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Agricultural Water and Poverty Linkages: Case Studies on Large and Small Systems

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Summary

This paper uses case studies to examine the linkages between agricultural water and rural poverty, and demonstrates how rural household deprivation of agricultural water leads to other socioeconomic deprivations.

There are five key interrelated dimensions of the agricultural water/poverty reduction relationship: production, income/consumption, employment, vulnerability/food security, and overall welfare. In general, irrigation access allows poor people to increase their production and incomes and enhances income diversification opportunities, reducing vulnerability caused by seasonality and other factors. Nonetheless, irrigation benefits may accrue unevenly across socioeconomic groups.

A framework for conceptualizing the impact of irrigation on rural poverty is provided, taking into account household status as well as the direct and indirect impacts of irrigation. Using this framework, the first study analyzes the impact of improved community/household access to irrigation on poverty in large-scale surface irrigation systems in Sri Lanka and Pakistan. The study finds that

- agricultural water/irrigation access reduces chronic poverty incidence;
- irrigation's impact on poverty is highest where landholdings are equitably distributed;
- effective rural poverty reduction requires that agricultural water/irrigation development be targeted at poor communities/areas/localities; and
- unequal land distribution is associated with inequitable distribution of agricultural water benefits.

The paper examines a study of water and poverty in six Asian countries. Key preliminary findings indicate that

- land and water resources are important determinants of rural poverty;
- there is significant inequity in the distribution of water across irrigation system reaches;
- the incidence of poverty at tail reaches is higher than elsewhere in irrigation systems, an outcome worsened when land distribution is unequal.

Finally, the paper outlines case studies of poverty reducing intervention strategies for agricultural water. In particular, a study of the pro-poor benefits from providing small-scale treadle pumps is examined, as are localized examples of pro-poor irrigation management, including an institutional/technology bundling in Pakistan, a community initiative in Indonesia, cropping shifts in India, and the Dual Canal and Bethma systems in Sri Lanka.

Introduction

The purpose of this paper is to examine the linkages between agricultural water and rural poverty. The paper demonstrates, through a series of real world case studies, how rural household deprivation of agricultural water leads to other socioeconomic deprivations, and how improved access can reduce the vulnerability of the poor. After presenting background information on the connection between agricultural water and poverty, the paper provides a framework for conceptualizing the impacts of irrigation on rural poverty, taking into account both direct and indirect effects as well as household status. The paper then presents a series of case studies, based on empirical data, examining the relationship between agricultural water and poverty. The case studies are based on the most recent research on agricultural water and rural poverty conducted by the International Water Management Institute (IWMI). The paper concludes with several examples, based on recent fieldwork, of agricultural water sector practices—initiated both through community action and external intervention—which have had a significant impact on rural poverty.

Background

Poverty is complex, multidimensional, and is the result of myriad interactions between resources, technologies, institutions, strategies, and actions. The multidimensional character of poverty has been reflected in a wide array of papers, poverty reduction strategies, and policies.[1] Although water provides only a single element in the poverty equation, it plays a disproportionately powerful role through its wide impact on such factors as food production, hygiene, sanitation and health, vulnerability/food security, and the environment. Indeed, development agencies, groups, and experts worldwide are increasingly recognizing the important role that water can have on poverty.[2]

Within the water and poverty debate, agricultural water holds a unique place. While solutions to other dimensions of the water and poverty problem such as sanitation, hygiene, and potable supplies, generally call for increased expansion of services, the agricultural water/irrigation problem requires drastic improvements in existing services. Furthermore, agriculture is now the world's largest user of water, consuming 80–90% of annual utilized supplies and providing livelihood for most of the world's poor.

Within agriculture, water is a vital resource for many productive and livelihood activities, and many developing countries have promoted water resources development over the last 5 decades to improve social outcomes. Huge investments

[1] UNDP, 1997; Asian Development Bank, 1999; World Bank, 2000; Dutch Ministry of Foreign Affairs, 2001; Government of The Netherlands: Ministry of Foreign Affairs, 2001; OECD-DAC, 2001.

[2] World Commission on Dams, 2000; Water Supply and Sanitation Collaborative Council, 2000; Zoysa, Lipton et al., 2001.

have been made in water resources to achieve such broad objectives as economic growth, rural and agricultural development, national food security, famine protection, and land use intensification. While irrigation development can have negative impacts on the poor under some circumstances, agricultural water/irrigation has been regarded as a powerful factor for providing food security, protection against adverse drought conditions, increased prospects for employment and stable income, and greater opportunity for multiple cropping and crop diversification. Access to reliable irrigation can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming. This, in turn, opens up new employment opportunities, both on-farm and off-farm, and can improve income, livelihoods, and the quality of life in rural areas. Overall, irrigation water—like land—can have an important wealth-generating function in agriculture, specifically, and in rural settings in general.

There are five key interrelated dimensions of the relationship between access to good agricultural water, socioeconomic uplifting in rural communities, and poverty reduction. The dimensions are production, income/consumption, employment, vulnerability/food security, and overall welfare (Figure 1).

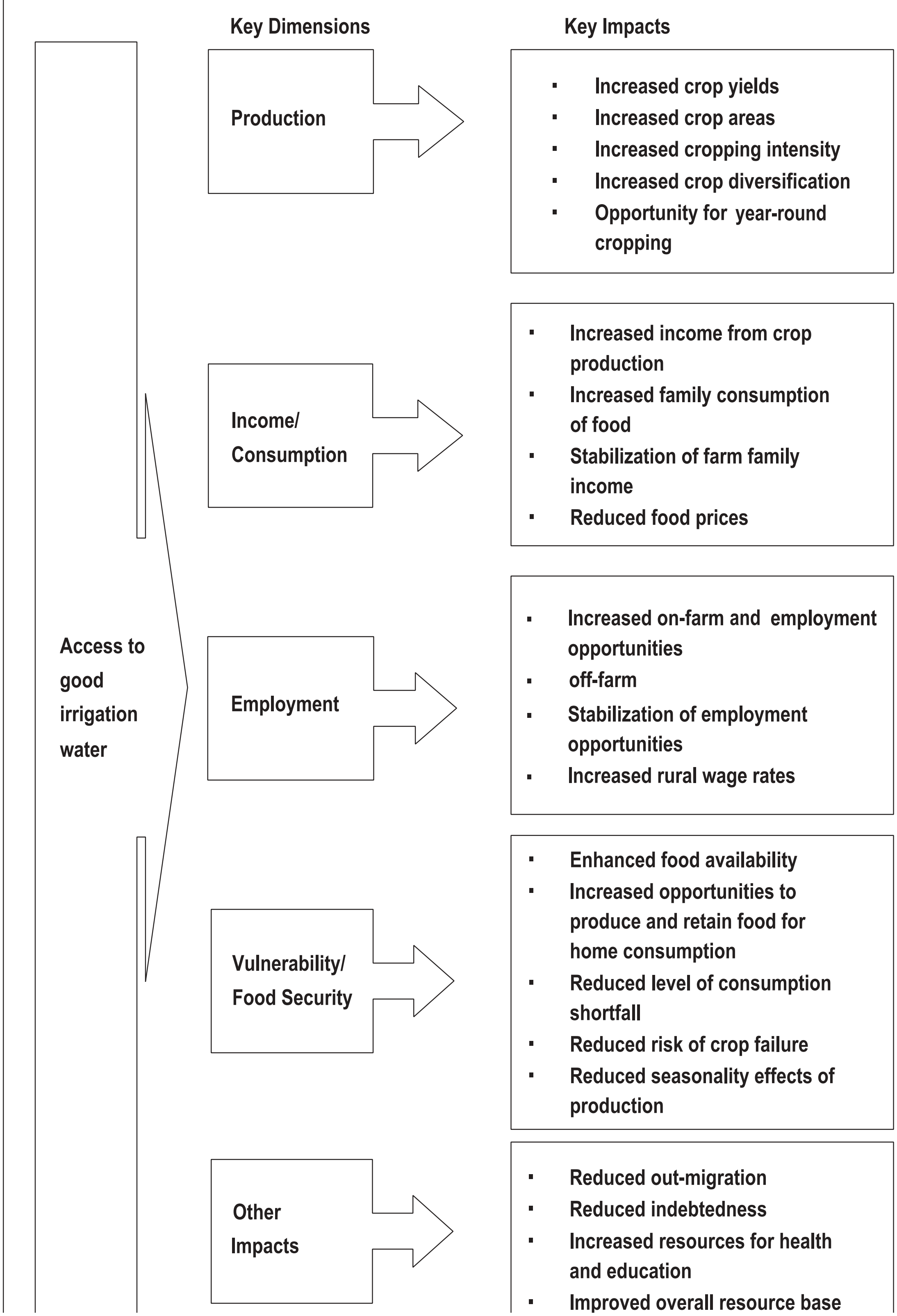
In general, access to good irrigation allows poor people to increase their production and income, and enhances opportunities to diversify their income base, reducing vulnerability caused by the seasonality of agricultural production as well as external shocks. Thus, access to good irrigation has the potential to contribute to poverty reduction and the movement of people from ill-being to well-being. While there is an enormous literature on the impact of irrigation on poverty reducing intermediate variables, particularly from South Asia, no review is made here. Rather, recent case studies are presented to identify the conditions under which access to agricultural water can have significant poverty-reducing impacts. Before reviewing the case studies, it is useful to have a conceptual framework for considering the potential impacts agricultural water can have on various segments of the rural population.

There is a common perception that the benefits from irrigation accrue primarily to large landholders. However, to understand the impacts of irrigation on the rural sector in general and the poor in particular, it is important to consider both the nature of rural households as well as the direct and indirect impacts irrigation services can have on the rural economy. As a conceptual framework, we can think of the rural population as comprising four groups

- the landless dependent on the non-agricultural sector;
- the landless dependent on agriculture (e.g., agricultural workers);
- smallholders; and
- large holders.

Given that water is generally linked to land, the direct benefits of irrigation, in terms of increased farm output, will tend to accrue in proportion to the size of landholdings, with large holders benefiting more than smallholders, and smallholders benefiting more than the landless. However, the landless can still directly benefit from increased irrigation services. For instance, those working in the agriculture sector can experience an expansion in employment opportunities and agricultural wages, enhancements to livestock and poultry raising, and

Figure 1. Agricultural Water and Poverty Reduction: Key Dimensions



improved opportunities in other noncrop, water dependent rural enterprises (e.g., brick making).

As with direct benefits, the indirect benefits of irrigation services will also not accrue evenly across household sectors. To the extent that irrigation increases crop production, food prices will decline due to increased overall supplies. For both categories of the landless, any fall in prices will result in an increase in real incomes and food security as well as increased employment and other opportunities via the multiplier effect in both local and regional economies. Smallholders will also receive indirect benefits from price declines to the extent that they are net food buyers whereas large holders—net food sellers—may experience low or negative indirect impacts. While the exact distribution of irrigation benefits among these various classes within any agricultural system is an empirical question and will be dependent on equity in land distribution, the important point is that direct and indirect effects must be considered to comprehensively understand the impact of irrigation on the rural poor. While the case studies presented here account for both direct and indirect impacts of irrigation on poverty, the focus is on more localized impacts. The cases do not explore the broader economy-level impacts of irrigation on poverty through multiplier effects.

Impact of Agricultural Water on Poverty: Large-Scale Surface Systems

The case studies begin with an examination of the relationships between poverty and agricultural water at the irrigation system level. The two studies presented examine how access to irrigation water, household location within an irrigation system, and other variables are related to poverty. A better understanding of these linkages can help determine strategies, which can be employed within existing irrigation systems for poverty reduction.

An Analysis of Selected Irrigation Systems in Pakistan and Sri Lanka

This first case study is based on a recently completed analysis of agricultural water and poverty in Pakistan and Sri Lanka.[3] The purpose of the research was to assess the impact of improved community/household access to irrigation (through the rehabilitation and/or development of irrigation infrastructure) on poverty reduction. The study was undertaken during 2001–2002, in Sri Lanka's Uda Walawe Left Bank Irrigation System, part of the Ruhuna Basin and an IWMI Benchmark Basin, and in Pakistan's Mandi Bahauddin and Gujrat districts, located in the upper portion of the upper Indus basin. Both study sites are representative of large-scale surface irrigation systems.

Context

The study site in Sri Lanka, the Walawe Left Bank Systems (WLB), is in the Walawe Ganga basin about 200 km southeast of Colombo. The study area is located in the dry zone within a scheme that is part of Sri Lanka's larger land

[3] Hussain, Marikar, and Thrikawala, 2002; Hussain, Jehangior, and Ashfaq, 2002.

resettlement policy. Within the scheme, significant investments have been made to establish irrigated land settlements for resettlement of poor, landless families from the more crowded wet zone and provide opportunities for livelihood enhancement through irrigated farming. By 1998, some 328,000 ha of land had been developed under irrigated settlements and about 200,000 poor families had been resettled in several schemes. The land settlement policy of the Government has had a multipronged strategy. Irrigation development was coupled with an expansion of other physical and social infrastructure. Many settlement schemes are now prosperous agricultural areas forming the cornerstones of agricultural production in Sri Lanka. The irrigated settlements within the scheme can be regarded as good examples of the use of water resources development in reducing poverty.

Within the WLB study site, about 12,000 ha of land provide direct and indirect support to the approximately 17,000 families settled in the system (including families encroaching lands in the area). Many families have been relocated from other districts. Each settler was given a parcel of 1–2 ha for cultivation of paddy and other field crops, in addition to land allotments for homesteads. The WLB has been developed in phases, gradually moving from upstream to downstream development. Recently, infrastructure in the upstream and midstreams of the WLB system was improved or rehabilitated to increase water availability in these reaches, as well as in downstream areas where new infrastructure is being developed.

The settlement is a mix of new and old settlers. Land distribution is fairly equal and there is public and private landownership. Paddy is the major crop, followed by other field crops including bananas, chilies, and onions. Overall cropping intensity is around 200%. Surface supplies are the only source of water for crop production. Average annual rainfall in the area is around 1,500 millimeters (mm).

The study site in Pakistan is located in the upper portion of the Upper Indus Basin (UIB). Irrigation systems were initially developed in Pakistan's Upper Indus during the colonial period. After independence, new works were initiated, particularly during the 1960s, including construction of dams and link canals to further expand the network of irrigation infrastructure. Since the late 1970s, efforts have been directed at improving efficiency of water use, with the focus on increasing conveyance efficiency at the tertiary level (where 40–60% of water is believed to be lost) through so-called on-farm water management programs. The core objective of these programs was to reduce water loss and improve access to water for crop production. Major components of the programs included development/improvement of tertiary level infrastructure and the formation of water users associations. In the study sites within the UIB, the On-Farm Water Management Program was implemented during the mid-1990s.

Settlements in the Pakistan study area are well established. As in other parts of the country, most land is privately owned, and there is significant inequity in the distribution of landownership. Wheat, rice, cotton, and sugarcane are major crops grown in the area. Overall cropping intensity, which ranges from 120% to 150%, is fairly low as compared with other Asian countries. Shared use of surface and groundwater is common, and inequity in distribution of surface water is widely observed. Average annual rainfall in the area is 800 mm. The area of the two districts selected for study is over 0.5 million ha and is home to over 3 million people.

Study Approach

In the absence of data availability prior to development/improvement of irrigation systems within the study sites, the research employed a “with” and “without” approach. Comparisons were made between sample areas with

- well-developed/improved infrastructure,
- less developed/unimproved infrastructure, and
- neither infrastructure nor irrigation.

The study used primary data collected through household-level surveys conducted three times during 2000–2001. The sample included 858 households in WLB and 720 households in UIB and used a detailed multi-topic questionnaire. In addition, the study employed a participatory poverty assessment approach to obtain qualitative information and data from the communities. Poverty was measured using monetary (incomes and expenditures) as well as nonmonetary indicators (under-5 mortality, dependency ratio, body mass index, housing quality, access to services, and agricultural performance). Further dynamics of income poverty were measured using the concepts of chronic or permanent poverty (defined as a state where household income/consumption is constantly below poverty line within a given time) and transient or temporary poverty (defined as a state where the household’s average income/consumption is above the poverty line but occasionally falls bellow the poverty line within a given time).

The selected study areas were divided into subareas or strata based on numerous criteria including availability of irrigation infrastructure, infrastructure condition (improved or unimproved), cropping patterns, and the nature of water supplies (perennial or nonperennial). A multistage sampling procedure was adopted for selecting households in each stratum. The overall approach to comprehensively assessing the impacts of access to irrigation/infrastructure on poverty, covering both its spatial and temporal aspects, consisted of

- comparing various strata representing the state of infrastructure development, quantifying the differences in the value of relevant variables by developing a socioeconomic profile for each strata;
- developing and quantifying key indicators of poverty covering both monetary and nonmonetary dimensions of poverty;
- using econometric analysis to estimate the household income/consumption smoothing effects of irrigation infrastructure development; and
- using econometric analysis to identify and quantify key determinants of household income/expenditure/poverty, including quantification of the impact of irrigation infrastructure development on these variables.

Key Results

In Sri Lanka’s WLB system, study results indicate that household income and expenditure levels are higher in areas with access to irrigation infrastructure, vis-à-vis to those without. Household average monthly expenditure in areas with irrigation infrastructure access is 24% higher than in areas with no access to irrigation infrastructure.

This is largely because areas where households have access to irrigation exhibit:

- higher cropping intensities and double cropping;
- higher crop productivity and overall production; and
- higher employment opportunities and wage rates.

For example, the agricultural wage rate in areas where households have access to irrigation is over Rs200 ($2.22) per day compared with Rs173 ($1.92) per day in areas with no irrigation.

The study also indicates that

- production activities in areas with access to irrigation infrastructure also provide support to households in nearby areas with no irrigation infrastructure, reducing levels of chronic poverty in these areas;
- access to irrigation infrastructure enables households to smoothen their consumption, with higher incomes received over extended period of time (resulting from higher productivity, crop diversification, and double cropping); and
- upgrades/improvements in infrastructure help improve crop productivity and help save water, resulting in more water available for downstream users (who are generally poorer compared with upstream households) and helping to improve equity in water distribution as well as incomes.

The results of the study suggest that the incidence, depth, and severity of poverty, as measured by both monetary and nonmonetary indicators, are highest in areas where households do not have access to irrigation/infrastructure and lowest in areas with access to established irrigation infrastructure and with adequate water supplies. Incidence of chronic poverty is highest in areas without access to irrigation infrastructure (typical rain-fed areas) vis-à-vis areas with access to irrigation infrastructure. As shown in Table 1, the rain-fed extension area had the highest level of chronic poverty, with one fourth of households living below the poverty line throughout the year. Overall, the highest chronic poverty is found among nonfarm households and in areas with no access to irrigation infrastructure, and lowest in areas with access to irrigation infrastructure and adequate water supplies. The study concludes that access to irrigation contributes to food security, balanced diets, and reduced vulnerability and poverty at the household and community levels.

Similarly, in Pakistan's UIB, the study indicated that access to irrigation/ infrastructure reduces the incidence of chronic poverty. Improvements in irrigation infrastructure have helped increase availability of water for crop production, resulting in higher cropping intensity, and crop productivity (up 5–25%) and improved crop incomes (with increases ranging from 12% to 22%). However, the overall impact of irrigation infrastructure improvements on poverty is found to be only marginal (with the incidence of chronic poverty only 0.8% less in areas with improved irrigation infrastructure than in those without) because of several factors including

- inequity in distribution of resources, particularly land, with those having larger landholdings benefiting more compared with small landholders and the landless; and

Table 1. Poverty Head Count (based on income) in Uda Walawe Left Bank Area, 2001

	Sevanagala Irrigated	Sevanagala Rain-fed	Kirribanara	Sooriyawewa	Extension and Rain-fed Area	Ridyagama	Irrigated All	Rain-fed All	Farm	Nonfarm	All
Incidence of Poverty (No. of Observations)	167	60	151	229	105	146	693	165	724	134	858
Total Poverty (%)	71	88	85	87	84	75	80	85	82	77	81
Chronic Poverty (%)	9	10	13	11	25	6	10	19	11	16	12
Transient Poverty(%)	62	78	72	76	59	69	70	66	71	61	69
Nonpoor (%)	29	12	15	13	16	25	20	15	18	23	19
Household Annual Expenditure (Rs)	64,360	59,024	67,243	64,907	49,398	94,283	71,473	52,898	69,856	57,341	67,901
Household Annual Income (Rs)	11,2062	11,1281	71,202	81,523	66,080	132,945	97,467	82,517	99,814	66,377	94,592
Value of Household Assets (Rs)	18,232	13,694	17,240	19,517	8,532	32,394	21,418	10,436	20,165	14,795	19,339
Value of Household Agricultural Assets (Rs)	17,415	1,752	21,731	18,837	10,484	27,749	21,002	7,309	19,811	10,575	18,369
Housing Index	74.4	73.6	78.9	73.3	69.2	84.6	77.2	70.8	77.5	67.8	76.0

Note 1: Sevanagala area is located at the upstream of the system (in the irrigated part of Sevenagala, irrigation infrastructure is well developed/improved/lined); Kirribanara is located in midstream where infrastructure is recently improved/lined; Sooriyawewa is located further downstream where infrastructure is recently improved/lined; extension and rain-fed area is located further down to Sooriyawewa where irrigation infrastructure is being provided now; and Ridyagama is located adjacent to Sooriyawewa and extension and rain-fed area, where there is irrigation infrastructure but unimproved.
Note 2: $1 = Rp90 in 2001.

- poor governance in the water sector (poor infrastructure condition, including improved infrastructure, due to inadequate maintenance, and unreliable water supplies due to lack of proper planning and water theft), which tends to negate any antipoverty impacts of improvements in infrastructure.

The study indicates that the incidence of chronic poverty is higher among nonfarm households (64.2%) than among farm households (6.5%). The majority of these nonfarm households, constituting over 39% of all households, are landless.

Why are the antipoverty impacts of irrigation development greater in Sri Lanka than Pakistan? As highlighted in Table 2, the primary reasons are related to inequity in landholdings coupled with infrastructure improvements that were not targeted at the poor.

Table 2. Reasons for Differences in Antipoverty Impacts of Irrigation in Sri Lanka and Pakistan

Selected Systems in Sri Lanka	*Selected Systems in Pakistan*
• Inequity in land distribution is low	• Inequity in land distribution is high
• Landlessness is limited	• Landlessness is high and increasing
• All irrigation infrastructure was improved without regard to landholding size	• Most irrigation infrastructure was improved in areas with large landholdings
• Irrigation infrastructure was improved uniformly	• In most cases, irrigation infrastructure was not improved uniformly
• Irrigation infrastructure improvement has resulted in increased crop productivity and incomes, and the poor have benefited the most	• While irrigation infrastructure improvement has increased crop productivity and incomes, much of the benefit has gone to non-poor (large landholders)
• Infrastructure improvement was targeted at the poor	• Irrigation infrastructure improvement was not targeted at the poor

The case study concludes that

- access to agricultural water/irrigation can significantly reduce the incidence of chronic poverty;
- the impact of irrigation on poverty is highest where landholdings are fairly equitably distributed;
- for effective poverty reduction, agricultural water/irrigation development must be targeted at the poor communities/areas/localities; and
- in situations where land distribution is highly skewed, such as in Pakistan, the benefits of agricultural water will continue to be inequitably distributed unless fundamental measures are taken, such as land redistribution.

Analysis of Selected Irrigation Systems in Six Countries

On a broader scale, IWMI is currently undertaking a study on water and poverty in 19 selected irrigation systems in six countries—Bangladesh, People's Republic of China (PRC), India, Indonesia, Pakistan, and Viet Nam. The overall goal of the project is to promote and catalyze equitable economic growth in rural areas through pro-poor irrigation interventions. The immediate objective is to determine realistic options to improve the returns to poor farmers in low-productivity irrigated areas within the context of improving the overall performance and sustainability of established irrigation schemes. The key hypotheses being tested in the study include the following.

- Canal reaches receiving less irrigation water have lower productivity and a higher incidence of poverty.
- Under existing conditions, small, marginal, and poor farmers receive less benefits from irrigation than large and non-poor farmers.
- The greater the degree of O&M cost recovery, the better is the performance of irrigation management.

- Participatory irrigation management (PIM) and/or irrigation management transfer (IMT) leads to improved irrigation system performance, which in turn reduces poverty.
- An absence of clearly defined water allocation and distribution procedures, and absence of effective and clear water rights (formal and informal) adversely affects the poor more than the non poor.
- There is scope for improving performance of irrigation systems under existing conditions, with effective and improved institutional arrangements.

The following are some of the preliminary findings of the study.

In selected irrigation systems, the incidence of rural poverty is highest in Bangladesh and Pakistan and lowest in the PRC. Estimates also suggest that the incidence of rural poverty is decreasing over time in all study countries except Pakistan.

In rural settings, land and water resources are important determinants of poverty. Past development of land and agricultural water resources in the six countries have played an important role in significantly improving household, community, and regional food security and in reducing the incidence of chronic poverty through increased productivity, employment, wages, and income, and by increasing consumption of both food and nonfood items. Preliminary results of the study suggest that there are strong linkages between agricultural water and poverty. However, most irrigated agricultural systems are still home to large numbers of poor.

Inequity in the distribution of land and water resources is highest in selected systems in South Asia—most inequitable in Pakistan and only marginal in the PRC and Viet Nam. In South Asia, much rural poverty is among

- landless households where household members are unskilled, without opportunities in nonagricultural sectors, and depend on agriculture for wage labor, and
- small landholders because of both water and nonwater-related constraints (e.g., information, technology, inputs, etc.).

In South Asia, landlessness is increasing rapidly with population increases. The rate of landlessness is rising faster in Pakistan than in other countries. In Pakistan, in the absence of nonagricultural/industrial sector development, fundamental land reform is essential to make significant reductions in rural poverty. Improvement in the governance and management of irrigation/agricultural water would provide some indirect benefits to the landless poor and would provide considerable benefits to poor smallholders.

Crop and water productivity levels in PRC, Indonesia, and Viet Nam, where landholdings are generally smaller, are fairly high with cropping intensities ranging from 200 to 300%. However, there is considerable scope to increase economic productivity of both land and water in these countries through crop diversification and value added to farm produce. On the other hand, crop productivity levels are generally low in South Asia, particularly in India and Pakistan, with substantial variations in productivity across households, communities, and systems. There is considerable scope to increase both the physical and economic productivity of land and water through interventions in the water and nonwater sectors.

The study finds significant inequity in water distribution across head, middle, and tail reaches of the systems studied. Inequity in water distribution exists even in systems in the PRC and Viet Nam where there is less inequity in land distribution. Inequity in water distribution translates into productivity differences, with lower productivity at tail reaches or downstream. For instance, in 10 distributaries studied in Pakistan, wheat productivity varied from 1,680 to 3,459 kg/ha at the head to 1,236–2,965 kg/ha at the tail. The study further found that, as a result of less access to water and lower productivity, poverty incidence at tail ends is higher than at head and middle reaches.

The problem of tail reach poverty exists mostly where there are neither alternative water sources (e.g. groundwater) nor alternative sources of employment (nonagricultural enterprises, market towns, etc.). These findings so far support the hypothesis that command areas of specific canal reaches receiving less irrigation water per ha have lower productivity and a higher incidence of poverty. Poverty incidence increases with reduced irrigation water access (tailends) or when there is no access at all (rain-fed areas), a situation worsened in low, dry season harvests.

Overall, the study findings suggest that the causes of poverty are complex and multidimensional. In rural agricultural systems, which support the livelihoods of 60–80% of the population, water availability and access may be a necessary, if not sufficient, condition for poverty reduction. Agricultural water deprivation leads to unacceptable socioeconomic conditions, including a lack of the basic food and nonfood supplies needed to fulfill human physical needs as well as ill health, lack of education and skills, and lack of reasonable living conditions. Any one of these factors can push the already poor and vulnerable into even deeper distress. Conversely, a considerable part of rural poverty can be reduced through improved access to water with well-planned and targeted interventions.

Institutional reforms and related interventions in the water resources sector are presently under way at the broader level in all the study countries, although progress is slower in South Asia than elsewhere. Reforms cover three major aspects: legal and regulatory measures, participatory management, and finance. Laws governing water use have been established in most countries, but there is often either overlapping authority or gaps in authority, lack of funding for enforcement, and lack of clarity regarding land and water rights.

The need for participatory agricultural water management has been recognized for transparent and effective water management, for sharing of information, and for building awareness among farmers of the importance of saving water. However, PIM or IMT through the formation of water users associations is still in the experimental stage. Results achieved so far are mixed. Early results from the study suggest that either IMT and/or PIM has the potential to create a conducive environment for improving performance of irrigation, including equity in distribution of water and improved access to water by the poor. In South Asia, for instance, there are indications that IMT and/or PIM (although implemented on only a limited scale) has led to a reduction in agricultural water-related corruption, disputes, and water theft.

Water charge recovery rates have increased (e.g., the recovery rate increased to 88–95% in systems where IMT was implemented in Indonesia and Pakistan). Along with improvements in water management, infrastructure improvements have also taken place. Also, confidence, awareness, and empowerment of farmers have improved through meetings and dialogues over water-related issues.

Given the scale and period of implementation of these reforms, it is too early to evaluate the full range of impacts. However, observations and preliminary findings of the study suggest that IMT and/or PIM efforts are likely to be successful where

- distribution of land is fairly equitable;
- irrigated agricultural systems are relatively small and manageable; and
- communities within the systems are fairly homogenous (e.g., not divided historically into lower or upper castes).

In areas where these conditions do not apply, it will take a relatively long time before the reform initiatives have a chance at successful and effective implementation. Enforcement of strict regulatory measures will remain crucial to avoid any negative impacts on the poor that might emerge when these initiatives are implemented.

Based on preliminary findings of the study, two sets of interventions are identified to increase the benefits of irrigation water to the poor:

- broad interventions for improved management of agricultural water to improve agricultural water/irrigation system performance that would have both direct and indirect positive impacts on poverty; and
- targeted interventions that would have direct positive impacts on poverty.

  The interventions relate to the following aspects:
  - institutional, legal, and regulatory policy;
  - management, allocation, and participation;
  - infrastructure and technology;
  - economic and financial; and
  - research, knowledge, information, and capacity development.

The initial menu of identified interventions is presented in Box 1.

Impact of Agricultural Water on Poverty: Small-Scale Systems

In recent years, there has been an upsurge in the adoption of irrigation technologies for smallholders such as low-cost pumps, treadle pumps, low-cost bucket and drip lines, sustainable land management practices, supplemental irrigation, and recharge and use of groundwater and water harvesting systems. This wide range of technologies, collectively referred to as "smallholder water and land management systems," attempts to create opportunities for the poor and small landholders in accessing presently unusable water supplies, which in turn leads to increased production and income. Emerging evidence suggests that access to agricultural water through these technologies offers tremendous potential to improve the livelihoods of millions of the poorest. Thus identification and promotion of these technologies present significant opportunities in the fight against poverty.

Poor smallholders and landless households around the globe are the main beneficiaries of microirrigation technologies. These technologies are particularly suited to small, poor, and even landless households as the costs self-select the poor

Box 1. Preliminary Menu of Interventions to Irrigation Water for the Poor in Surface Irrigation Systems

Broad Interventions

- Improve institutional environment and governance in the agricultural water sector.
- Involve communities in the management of agricultural water resources.
- Encourage public-private partnership in managing agricultural/irrigation water resources.
- Establish effective regulatory measures and mechanisms for transparency and accountability among service providers and water users.
- Establish clear water rights and water entitlements in the systems by introducing effective and enforceable legal frameworks with flexible provision for seasonal water use.
- Promote full O&M cost recovery to improve and maintain system performance (from which the poor benefit directly or indirectly) and to redistribute benefits of irrigation through larger contribution from the non poor for improving productivity of landless and marginal farmers.
- Introduce systems of advance payments of water fees by users to improve on collection rate.
- Promote shared management of surface and groundwater to help reallocate water to areas where groundwater is of poor quality.
- Develop, improve, and/or line canal infrastructure in areas where groundwater is not suitable for crop production.
- Introduce season-wise planning for equitable distribution and efficient use of available water resources.
- Improve markets for inputs and outputs.
- Improve economic value of water through diversification of both crop and non crop farm outputs.
- Promote cropping pattern changes from high water-consuming crops to low water-consuming, but high-value crops (e.g., paddy to high-value crops).
- Clearly recognize and incorporate rural poverty concerns and the need and importance of pro-poor interventions in national and subnational-level policies and plans.

Targeted Interventions

- Promote pro-poor institutional arrangements, including
  - Involving the poor/smallholders in water management decisions, i.e., establishing and strengthening water users associations (WUAs) with due representation of the smallholders and the poor; and
  - Establishing and strengthening separate WUAs of tailenders in situations where there are significant head-tail inequities in water distribution.
- Establish guaranteed minimum water rights for smallholders in drought and scarcity conditions to ensure household food security.
- Especially where there is significant inequity in land distribution, establish pro-poor water allocation/distribution rules that will allocate more canal water per unit of area for smallholders as compared with large farmers. Give priority in water allocations to areas and command reaches where poverty incidence is higher.
- Promote canal water reallocations to canal command areas or reaches where groundwater is of poorer quality, mostly tail ends where incidence of poverty is relatively higher.
- Develop pro-poor (discriminatory) pricing systems such as differential pricing for larger areas beyond specified ceiling per farm household.
- Create employment opportunities for the poor, including the landless, by involving them in O&M, water fee collection, and other supervisory activities.
- Increase productivity and value of water in ways that favor the poor, such as promoting crop diversification toward high-value crops on smallholder farms through the provision of necessary incentives, information, and support.
- Target technological support, such as providing high-quality seeds, fertilizers, credit, and agricultural equipment to land leveling for the poor communities in canal commands.
- Provide monetary and technical support to install pumps or other water-lifting devices for communities in command areas or canal reaches that are relatively poorer but have good quality groundwater.
- Prioritize command areas or reaches with relatively greater poverty incidence for infrastructure rehabilitation and upgrading, and for new infrastructure for storage and distribution of water.
- Improve markets for the inputs purchased and outputs produced by the poor.
- Build capacity of smallholders and the poor through information and training programs.
- Develop databases on poverty, location, incidence, and depth of poverty, and monitor poverty regularly.
- Encourage research on agricultural water and poverty.

Box 2. Small Irrigation Technologies and Poverty Reduction

The Case: The Global Initiative for Smallholder Irrigation is the world's most ambitious poverty reduction plan aimed to enable 2 million rural poor households a year to take a major step on the path out of poverty. The approach exploits the fact that small, low-cost, and affordable irrigation technologies that can fit small plots and even be useful for landless households, self-select the poor and have strong *land and water augmentation effec*ts. The pro-poor technologies successfully tested so far include treadle pumps, rope and washer pumps, low-cost drip and micro sprinkler, and bucket kits. The poverty reduction objective would be achieved through production of high-value crops, expansion of markets for the outputs produced by the poor, and job creation enabled by smallholder irrigation. The initiative is expected to benefit 30 million poor and landless households around the globe, and would bring 1 million ha under cultivation each year over 15 years. These technologies have so far been successfully tested in several countries in eastern Asia (People's Republic of China), South Asia (Bangladesh, India, and Nepal), Latin America (Brazil, Nicaragua, and Mexico), and Africa (Kenya and Zambia). We present here a summary of issues and lessons learned from case studies undertaken on smallholder irrigation in India and Nepal (Winrock International and IDE 2001).

Major Beneficiary	• All those who often are deep down or below the poverty line including poor rural households and landless families
Core Pro-Poor Intervention(s)	• Here the private sector is the key player in the promoting and marketing irrigation technologies and providing other related inputs to the poor. An initial price subsidy enables private sector entrepreneurs to mass-market these technologies among the rural poor and landless. • Poor landless households use horticultural kits for income generation. • The package consists of bucket kits, seed, fertilizer, pest control, and other information. • Wealth creation becomes possible by growing high-value crops like papaya mixed with other vegetables, bitter gourd on the fence, and pumpkins on the roof.
Opportunities to Serve the Poor	• Poorest households with land as little as 40–100 m^2 and water as meager as 2–10 buckets a day can earn $100 per year in net income. • Virtually all rural families have access to that much land and water and therefore, virtually all rural poor stand to benefit from this pro-poor intervention. • Intervention has the potential to improve health and nutrition as well as generate new income for the landless.
Cross-cutting Issues	• Access to low-cost drip irrigation technology • Access to credit • Access to inputs • Access to markets • Access to additional water • Active involvement of private sector to mass-market these pro-poor technologies
Pro-Poor Policy Implications	• Landless families are too poor to afford even these low-cost kits; therefore, seed capital or access to credit is vital. • There is a need to shift from subsistence to market-oriented horticultural production.
Equity Assessment	• Small irrigation technologies have strong potential to self-select the poor. • The technologies offer a "win-win" gift for the poorest and landless households around the globe.

Source: Winrock International and IDE. 2001. *Study on the Dissemination Potential of Affordable Drip and Other Irrigation Systems and the Concrete Strategies for Their Promotion*.

and have a strong land and water-augmentation effect. Box 2 presents an overview of potential antipoverty impacts of microirrigation technologies worldwide.

Treadle Pumps in South Asia's "Poverty Square"[4]

A treadle pump is a foot-operated device that uses bamboo or flexible pipe for suction to pump water from shallow aquifers or surface water bodies. Since it can be attached to a flexible hose, a treadle pump is useful for lifting water at shallow depths from ponds, tanks, canals or catchment basins, tube wells, and

[4] Shah, Tushaar, M. Alam, Dinesh Kumar, R.K.N. Nagar, and Mahendra Singh. 2000. Pedaling Out of Poverty: Social Impact of a Manual Irrigation Technology in South Asia, IWMI Research No. 45. Colombo: IWMI.

other sources up to a maximum height of 7 meters (m). It performs best at a pumping head of 3.0–3.5 m, delivering 1.0–1.2 liters (l) per second.

Recent research by IWMI suggests that treadle pump technology has had a tremendous impact in improving the livelihoods of the poor in Bangladesh, eastern India, and the Nepal Terai (the heartland of the Ganga-Brahmaputra-Meghna basin), South Asia's so-called "poverty square." This region, which contains 500 million of the world's poorest people and is characterized by tiny landholdings, is underlain by one of the world's best groundwater resources, available at a depth of 1.5–3.5 m.

The treadle pump is truly a pro-poor technology. It is cheap and affordable at $12–30, is easy to install, operate and maintain, and has no fuel costs. Treadle pump technology has the unique property of self-selecting the poor and positively impacting their livelihoods. Based on an extensive 1998 survey of 2,400 households in parts of Bangladesh, eastern India, and Nepal Teri, a study by Shah et al. suggests that

- for poor smallholders constrained by limited land, treadle pump technology works as a land augmenting intervention, enabling users to raise crops in both summer and winter, thereby increasing overall cropping intensity;
- treadle pump technology enables farmers to grow high-yielding varieties such as Chinese rice and high-value crops such as vegetables); and
- the technology increases crop yields. For instance, in Uttar Pradesh and north Bihar, treadle pump users had average potato yields of 16–17 t/ha, a level 60–70% higher than those of diesel pump users.

As a result of improvements in these intermediate variables, the study estimates that farms using treadle pump technology see an average increase of $100 per year in annual net income with gross incomes of $300–400 per acre quite common. Net incomes with use of the technology did, however, vary across households and regions. International Development Enterprise (IDE), a US-based NGO that developed and promoted the technology, claims to have sold 1.3 million pumps since the mid-1980s in Bangladesh, and 200,000 in eastern India and the Nepal Teri since the mid-1990s. IDE indicates that, "eastern India and the Nepal Teri have an ultimate market potential for some 10 million treadle pumps. If and when IDE does saturate this market potential, it will have probably accomplished one of the world's biggest and best-targeted poverty reduction interventions, by increasing the net annual income of South Asia's poorest rural households by a billion dollars" (Shah, et al. 2000).

Examples of Pro-Poor Interventions

The case studies presented above demonstrate linkages between agricultural water and poverty at the system and household levels as well as the implications for poverty reduction. Based on the results of our recent fieldwork, we now outline examples of intervention strategies that have a potential for increasing the benefits the poor receive from irrigation systems, thereby improving the lives of the most vulnerable.

Institutions and technologies: Pakistan's Chaj Subbasin

> A major breakthrough in wheat yield: When the crop assessment official announced from the rostrum that the average wheat yield had gone up to 51.62 maunds per acre, the jampacked **pandal** for the "farmers' day" broke into loud and spontaneous clapping (Dawn, 26 April 2000).

In 1998, the Food and Agriculture Organization (FAO) introduced productivity enhancing interventions (for experimental and demonstrative purposes) at selected sites in Punjab. The interventions included creating new institutional frameworks (organizing farmers into farmers organizations) and supplying technological packages (providing inputs such as new seed varieties, fertilizers, farm equipment, information on timings and quantities of input use, and introducing measures such as laser land leveling). The farmers organizations (FOs) were provided the following inputs/services:

- farm implements and equipment for use by members as well as for renting out to nonmembers, with revenues used to build and strengthen the FO Fund;
- fertilizers and improved seed varieties to members at half the cost under the condition that the inputs be used at the recommended quantity and time;
- laser land leveling for members; and
- agricultural extension services through the appointment of an agricultural extension advisor.

This combined technological and institutional intervention package resulted in significant improvements in overall farm management, cropping intensity, and crop yields. Land leveling enabled farmers to save water and increase the irrigated area by 15–20%. IWMI's study in the Chaj area suggests that wheat yields have significantly increased (more than doubling from 2 t/ha to over 4 t/ha), resulting in improving food security at both the community and household levels. This example shows how the interactions of institutions and technologies can create an enabling environment and opportunities for the poor to improve their livelihoods and food security as well as reduce poverty.

Community Initiatives: An Example from Indonesia

Pasir village, situated near Semarang in Central Java, is located at the tail end of the middle reach of the Klambu Kiri irrigation system. The village is home to 2,050 residents, has a total area of 929 ha and average landholdings of 0.3–0.6 ha. The village is fully agriculture dependent, with no industry or other non-farm activities. Given its location within the irrigation system and with no suitable quality groundwater available, the village was once faced with the classical tail-end problem of water shortages. However, the village took the initiative collecting funds from community members to build infrastructure that will divert and use drainage water previously flowing to the sea. With the increased availability of water, land is now cultivated three times a year.

About two thirds of the area are cultivated with high-value crops, such as onions and chilies, with the remaining third in paddy. Crop yield is high at 7–8 t/ha for onions, 1 t/ha for chilies, and 6–7 t/ha for paddy with production taking place at reasonably profitable rates. Traders come to the area to buy produce that is then transported to Semarang and even Jakarta. Demand for labor has significantly increased, especially during sowing and harvesting seasons, with wage rates ranging from Rp20,000 per day for female labor, to Rp40,000 per day for male labor. The availability of water and the increased economic productivity of water through crop diversification have brought enormous prosperity to the village. Poverty has disappeared, the village is fully food secure, and no village residents are now accepting food from the government social safety net program.

Response to Water Scarcity: Madhya Pradesh, India

In Madhya Pradesh, India, farmers have adopted unique cropping patterns in response to water scarcity. In most parts of the state during the rabi season, farmers allocate a significant part of their farm area to less water and fertilizer demanding wheat varieties (e.g., non-Mexican varieties requiring only 1–2 irrigations per season as compared with Mexican high-yielding varieties requiring 4–5 irrigations per season). While the yield of the less water-intensive varieties is generally lower than high-yielding Mexican varieties, production costs are lower and sales prices higher (due to a taste preference for breads made with traditional varieties), resulting in overall returns similar to or even higher than those from high-yielding varieties. The major pro-poor feature of the technology is the cultivation of traditional varieties, which require less water and lower cost of production.

An Innovative Approach to Promote Equity: The Dual Canal System in the Ruhuna Basin, Sri Lanka

Upstream-downstream inequity, commonly known as “head-tail” inequity, in water distribution is a classical problem in most surface irrigation systems. There is evidence that the problem exists even in relatively small systems such as those in Sri Lanka (smaller relative to systems in, for instance, India and Pakistan, where the problem of inequity is much more severe). In the absence of alternative sources of water (e.g., groundwater), head-tail inequity in water distribution translates into differences in productivity levels and inequity in farm incomes, with those having better access to water (e.g., head-enders) generally economically better-off than those at the tail end.

In response to growing water scarcity, and specifically to address head-tail problems in the Walawe Left Bank (Ruhuna Basin) of Southeast Sri Lanka, an innovative approach known as the “dual canal system” was introduced in the tail-ends of the existing irrigation systems and in a newly developed area further downstream that forms part of Sri Lanka’s resettlement program.

Under the dual canal system, mini-water storage tanks with a command area of about 80 ha were designed based on the topography of the area. Some tanks have their own catchments while others are fully fed by distributary or branch canals. Each tank has four sluice gates to regulate water supplies in four lined distributaries, two each for paddy and upland crops. Farmers in the paddy canal command are given 1 ha of land while upland crop farmers are given 0.8–0.9 ha (returns from upland crops are higher than those from paddy). In addition, each farmer is allotted 0.1 ha for a homestead. Farmers in the paddy canal command can cultivate paddy, a water-intensive crop, or less water-intensive upland crops, while farmers in the upland canal command can only cultivate upland crops (with the exception that a small paddy plot is allowed for home consumption to ensure household food security). Water supplies in paddy canals is 24 hours, while that in upland crop canals is for only 12 daytime hours. The system promotes user participation in water management. While the system is quite new and its success and effectiveness remains to be seen, overall water management within the system is considered better than in conventional canal systems and early indications suggest that the approach has significantly improved the equity of water distribution, with almost all benefits accruing to poor areas.

Community Sharing of Land and Water: The Bethma System in Sri Lanka[5]

Dry zone villages in Sri Lanka have traditionally been located near man-made tanks. Water was distributed from the tank outward, toward paddy fields divided into three echelons where each household in the village maintained holdings. During water-rich periods, water was distributed to all fields within the system, while in drier periods the echelons farther from the tank were allowed to go fallow. This arrangement, known as the Bethma system, helped ensure not only optimal use of available water supplies, but also maintained equity across households. A variation on the traditional system is currently being followed in modern systems managed by the Mahawelli Authority of Sri Lanka in an effort to promote long-term equity among farmers and ensure household food security. In normal years, land use rights are not allocated according to the Bethma system. However, in dry years those farmers located further downstream in the irrigation systems with locational disadvantage in water access are temporally reallocated to land in the upper reaches. Simultaneously, those farmers whose plots were located in the upper portion temporarily sacrifice some of their holdings, thereby sharing the costs of any water shortage. While not equivalent to the former system, the use of concepts from the traditional Bethma system provides an innovative example of how traditional concepts can be used to increase equity in modern irrigation systems.

Enhancing Antipoverty Impacts of Irrigation

Based on the material presented in the case studies and a review of global literature, we identify the following factors that will determine the direction and magnitude of antipoverty impacts of irrigation. While impacts of irrigation on poverty reduction will vary by agro-climatic regions and institutional settings, these are essentially the generic conditions that will determine the magnitude of the impact of any irrigation intervention on poverty

- (in)equity in land distribution;
- irrigation infrastructure condition/management;
- irrigation water management/allocation, and distribution policies, procedures, and practices;

[5] Extracted from note on Inter-temporal Reallocation of land to address the problem of Water Scarcity: The Case of Bethma in Sri Lanka by Samad, Madar, Parakrama Weligamage and Bandula Senaviratne. Note prepared for the Dhaka Meeting on Water and Poverty Initiative, led by the Asian Development Bank, 22–26 September 2002.

- type of irrigation technology;
- quality of irrigation water;
- production/cultivation technologies; cropping patterns, extent of crop diversification; and
- support measures (e.g., input and output marketing, information, etc.)

The antipoverty impacts of irrigation can be enhanced by creating conducive conditions that could achieve *functional* inclusion of the poor. These conditions include

- equitable access to land;
- integrated water resources management;
- access to and adequacy of good quality surface and groundwater;
- modern production technology;
- shift to high-value market-oriented production;
- opportunities for the sale of farm outputs at commensurate prices but at low transaction costs; and
- opportunities for nonfarm employment.

To the extent these conditions or enabling environments are lacking or imperfect, on-ground benefits of irrigation to the poor would continue to be discounted. For instance, in settings with high degree of inequality in land distribution, irrigation would have lower impact on poverty, as water rights and potent benefits are virtually tied to landownership. Lack of ownership or formal land titles and poor-insensitive land tenure systems, as is the case in many developing countries, result in *self-exclusion* for the poor, such that benefits of public irrigation accrue mainly to fewer landholders. Even if landholdings are equitable, as is the case in irrigated land resettlements in Sri Lanka, when irrigation resources are poorly managed, or access to complementary production inputs (agro-chemicals and credit) is poor, the impact of irrigation interventions on poverty is likely to remain small. Even if the first two conditions are met, but canal water supplies are inequitably distributed or inadequate, and opportunities for conjunctive use of groundwater are constrained due to its poor quality or high abstraction costs, possibilities for reaching out to the poor through irrigation will remain minimal. A shift from low-value subsistence production to high-value market-oriented production is the next step to the road out of poverty, as it is a key driver of income diversification and risk management. Similarly, newer production technologies and crop varieties, geared to suit small farmers and fit small plots, are a must for pulling the poor out of poverty through irrigation. Even if all these aforesaid conditions are met, when poor farmers remain unable to sell their bumper harvests in distant markets, due to market imperfections or high transaction costs, actual benefits of irrigation to the poor will fall short of their potential. Existence of employment opportunities outside the farming sector, especially in areas with high land-to-man ratios, would further help diversify incomes, minimize risk, and reduce poverty. In short, it is the "package" that matters for effective poverty reduction and not the mere supply of irrigation water.

Concluding Remarks

There are strong direct and indirect linkages between irrigation and poverty. Direct linkages operate via localized and household-level effects, and indirect linkages operate via aggregate or national-level impacts. Irrigation benefits the poor though higher production, higher yields, lower risk of crop failure, and higher and year-round farm and nonfarm employment. Irrigation enables smallholders to adopt more diversified cropping patterns and to switch from low-value subsistence production to high-value, market-oriented production. The transition to the market economy integrates the poor into land, labor, and commodity markets and empowers the poor by putting them at a level playing field with other market entities, including the non-poor. Increased production makes food available and affordable for the poor. The poor and the landless are main beneficiaries of low food prices as they are net buyers of food.

Indirect linkages operate via regional, national, and economy-wide effects. Irrigation investments act as production- and supply-shifters, and have a strong positive effect on growth, benefiting the poor in the long run. The magnitude of indirect benefits could be many times more than the direct and household-level benefits. Further, irrigation benefits tend to fall more squarely on the poor and the landless alike in the long run, although in the short run, relative benefits to the landless and land-poor may be small, as the allocation of water often tends to be land-based. Allocating water to the land and not to the households, is inherently biased against the landless. Despite that, the poor and the landless benefit, in both absolute and relative terms, from irrigation investments. Recent advances in irrigation technologies, such as microirrigation systems, have strong antipoverty potential.

Ongoing studies in Asian countries document strong evidence that irrigation helps reduce permanent and temporary poverty. Further, it helps reduce poverty in its worst forms, namely chronic poverty. This supports the view that irrigation is productivity enhancing, growth promoting, and poverty reducing.

The benefits of irrigation to the poor can be intensified by affecting broader level and targeted interventions simultaneously. Interventions should focus on reaching out to the poor through improved economic, policy, institutional, and governance measures. Generating a knowledge base through multicountry studies on constraints to productivity in irrigated agriculture is the first step to help identify the opportunities to serve the poor.

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