary source: Economic and Political Weekly, December 30, 2000.
Currency rates: US$1 = Indian Rs 47 in 2000.
                      US$1 = Sri Lankan Rs 83 in 2000.

Irrigation and Declining Food Prices:
Implications for Poverty Alleviation

Declining real world market food prices is one of the main factors for the reduced rate of expansion of irrigated areas during the late 1980s and the 1990s, unlike in earlier decades. Declining food prices have also created less incentive for national governments and international development agencies to provide additional funding to the irrigation sector. The real world price of rice dropped from US$ 1,050/mt in 1974/75 to US$ 200/mt in 1998 (at 1995 US$ value); in other words, the real price of rice has dropped more than 75 percent during the last 25 years.[2] Similarly, the real price of wheat in the world market has declined from US$ 500/mt in 1975 to US $ 175/mt in 1996, more than a 65 percent decline in real terms over the last 20 years. The level of decrease in world food prices is, in fact, the result of the higher rate of expansion of world food supply compared to the rate of increase of food demand caused by population growth. During the period from 1960 to 1990, global cereal production has expanded by more than 100 percent, whereas global population expansion is around 70 percent (FAO STAT 1998). Timely access to irrigation infrastructures in the past was one of the main reasons for the level of increase in food production worldwide, along with other contributory factors like timely availability of HYV, fertilizers and other technologies.

The reduced price of food grains in world markets is one of the reasons for the recent reduction of rate of returns from irrigation projects, limiting the incentives provided by governments, development agencies and private sector investment to the irrigation sector. Kikuchi et al. (2001) have estimated that the benefit-cost ratio of irrigation construction investment in Sri Lanka as a whole had picked up more than 3.5 points in the mid-1970s and then sharply declined to a level of 1.5 in the mid 1990s. The slack crop prices in Sri Lanka, and in the world market, was one of the major factors for such a declining benefit cost ratio and declining additional investment in the irrigation sector in the recent past. This is equally applicable to several other countries in the region. The benefit-cost ratio of an irrigation project is in fact a very important criterion for the justification of new investment in the sector, which is very sensitive to fluctuation in output prices.

Declining real world market food prices also have large implications for the level of cost recovery and service charge set in a system. Issues like who should pay what for improved irrigation access in a region are important. Due to the inelastic nature of demand for food, farmers are not the only beneficiaries of increased food production in the face of declining food commodity prices. Rather, a larger section of society benefits from improved irrigation and expanded crop production. Direct benefits of irrigation accrued at farm level, such as increased crop yield and farm income, are often only a small fraction of the total benefits to society. An irrigation impact study in Alberta and Saskatchewan, Canada, reported that only 15 to 20 percent of the total benefits of irrigation development go to the farming sector in terms of increased agricultural production, with the remaining incremental benefits of irrigation projects realized by wider sections of the society (Hill and Tollefson 1996). The widespread secondary benefits of irrigation include rural employment and economic activities induced in the region. Moreover, these secondary benefits induced by irrigation are usually not valued when deriving the rate of return of the project. Their importance, compared to direct benefits, has been increased in the face of declining real world

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[2]The world market prices of rice and wheat are from data compiled by IWMI researchers in the past.

market food grain prices. More than five times additional secondary benefits compared to primary benefits were reported in the Canadian project. This has large policy implications on cost recovery policy and the level of service fee set in an irrigation system and in the efficient sharing of irrigation service costs across different sectors of society.

The sharp decline of real world market food prices in the recent past also has large implications on poverty reduction and improving food security and food access to poor and marginal communities. Lower food prices have reduced vulnerability (risk on access to food) associated with distribution of food and its access among poor and marginal communities. "Inadequate access", or "lack of entitlement," over resources needed for food and survival are some of the root causes of poverty. Recently, issues such as "lack of entitlement" and "inaccess" to basic resources have assumed renewed focus in poverty reduction strategies, especially after Nobel laureate Sen's (1982) contribution to the topic of inequality and entitlement over food and other resources in society. According to Sen's (1982) version, poverty is increasingly seen as a state of lack of entitlement and deprivation of some minimum fulfillment of elementary capabilities. It also has both absolute and relative aspects. This "inadequate entitlement" or "inaccess" to resources is particularly more relevant in understanding the nature, gravity and structure of poverty across communities, as well as equally applicable to the distribution of resources (water) within an irrigation system.

Understanding the secondary impacts of irrigation and the economic multiplier and output as well as employment multipliers, is more meaningful in resolving some of the puzzles on the nature of the relationship between access to irrigation and poverty situation in a region. Irrigation is linked mostly with the alleviation of rural poverty, which is the most predominant form of poverty in developing countries. However, irrigation also indirectly affects urban poor by providing food commodities at affordably low prices. By and large, rural sector off-farm activities (like village crafts, and agro-services) are not internationally tradable but these activities produce domestically consumed goods and services, except plantation agriculture practices like, tea, coffee, rubber, etc. However, these off-farm activities are very labor-intensive in nature and are therefore effective in spreading farm sector benefits to the landless rural poor. To further enhance the effective domestic demand for these sort of off-farm goods and services, the overall economy has to generate increased absorption capacity, which the increased farm income will create because of its scale and nature of spread within the economy (Mellor 2001). Considering the scale of farming activities in developing countries, increased farm products and farm income due to improved access to irrigation will help create mass scale expansion of the effective demand for these non-tradable goods and services. The feedback mechanisms and linkage effects associated with expanded domestic demand from mass scale increased farm income and rural employment will help alleviate poverty at a much faster pace (Mellor 2001,1999).

A recent empirical analysis on poverty from long duration time series data in India has reported that the ratio of long run elasticity of rural poverty to average farm yield is around 1.93 (Datt and Ravalian 1998). Likewise, some of the empirical studies on the relationship between poverty and income growth by the World Bank's economic growth research team have reported that the elasticity of poverty reduction with respect to income increase is around 2 (a synthesis of these findings is presented in Mellor 2001). This means that, for a nation with 50 percent of its population below the poverty line, an economic growth that increases per capita income by 4 percent per year will bring down the percentage of population below the poverty line from 50 to 42 within a year. However, this type of massive scale of poverty reduction can only be achieved if growth is more pronounced in the rural sector, and if the distribution of rural land and rural wealth is less skewed (Mellor 2001). The elasticity of agricultural sector growth to poverty reduction is much

higher than the elasticity of industrial sector growth due to the extent of expanded effective demand associated with rural sector growth. This is because of the relatively more labor-intensive nature of the agricultural production process compared to the manufacturing sector. The above discussion reinforces the importance of feedback relationships between scale of employment generation and poverty alleviation within a region, as discussed in the earlier sections.

Distributional Consequences of Irrigation

The question of whether, in the past, the benefits of irrigation have accrued to wider sections of society has not yet been answered adequately. The existing literature on this topic is either ambiguous or unconvincing (Chambers 1986; Chambers 1988; Chitale 1994; Sampath 1990). Irrigation induced inequality depends on several locally specific factors like the structure of irrigation—whether it is surface systems (canal or tank), or groundwater systems (deep tubewell, or micro pump sets). Several studies have reported that surface flow irrigation has produced higher inequality in the distribution of benefits across farms than lift irrigation (Sampath 1990). The effect of unequal distribution of irrigation benefits becomes severe when it is coupled with skewness in landholding. Due to highly skewed land distribution, large farms can obtain disproportionately large shares of incremental benefits from irrigation development—both in relative as well as in absolute terms. For example, small farms in India constitute about 46 percent of the total rural households, but they only get access to 15 percent of the total irrigable land and 14 percent of the total canal-irrigated area. However, larger farms (more than 4 ha), representing the top 12.5 percent of the households, get about 40 percent of the total canal-irrigated area and 38 percent of the total irrigated land (Sampath 1990). However, the situation is different in lift irrigation and groundwater uses. Empirical evidence on lift irrigation in India and Bangladesh has shown that privately operated lift irrigation is more equitable in irrigation distribution than canal irrigation in general (Sampath 1990; Shah 1998; Shah 2001).

In addition to constraints originating from the social structure, such as skewed distribution of land, the cropping patterns also greatly influence income distribution. The distribution of income benefits from new irrigation projects depends on whether the crops grown are capital intensive and high value plantation crops like rubber, coconuts, etc., and/or labor intensive crops like vegetables and cereals (rice and wheat). If the labor-intensive crop area is expanded with improved access to irrigation, rural poor will get a relatively greater share of incremental benefits from irrigation development. This will occur through expanded employment opportunities, stabilized and secured employment due to increased crop intensity, increased rural real wage rates, etc. The nature and magnitude of these employment opportunities originating from access to irrigation have large implications for the reduction of poverty and income inequality within a region.

The economic impacts of irrigation in a region are shown conceptually in figure 1. Region A is the rain fed environment and region B represents the irrigated environment. The vertical axis represents the average family income in monetary terms whereas the horizontal axis represents the time development horizon of irrigation. It is clear from the figure that the average income of region B is higher than that of region A. This increase in income is largely due to increased cropping intensity, increased crop yields and increased rural employment.

As shown in figure 1, inequality levels may rise (or fall) as income grows through improved crop productivity in the irrigated area—which again depends upon the structure of the economy. However, based on the Kuznetian economic theory, income inequality may increase at least in the short run (Kuznets 1955), but it would improve in the long run due to trickle-down effects. The policy goal, at least in the case of an irrigation command, is to reduce this income inequality to a level accepted by society through appropriate institutional and policy changes in the irrigation system operation, and through improved maintenance and overall management of irrigation systems. This would help the poor and marginal sections of society to gain from the benefits of

the windfall (irrigation infrastructure) provided by government. The ideal goal should be to move society towards an equitable distribution path, as shown in region C, by appropriate institutional and policy changes. By doing this, even the average income of society could be increased without any negative impacts on productivity growth—a "win-win" situation for all.

However, such institutional and policy changes presented in figure 1 are only a hypothetical situation. In practice, there are always winners and losers when a policy is changed or an institution that is already in place is reformed. There is a rent attached to any institution in a given place, and any change in such an institution or a policy will shift the relative positions of existing beneficiaries. The losers will always oppose institutional changes unless they are properly compensated in the process. Implementation of such a "pro-poor" targeted institutional and policy reform, in reality, is always a difficult task and needs a high level of political commitment.

Figure 1. Irrigation impacts and income inequality in unirrigated and irrigated agriculture.

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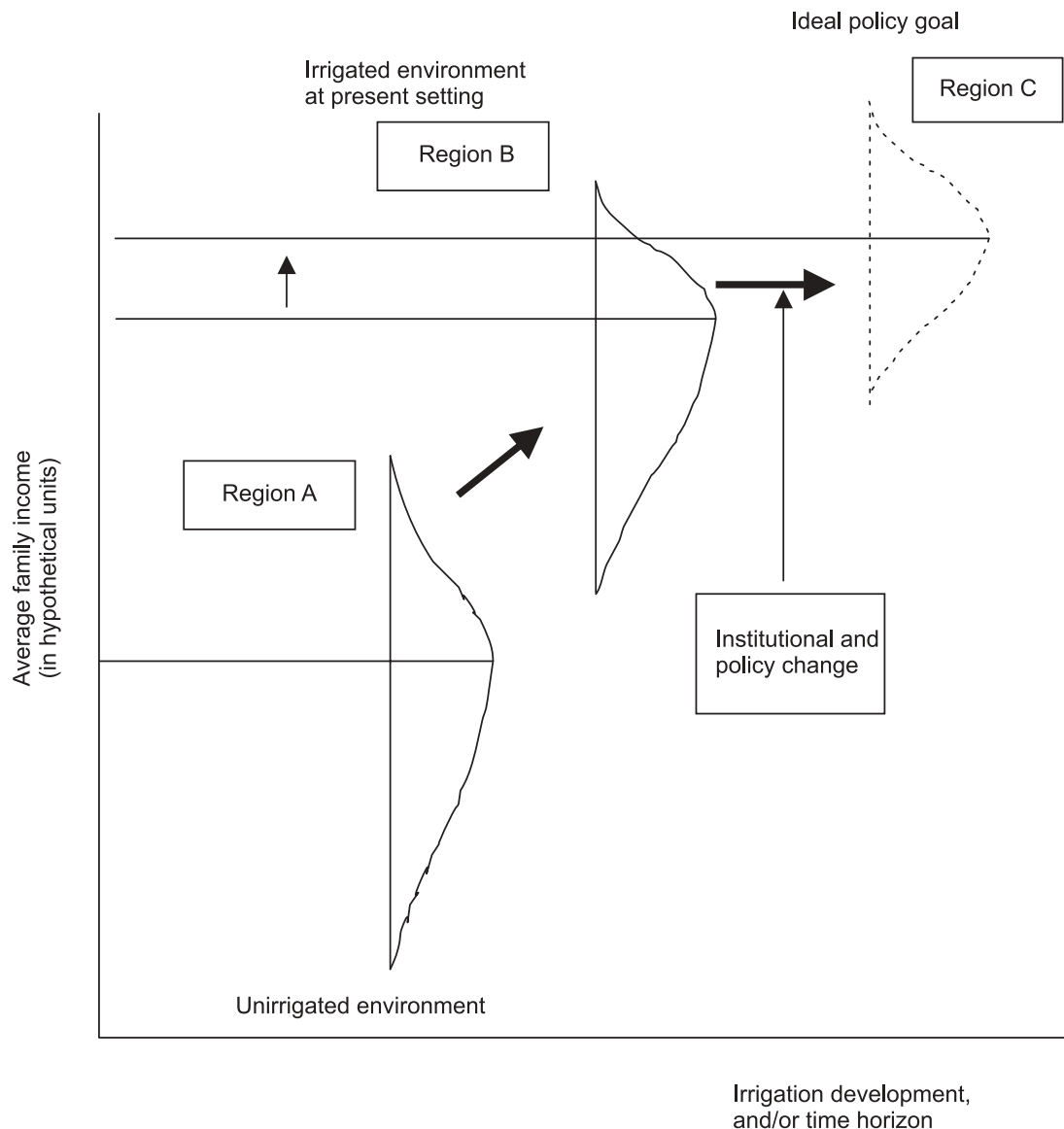
However, income inequality in the irrigated area compared to the unirrigated area could deteriorate or improve depending upon several underlying structural and institutional factors in society such as landholding skewness and economic structures. Some of these factors may not be associated with productivity improvement per se. Access to irrigation may actually decrease income inequality—mainly through increased rural employment and trickle down effects of the growth process. The literature available on quantification of such employment and indirect impacts of irrigation are sparse (Chambers 1988; Mellor 1999; Bell et al. 1982).

There is evidence emerging that irrigation has contributed significantly to increasing farm income, reducing income inequality and reducing poverty in irrigated agriculture in Asia (table 4). For example, recent research led by IRRI in India (Bihar and Madhya Pradesh/ Chattisgarh regions), Philippines, Thailand and Vietnam suggests that the incidence, depth and severity of poverty is substantially lower in irrigated and agriculturally developed areas compared to unirrigated and less-developed areas (Thakur et al. 2000; Janaiah, Bose and Agarwal 2000; Hossain, Gascon and Marciano 2000; Isvilanonda, Ahmed and Hossain 2000; Ut, Hossain and Janaiah 2000). Income inequality measured using the Gini concentration ratio[3] indicates that, on average, income inequality in irrigated agriculture is much less than in rain-fed agriculture. Similar trends have been observed in Bangladesh. Hossain, Sen and Rahman (2000) found that " benefits of expansion of irrigation and technological progress have been fairly equally distributed in irrigated environments compared to nearby rainfed environments in Bangladesh."

Table 4. Recent evidence on the incidence of income inequality and poverty in irrigated and unirrigated agriculture.

Country	Irrigated agriculture			Unirrigated agriculture		
	Head Count	Poverty Gap	Gini CR	Head Count	Poverty	Gap
	(%)	(%)	(%)	(%)	Gini	CR
Vietnam (1996)	17.9	5.7	0.46	60.6	33.4	0.49
Thailand (1998)	20.8	10.8	0.53	55.8	31.8	0.61
Philippines (1997)	30.0	11.0	0.31	39.0	16.0	0.35
India, Bihar (1996)	34.3	10.0	0.29	65.7	33.4	0.40
India, Chattisgarh (1996)	38.0	5.4	0.30	55.0	13.3	0.34

Note: Gini CR is Gini Concentration Ratio.
Source: Figures obtained from various articles and special issues in Economic and Political Weekly, 30 December 2000.
Vietnam: Ut, Hossain and Janaiah 2000.
Thailand: Isvilanonda, Ahmed and Hossain 2000.
Philippines: Hossain, Gascon and Marciano 2000.
India, Bihar: Thakur et al. 2000.
India, Chhattisgarh: Janaiah, Bose and Agarwal 2002.

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[3]The Gini concentration ratio on income indicates concentration or level of skewedness of per capita income among various income groups; greater the value of Gini concentration ratio, greater the level of income inequality.

Alternate Policy Options

Some alternative conceptual policy strategies for reducing the income inequality associated with irrigation development are shown in figure 2. These strategies have large implications on poverty alleviation and designing of pro-poor policy prescriptions for an irrigated agriculture. The curved lines in regions A and B in figure 2 represent the income share of the number of households (farmers) and are drawn on a numerical scale to better explain the characteristics of each of the policy criteria for poverty reduction strategies (income inequality reduction). The vertical axis represents average household income level (hypothetically) and the horizontal axis shows the number of households. Region A represents a typical unirrigated environment has a certain level of income inequality due to underlying structural factors like landholding skewness, social factors, etc. Irrigation access, no doubt, will increase the average income of the locality and will move the locality into region B—as shown in figure 2. For example, the region could move from the situation of line AB in the rainfed environment (region A) to line A^oB^o in the irrigated environment (region B) with the same proportionate level of income increase for all the households. This scenario will maintain the same income inequality level in region B as it was in region A earlier, but with a higher level of average income for each of the households and for the region as a whole.

Policy instruments for correcting income inequality and/or poverty alleviation strategies will be different in nature, depending upon the goal of poverty reduction objectives chosen by society. Each of the policy objectives or policy criteria will have different policy instruments and so their implications to society may be different. For example, we can potentially move curve A^0B^0 to A^1B^1, with all individual members (farmers) of the systems moving upward in equal proportion, and uplifting the poor households above the absolute poverty line, compared to the earlier situation. Assuming that the 100 scale (in figure 2) is an arbitrarily set poverty line of the locality, the above strategy would reduce poverty but would not reduce existing income inequality in the society. For example, yield improvement technology, similar research across the board and extension services are neutral types of policy strategies, through which all members of society, in principle, get equal benefits. Benefits obtained from such strategies are also proportionate to the existing landholding structure. As given in figure 2, there could be a range of other policy alternatives for uplifting poor households in the system, within the line segment between A^0B^0 to A^1B^1. The attempt to move household income towards A^0B^2 represents a typical strategy of pro-poor targeted policy, since this policy is targeted only to the upliftment of the lower income households. At the same time, this sort of policy will also potentially reduce income inequality in the region. The Gramina bank type of rural credit system and "Work for Food" type of rural development program come under this sort of pro-poor targeted intervention in the rural development sector. Landless and marginal poor farmers, in the long run, may get large benefits out of the increased farm employment in a better managed irrigation system which helps to reduce poverty at a faster rate. Detailed discussions on employment effects of irrigation can be found in Chambers 1988 and Mellor 2001. The extent of employment-induced benefits depends upon the type of crops grown (capital intensive or labor intensive) and the nature and scale of linkage effects (multipliers) in the economy.

Po-poor targeted policies in irrigation systems, particularly in relation to water allocation between the head reach and tail reach, could be institutional measures (IMT and reforming water users associations), technical measures (community storage systems, tubewells, lining and piped distribution) or managerial measures (providing subsidized loans to targeted households, trading

Figure 2. Framework for analyzing income inequality, poverty, and policy interventions in canal systems.

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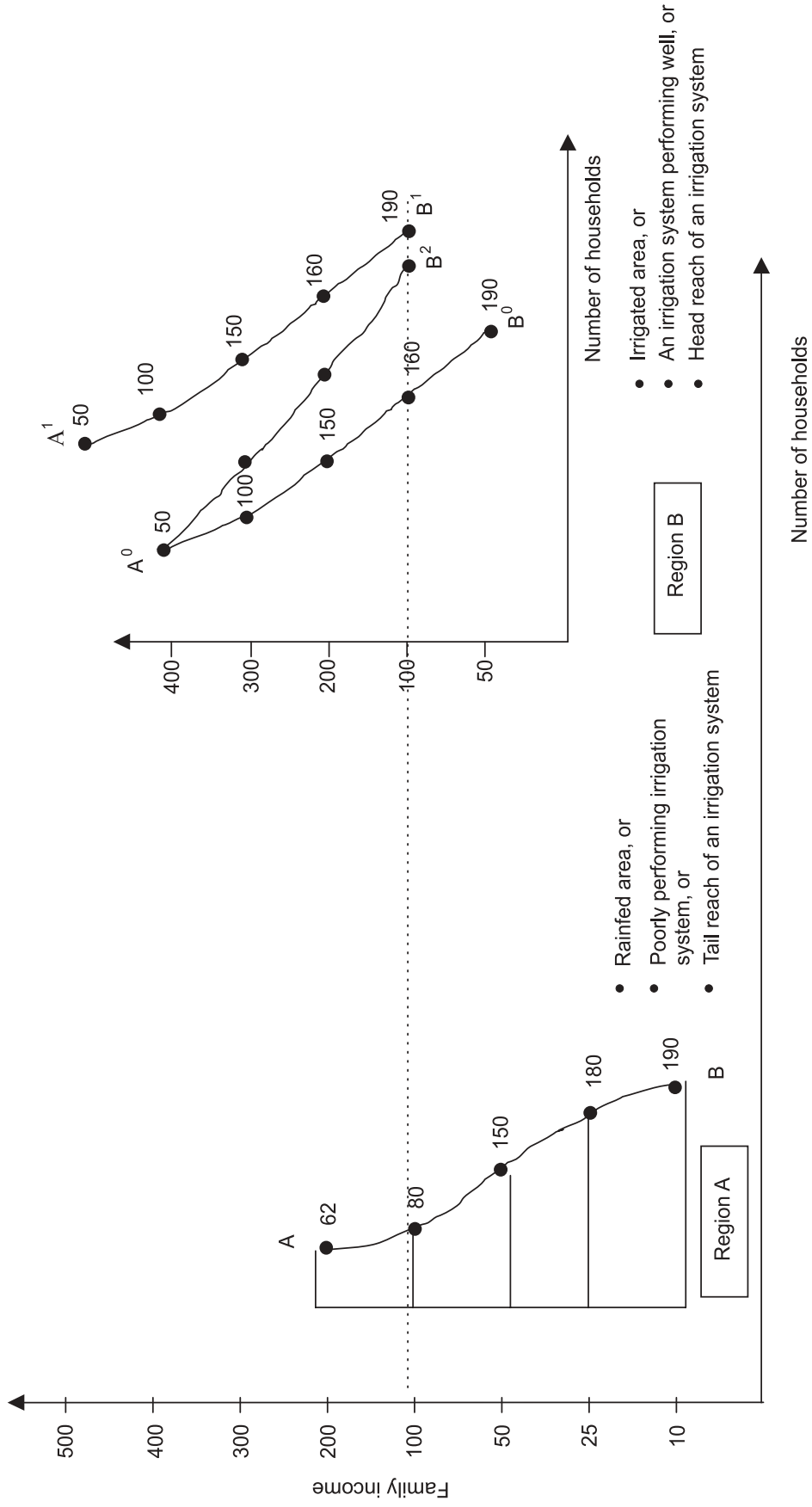
and marketing support, etc.). In fact, these managerial measures could be either water related or non-water related, both affecting the production activities and the income distribution in the locality.

The above discussion was concerned only with the income distribution impacts of the irrigation system, and on how we can design a pro-poor policy strategy that is targeted towards lower income households in irrigation systems. Considering the wider dimensions of poverty, discussions here are largely limited to irrigation water allocation related poverty reduction strategies, i.e., better allocation of water across the different reaches of canal systems.

Institutional and policy reforms in irrigation should not be seen in isolation from other reforms taking place in an economy. The impetus for reforming irrigation institutions usually comes from government induced financial compulsion or reform taking place in other sectors of the economy. Pro-poor institutional reform in irrigation may not be effective if only petty operational rules (water allocation rules and regulations) are reformed. It may require a much larger scale institutional shakeup such as reforming irrigation governance through public, private, cooperative or NGO involvement and thereby empowering poor farmers who lack resources. In some cases it may even require a shake up of constitutional-level institutions like water rights and property rights, ownership of resources including irrigation infrastructure, nature and extent of the collective authority structures governing individual agents—both farmers and agency personnel.

Head-Tail Inequity: Impacts of Canal Water Reallocation

The discussion on the poverty dimensions of irrigation projects is closely related to the unequal distribution of water resources across systems and across reaches of canals. Inequitable water distribution in a surface irrigation system (large scale canal system) is one of the major factors contributing to income inequality in irrigated agriculture. This is, however, still one of the unresolved issues in water distribution policies in irrigation commands. The problem is particularly severe in large-scale irrigation commands in developing countries with large numbers of smallholding farmers. Several studies on water allocation between head and tail reaches have reported that farmers at the tail end of the canal receive a disproportionately small amount of irrigation water and at times no water at all. The head-end farmers, however, receive an unduly large share of canal water (Chambers 1988; Shah 1998).

Recent data on canal water distribution at head, middle and tail reaches of distributaries in four selected irrigation systems in India and Pakistan are presented in table 5. The inequitable distribution of water across the head and tail ends of the canal system is clearly depicted through the farm-level actual water application data for these irrigation commands. The tail-end farmers unequivocally received a smaller share of water than the head-end and middle-end farmers did. The data in table 5 shows that within different reaches of the Rohera irrigation command in India, and the Khadir irrigation command in Pakistan, the tail-end farmers received, on average, only about 20 percent of the water than what head end farmers of the respective irrigation commands received for winter wheat in 2000-01. These farm-plot level water application data show the severity and gravity of the water allocation problem across the different reaches of the irrigation systems.

In addition to receiving a smaller amount of water in absolute terms during any crop season, the tail-end farmers also face the high level of uncertainty and fluctuation associated with water supply at the end reaches—inhibiting the adoption of improved agricultural technology and use of modern inputs (fertilizers and HYV) compared to their fellow farmers at head reaches. Likewise, other irrigation water induced crises commonly seen at tail-end reaches are less irrigation intensity, low level of agricultural intensification, widespread adoption of low yielding varieties (that can withstand water stress) and poverty stricken livelihoods compared to the head end.

The impact of the high variability in water allocation is one of the critical factors influencing poor performance of agriculture at tail reaches in relation to head reaches—leading to the underperformance of the system as a whole. The disproportionate agricultural production between the reaches ultimately produces a large degree of income inequality and a long-run impact on wealth difference between reaches in an irrigation command. This is also largely due to differences in wealth accumulation effects. The cumulative impact of irrigation access on income in an irrigated system that functions well, in comparison to a poorly managed system (or rainfed system) is still a sparsely explored topic in irrigation literature. In reality, these total income impacts can be seen only after a certain time lag from the provision of irrigation infrastructure has passed. Moreover, this income effect is not easily captured by simple crop yield comparisons across agro-environments (the usual practice for system comparisons). It requires a comprehensive assessment of several dimensions of factors (impacts) across agro-environments, with and without irrigation access.

Table 5. Water allocation for wheat production in selected irrigation commands in India and Pakistan (2000-2001).

Distributory/ Minor	Amount of canal water applied (m^3)
India	
Batta-head	849
Batta-middle	897
Batta-tail	700
Rohera- head	584
Rohera-middle	148
Rohera-tail	122
Batta-all	816
Rohera-all	285
All	550
Pakistan	
Lalian-head	1,500
Lalian-middle	2,745
Lalian-tail	345
Khadir-head	606
Khadir-middle	600
Khadir-tail	187
Lalian-all	1,458
Khadir-all	465
All	980

Note: Water applied to wheat during Rabi (winter crop season) 2000-2001was measured at the field level.
Source: Hussain, Sakthivadivel and Amarasinghe, Forthcoming

In practice, it has been observed that higher valued and water intensive crops like sugar cane are grown at head ends of the canal—which also means more yield and more net return per hectare compared to other cereals and crops relatively tolerant to water stress. This further aggravates income inequality across the different reaches of a canal system. Several studies in the past have shown that the yield level of crops in field plots, away from the water courses, sharply declined across the gradients of the irrigation outlet, i.e., yield declines when moving from the head towards middle- and tail-end locations, respectively. This is mainly due to disproportionate water allocation among the reaches. In addition to crop yields, labor income and farm employment opportunities and livelihoods—both hired as well as family labor income—also declined sharply across the gradient of the irrigation channels. Studies, in some cases, have also reported that the income of head reach farmers was more than six times higher than that of tail-reach farmers in a minor (Chambers 1988).

Not only is the farm level income and crop production reduced at the tail end, the quality of farm infrastructure and governmental services also deteriorate. More incidence of water related conflicts and quarrels and water related disputes and court cases are found in tail-end locations than at head- end locations. Thus, the overall earnings and livelihoods in the tail end are at much lower levels than at the head end, and this is in fact much more serious than waterlogging and increased salinity impacts occasionally reported in the head end—arising out of poor drainage facilities and overirrigation of fields.

In principle, it is possible that better management of canal water, and more equitable distribution of water across the head-, middle- and tail-end plots could potentially improve total social benefits and water productivity of an irrigation system with minimum or no negative effects on the level of water use at the head end. There are institutional and policy options to compensate losses suffered by head-end farmers and to increase the size of pie (total production level) of the system. The water uses and water allocations across the head-end farmer (W_0) and the tail-end farmer (W_T-W_0) in the context of limited availability of canal water resources (W_T) are clearly depicted in figure 3 using a hypothetical situation, where the PF(H) curve represents the production function of the head-end farmer and the PF(T) curve is the production function of the tail-end farmer (adapted from Bromely et al. 1977).[4] The vertical axis here is the production function per unit of land in monetary terms—so that it also measures the marginal return per unit of land. The horizontal axis represents the total availability of water in the canal and its allocation between the head-end and tail-end farmers. The other terms and their explanations and the total gains from the policy of water re-allocation from head end to tail end are self-explanatory in figure 3. The reduction of water use by the head-end farmer from W_0 to W_1, and through the reallocation of this water to the tail end, even within a season, allows a gain of per hectare marginal revenue of R_b-R_a to the tail-end farmer. The revenue loss to the head-end farmer would be only R_e-R_f. As per the shape of the production function (concave), the difference between R_b-R_a is greater than R_e-R_f. There is a potential net social gain from such a policy decision. However, there will be differential wealth impacts between head-end farmers and tail-end farmers. Such a policy will be strongly opposed by the head-reach farmers, unless there is a proper mechanism for compensating their loss caused by the reallocation of water.

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[4]However, it should be noted here that both head-end and tail-end farmers may be on the same production function. Tail-end farmers, with less access to canal water, may be operating at the bottom part of the production function (or zone of increasing marginal returns), while head-end farmers (with relatively greater access to canal water) may be operating at the top end or decreasing part of the production function (i.e., in zone of zero or negative marginal return, especially if overapplication results in decreased total output). The presentation in figure 3, using separate production functions for head-end and tail-end farmers, is for ease of understanding the concept of distribution of limited available water across the reaches in any irrigation command.

Figure 3. Hypothetical production function and marginal return to the land for head end and tail end farmers in a typical canal system (adapted from Bromely et al. 1977).
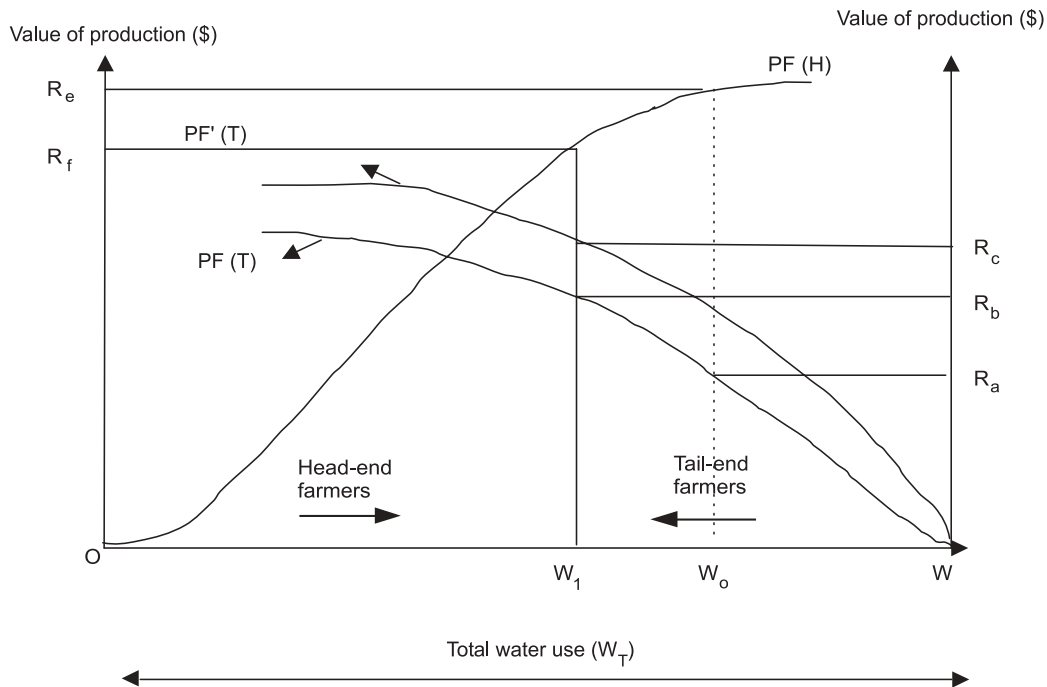
Abbreviations:

PF(T)	=	Production function of tail-end farmer.
PF(H)	=	Production function of head-end farmer.
R_a....R_f	=	Marginal revenue from each unit of water use in dollar terms.
OW	=	Total quantity of water available in the irrigation canal command (W_T), which is divided between head-end farmers and tail-end farmers.
OW_0	=	Water used by the head-end farmers initially in case 1.
$OW-OW_0$	=	Water availability to tail-end farmers initially in case 1.

IWMI is currently undertaking a study on analyzing the socioeconomic impacts of canal water reallocations (Hussain et. al., forthcoming). Preliminary results from the study suggest that overall gains, at the irrigation system level, can be achieved by adopting canal water reallocation to canal reaches currently receiving less canal water (particularly tail ends where groundwater is of poor quality). The results of the study suggest that reallocation of canal water will result in significant gains to tail-end farmers without any loss to head-end users (or in some cases only marginal losses). For example, in the two systems studied in India, per hectare gross margin for wheat (dominant Rabi crop) can be increased by Rs 724/ha through reallocation of water across the reaches.[5] In Pakistan, per hectare gross margins from canal water reallocation could be increased by Rs 555/ha. Much of these gains will be achieved at tail ends where groundwater quality is relatively poor. These are the poorest areas in the systems. Canal water reallocation will have a dual effect in terms of enhancing productivity and reducing poverty in these areas.

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[5] US$1 = Indian Rs 47 in 2000. US$1 = Pakistan Rs 55 in 2000.

In fact, the above-mentioned gain is only one of the short-term impacts of water reallocation. The social benefits would be much higher in the long run—once full benefits of the additional water are realized by the tail-end farmers through increased input uses and adoption of more intensive cultivation practices. The long-run gains of water reallocation or better management of water across the different reaches of a canal is depicted in figure 3 by the upward shift in the production function of tail-end farmers PF'(T), i.e., technical changes facilitated mainly in the tail-end reaches by the increased level of water supply. Thus, long term gains to society from such water allocation is much higher than the gains described in the short run earlier—as long as the loss of water during conveyance is within the acceptable range. In figure 3, the marginal gains to the tail end from such improved water reallocation decisions could be increased up to R_c due to the upward shift in the production function (technical change). The movement in the head-end farmer, however, would be within the same production function—that is, reallocation of input resources is within the production path. Hence, such pro-poor targeted policy interventions in water allocation mechanisms in irrigation systems have the potential to produce desirable results on income inequality, poverty alleviation as well as increased social gains in systems.

In reality, the head-end farmers would certainly oppose any such institutional change, unless they are well compensated for any potential loss caused by re-allocation of water across the reaches. Their opposition could be minimized if the reallocation of water would substantially increase the reliability of water supply in the system for all, and if we can also ensure reduced water-related conflicts. Appropriately designed policy strategies and effective management of water systems could produce such win-win situations, which would minimize the opposition even from head-end farmers. Head-end opposition may be less in areas where there is already a waterlogging situation in the head reaches due to overuse of water resources, as in some of the large scale systems in Asia. Particularly, if the head-end farmers are assured of their share of water and increased reliability in the system as a whole, they will have enough incentive not to oppose such water reallocation. In principle, improved reliability of water supply for all, including the tail end, could compensate any loss to the head-end farmers caused by such water reallocation across the reaches.

The head-tail inequity in water allocation is not just due to petty operating rules and tertiary-level water allocation procedures, nor are they only due to technical constraints and conveyance losses. Generally, such inequity is the result of overall poor governance in the irrigation system, and a high level of institutional failure (not being able to function to set objectives) associated with public sector agencies responsible for managing the systems. Repeto (1986) and Chambers (1988) have documented several cases on issues of rent seeking, and of bureaucratic failures in irrigation agencies. In particular, the extent of rent associated with maintaining the *status quo* in the system provides a strong motive for the agency to block any attempts at reform. Likewise, powerful head end farmers exerting undue influence on project authorities and thereby tapping a large share of the water from the distributaries is a common phenomenon in many large-scale systems in Asia. In turn, all these factors contribute, to a large extent, to the rents head-reach farmers receive—they typically consume more water than planned during the project design period. They also grow relatively more water consuming crops and high value crops like sugar cane. A properly structured incentive based cost recovery system (at least, full charges for operation and management costs) based on incremental benefits derived from irrigation access, or even a proxy form of volume or quantity based water fee, in principle, could potentially reduce such inequity in water allocation across the reaches. However, the transaction costs involved in monitoring and fee collections, and relatively less suitable technology for small-scale farming are some of the major hurdles in implementing such policies.

Considering the inequities in water distribution across different reaches of the canal in irrigation systems, some suggested pro-poor targeted policy interventions are:

- Reallocation of canal water supplies among head and tail reaches of watercourses, distributaries, branch canals, etc.

- Adoption of rotational water allocation systems like the warabandi water allocation system practiced in northwest India and the Punjab province of Pakistan.

- Construction and operation of a water storage system in areas where water distribution is unpredictable and undependable, so that farmers of the area can better cope with risks associated with water availability.

- Lining of canals and provision of control structures to push the water to the tail end.

- Targeted provision of subsidized groundwater pumps to tail reaches, where the surface flow of canal water is unreliable but adequate good quality groundwater is available due to recharging of the system from head-water uses and middle- end uses.

- Other targeted credit and financial assistance to irrigation commands; for example, targeted short-term loans for water harvesting projects and water extracting equipment (tubewells), small dam construction (check dams) in areas where water is unreliable.

- Crop diversification through modern irrigation technologies such as laser leveling, sprinkler and drip irrigation, etc.

Summary and Conclusion

Improved irrigation access will increase crop yield and production, and in turn, result in increased farm income, but the less understood issues are how this differential access to irrigation will actually affect the income inequality and poverty status in an irrigation system—and the nature of the feedback effects of this process. From the evidence presented earlier, we conclude that irrigation access is a crucial instrument for reducing (rural) poverty within a region. This is not so much through direct impacts of increased yield and farm returns per se, but more through indirect impacts associated with increased rural employment—especially the scale of economic multipliers operating in the rural economy. The level of multiplier effects depends upon the nature of backward and forward linkage effects in the regional economy, i.e., the scale of interlinkage within and among the rural enterprises and market infrastructures. The nature and management of multiplier effects available in a rural economy is important in determining the level of irrigation impacts on rural poverty. In other words, increased farm-level crop yield is a necessary condition but is not a sufficient condition for the reduction of poverty in a region. Irrigation impacts on poverty reduction depend upon the structure of the rural economy, and how the additional farm incomes generated by improved access to irrigation is actually spent in the rural economy, and also its feedback impacts on rural employment and rural wage structures.

The employment effects of irrigation are gaining more importance today—particularly in the context of reduced global food grain prices during the past two decades. Reduced food grain prices are, essentially, the result of the success of irrigated agriculture in the past. Thus, there is a complex set of interdependencies between the causal factors that affect these feedback relationships. The incremental benefit generated by improved access to irrigation is several times higher for the regional economy as a whole than to the farming sector. The differential impacts of irrigation across sectors, which changes over time based on agriculture prices, has large implications on setting service fees and irrigation investment policies. There is a complex feedback relationship between increased crop yield and farm income along with the growth of rural off-farm sector activities and their capacity to absorb the increasing rural population. In turn, the nature and scale of feedback relationships determines the irrigation impacts, degree of inequality in resource use and the prevalence of poverty in a system.

After the large-scale expansion of the global irrigated area in the 1960s and the 1970s, the central policy focus in the irrigation sector has now shifted to issues like irrigation water management, environment management for system sustainability and more equitable distribution of benefits across irrigation systems and across agro-environments. Often, irrigation systems have not performed as envisaged at the project appraisal phase. Underperformance of systems, in relative terms, has affected the poor and marginal farmers of canal commands more adversely than relatively prosperous farmers. The relatively prosperous farmers, in any case, would obtain the necessary canal water by exercising their legal rights, or even illegally exerting their social influence to agency staff. Numerous case studies on canal irrigation systems in India and Pakistan have highlighted these issues of poor governance in large-scale irrigation systems (Shah 1998; Chambers 1988). The high level of *governmental failures* is one of the root causes for the underperformance and the chaotic situation in water allocation procedures in irrigation commands—particularly where water scarcity is also increasing. The underperformance of the canal system has, therefore, further aggravated the income gap and the relative poverty level in irrigation commands.

Unequal distribution of irrigation benefits across sub-systems was a common feature in most systems. Indeed, the International Irrigation Management Institute (IIMI) (now the International Water Management Institute—IWMI) was set up in mid- 1980s for the very purpose of conducting research in irrigated areas to provide practical policy alternatives to improve the management and performance of irrigated agricultural systems. Due to the uneven distribution of irrigation benefits across different reaches, several institutional reform processes for better management of irrigation systems have been initiated in the recent past. These were started with the intention of providing equitable distribution of benefits across reaches. Provision of irrigation is a public good funded largely from public funds. Therefore, the provision of irrigation services ought to be equitable, with benefits accruing to all service users within a system. However, in reality, such equitable distribution of benefits across reaches or locations is rarely seen. There is potential to increase social benefits by reallocation of available water across reaches, by effective management of systems, and by putting scarce water resources to productive use. This fact has been clearly demonstrated through the comparison of crop yield and crop return per hectare on field-level analysis of farmers across different reaches of irrigation commands in India and Pakistan—as described earlier.

Large scale institutional reforms in irrigation, like participatory irrigation management (PIM) and irrigation management transfer (IMT), are all guided by the objectives of creating a greater role for service users (water users) in managing and improving the performance of their systems. Effective user participation would reduce the information and transaction costs involved in managing irrigation institutions and help better enforce irrigation rules and regulations. This helps to properly tailor the incentive structures of both irrigation service providers (agency staff) as well as service users (farmers). However, the success of such water users associations and irrigation management transfers in improving the overall performance of the irrigation sector is varied across systems—which also largely depend upon the contextual situation and site-specific factors. There is no "one-size cut that fits for all" type of IMT and institutional reforming policy equally applicable to all parts of the world. The nature of such institutional reforms and specific policy instruments depend largely upon the specific contexts and the underlying socio-political environments in which the irrigation system is embedded.

Wealth creation and trickle down effects targeted at alleviating poverty in irrigated areas are not taking place at the required pace in all irrigation systems, as envisaged in the design stages. This specifically applies to some of the large-scale irrigation systems in Asia. It is now considered essential that direct pro-poor targeted interventions need to be put in place to tackle this issue. The basic problem in all these cases is how to distribute the available water supply in an equitable manner so that it will generate greater benefits to society as a whole. Ultimately, irrigation is a public good provided by the government for societal well-being. In this context, this paper illustrates some of the conceptual issues involved in improved management of irrigation systems, which also aim to be consistent with pro-poor targeted intervention of social objectives.

In addition to handing over the system for operation, maintenance and management to water users, improving the technical and managerial performance of the irrigation system through better stakeholder participation will help to improve water allocation as well as the governance of the irrigation system. Moreover, there is no consensus in irrigation literature yet on how to design a system and water management policy setting that provide increased productivity and at the same time enhance equal distribution of irrigation induced benefits across locations and sectors. Considering all these ambiguities and limitations in the available literature on irrigation, some selected policy options for improved management of irrigation commands, which we think would provide productive and equitable distribution of water related benefits throughout locations are:

1) Putting in place a system of efficient fee recovery, based on volume of water use, or sharing the operation and management costs based on incremental water uses and benefits derived from irrigation systems.

2) Establishment of clear water rights and water entitlements in systems, as far as possible, through the introduction of legal and third party enforceable service contracts, with flexible provisions for seasonal water use in the system. A clearly defined separate water entitlement provision for maximum flow and average flow in relation to minimum flow in the system will minimize the uncertainty involved in water availability in the system and its variable allocation to farmers' plots.

3) Introduction of some additional pro-poor targeted policy interventions in canal commands, such as targeting canal water supply to tail end farmers where poverty tends to be highly concentrated.

4) Better enforcement of water allocation rules and regulations already in place in the canal command—thereby avoiding the "law of the jungle" type of situation prevalent in canal systems. This is particularly evident in some large-scale systems in South Asia where smallholder farmers are also present in large numbers. In that context, designing self-enforcement type of regulations, like individual farmers' incentive based water allocation rules and regulations, will significantly minimize the transaction costs involved in enforcing rules and regulations in systems.

5) Targeted additional financial and credit interventions in irrigation commands for irrigation equipment (pumpset and tubewell) like "Gramina Bank" type of soft loan system in irrigation financing—particularly considering the needs of tail-end locations. This will ensure improved reliability of water even for smallholders in times of water scarcity in the canal system.

6) Giving due attention to the structure of irrigation associations (water users associations) while designing new water institutions and water allocation policies. Reforming existing irrigation institutions and water users associations already in place so that the concerns of the tail-end farmers or the small farmers could be better heard in the water users association decision-making process.

Irrigation development and access to irrigation are ultimately typical public goods type of services—highly subsidized, almost everywhere in the world, from state coffers for major components of construction and also for service costs. Hence, there is an inherent social responsibility involved here to ensure that the benefits derived from such public goods and services should be distributed, as far as possible, equally among all members of society. Some of the issues and policy options discussed in this paper will go a long way in improving and sustaining the productivity and equity of irrigation commands and irrigated agriculture in general.

Literature Cited

Barker, R.; B. Van Koppen; and T. Shah. 2000. *A global perspective on water scarcity and poverty: Achievements and challenges for water resources management*. Colombo, Sri Lanka: International Water Management Institute.

Bell, C.; P. Hazell; and R. Slade. 1982. *Project evaluation in regional perspective: A study of an irrigation project in northwest Malaysia*. Baltimore, USA: The John Hopkins University Press.

Bhatia, R. 1991. Irrigation Financing and Cost Recovery Policy in India: Case studies from Bihar and Haryana. In *Future Directions for Indian Irrigation: Research and Policy Issues*, ed. R. Meinzen and M. Svendsen. Washington DC: International Food Policy Research Institute.

Bromely, D. 1977. *The economics of water reform: Institutional design for improved water management in the LDC's*. Working Paper 8. Wisconsin, USA: Center for Resource Policy Studies, School of Natural Resources, University of Wisconsin-Madison.

Chambers, R.1988. *Managing canal irrigation: Practical analysis from South Asia*. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.

Chitale, M. A. 1994. Irrigation for poverty alleviation. *Water resources development* 10(4): 383-391.

Datt, G.; and M. Ravallion. 1998. Farm productivity and rural poverty in India. *The Journal of development Studies* 34(4): 62-85.

FAO (Food and Agriculture Organisation). 1998. *FAO Statistics*. Rome, Italy: Food and Agriculture Organisation. CD-ROM.

FAO. 2000. *The State of Food and Agriculture, 2000*. Rome, Italy: Food and Agriculture Organisation.

Hill, H.; and L. Tollefson. 1996. Institutional questions and societal challenge. 1996. In *Sustainability of irrigated Agriculture*, ed. L. S. Pereira; R. A. Fedds; J. R. Gilley; and B. Lesaffre. Dordrecht/ London: Kulwer Academic Publishers.

Hossain, M.; B. Sen; and H.Z. Rahman. 2000. Growth and distribution of rural income in Bangladesh: Analysis based on panel survey data. *Economic and Political Weekly, December 30:* 4630-4637.

Hossain, M.; F. Gascon; and E.B. Marciano. 2000. Income distribution and poverty in rural Philippines: Insights from repeat village study. *Economic and Political Weekly, December 30*: 4650-4656.

Hussain, I.; R. Sakthivadivel; and U. Amarasinghe. Forthcoming. *Land and water productivity of wheat in western Indo-Gangetic plains of India and Pakistan: A comparative analysis*. IWMI Research Report (under review).

Isvilananda, S.; A. Ahmad; and M. Hossain. 2000. Recent changes in Thailand's rural economy: Evidence from six villages. *Economic and Political Weekly, December 30* : 4644-4649.

Janaiah, A.; M.L. Bose; and A.G. Agarwal. 2000. Poverty and income distribution in rainfed and irrigated ecosystems: Village studies in Chhattisgarh. *Economic and Political Weekly, December 30* : 4664-4669.

Kikuchi, M.; R. Barker; P. Weligamage; and M. Samad. 2001. The Irrigation Sector in Sri Lanka: Recent Investment Trends and the Development Path Ahead. Research paper. Colombo, Sri Lanka: IWMI.

Kuznets, S. 1955. Economic Growth and Income Inequality. *American Economic Review* 45(1):1-28.

Mellor, J.W. 1966. *The Economics of Agricultural Development*. Ithaca, New York: Cornell University press.

Mellor, J. W. 1999. *Faster more equitable growth: The relationship between growth in agriculture and poverty reduction.* A conference paper presented at Harvard Institute for International Development. Cambridge, USA. September 1999.

Mellor, J. W. 2001. *Irrigation agriculture and poverty reduction: General relationships and specific needs*. Workshop paper presented at the Regional Workshop on Pro-Poor Intervention Strategies in irrigated Agriculture in Asia. International Water Management Institute, Colombo, Sri Lanka, August 9-10, 2001.

Narayanamoorthy, A. 2001. Irrigation and rural poverty nexus: A state wise analysis. *Indian Journal of Agriculture Economics* 56: 40-56.

Powell, R. A.; R. C. Jenson; and A. L. Gibson. 1985. *The economic impact of irrigated agriculture in NSW*. Australia: New South Wales Irrigators' Council Limited.

Repetto, R. 1986. *Skimming the water: Rent-seeking and the performance of public irrigation system*. Research Report 4. Washington DC: World Resources Institute.

Sampath, R. K. 1990. On some aspects of irrigation distribution in India. *Land Economics* 66(4): 448-463.

Sen, A. K. 1982. *Poverty and famines: An essay on entitlement and deprivation*. Oxford, UK: Claredon Press.

Shah, T. 1998. Water against poverty: Livelihood-oriented water resource management. *Water Nepal* 6(1): 117-143.

Shah, T. 2001. *Wells and welfare in Ganga basin: Essay on public policy and private initiative in eastern Uttar Pradesh, India*. Research Report 54. Colombo, Sri Lanka: International Water Management Institute.

Shah, T.; M. Alam; M. Dinesh Kumar; R.K. Nagar; and M. Singh. 2000. *Pedaling out of poverty: Socioeconomic impact of a manual irrigation technology in South Asia.* Research Report 45. Colombo, Sri Lanka: International Water Management Institute.

Thakur, J.; M.L. Bose; M. Hossain; and A. Jinaiah. 2000. Rural income distribution and poverty in Bihar: Insights from village studies. *Economic and Political Weekly, December, 30* :4657-4663.

Ut, T.T.; M. Hossain; and A. Janaiah. 2000. Modern farm technology and infrastructure in Vietnam: Impact on income distribution and poverty. *Economic and Political Weekly, December 30:* 4638-4643.

WCD (World Commission on Dams). 2000. *Dams and developments*: *A new framework for decision-making*. London, UK: Earthscan Publishers.

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