Assessing Impacts of Irrigation on Poverty: Approaches, Methods, Case Studies and Lessons[1]

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Conceptual Frame

As a vital resource in agriculture, irrigation water contributes to many productive and livelihood activities. With the common belief on the important role of irrigation in agricultural growth, many developing Asian countries have promoted irrigation development over the last five decades to achieve such broad objectives as economic growth, rural and agricultural development, food security, and protection against adverse drought conditions—all expected to contribute to improved social outcomes. Conceptually, the benefits of irrigation are realized through improvements in: agricultural productivity per unit area and overall agricultural production, employment and wages, incomes, consumption, food security and overall socioeconomic welfare. These benefits tend to be interrelated and reinforce the impacts of each other. Through these benefits, irrigation water is linked to poverty alleviation both directly and indirectly. Direct linkages operate via localized and household-level effects, and indirect linkages operate via aggregate or subnational- and national-level impacts. Irrigation can benefit the poor through raising yields and production, lowering the risk of crop failure, and generating higher and year-round farm and nonfarm employment. It can enable smallholders to adopt more diversified cropping patterns, and to switch from low-value subsistence production to high-value market-oriented production. The indirect linkages operate via regional, national, and economy-wide growth effects. Irrigation investments act as production and supply shifters, and have a strong positive effect on growth, benefiting populations in the long run. Further, irrigation benefits also accrue to the poor and landless 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. In spite of this, the poor and the landless also benefit from irrigation investments through increased food supplies and lower food prices. In sum, irrigation can influence poverty through three pathways: a) micro-pathway—through increasing returns to physical, human, and social capital of the poor households (productivity pathway); b) meso-pathway—through integrating the poor into factor-product and knowledge/information markets (market participation pathway); and c) macro-pathway—through improving growth rates and creating second-generation positive externalities (growth pathway). These pathways are very much interlinked. What happens on one particular pathway does have impacts on others. On the other hand, there can be instances where irrigation generates negative outcomes, adversely affecting resources, opportunities and overall social outcomes. Negative impacts can adversely influence poverty through the abovementioned direct and indirect linkages and pathways.

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There is a plethora of studies documenting evidence on poverty-related benefits and costs of irrigation. While the studies vary widely in terms of scope, methodology and geographic coverage (and most of them are from South Asian countries/Indian subcontinent), a large majority of the studies conclude that irrigation reduces poverty, although antipoverty impacts of irrigation vary widely across settings (see Hussain and Hanjra 2004 for a detailed review of irrigation-poverty impact literature). More recent multi-country studies, in addition to providing more evidence from diverse settings on the antipoverty impacts of irrigation through systematic analyses based on a consistent set of methods and procedures across locations, also identify conditions under which irrigation has greater or lesser impacts on poverty (see Hussain 2004 for details).

The purpose of this brief paper[2] is to outline main approaches and methods for irrigation-poverty impact assessment and key lessons learnt from recent multi-country studies. The paper highlights key dimensions and aspects of irrigation and poverty that should be considered in designing impact assessments. The aim is to provide input into the planned irrigation-poverty impact assessment work in Ethiopia.

Assessing Irrigation-Poverty Impacts—Multi-dimensions of Irrigation and Poverty

Impact assessment of any development intervention is a difficult and tricky task. Difficulties arise not only in tracing all relevant impacts, but in attributing and linking them to relevant interventions, and importantly, in valuing and translating them in forms that could be used in decision-making processes. In irrigation-poverty impact assessments, complexities arise due to a number of factors including: a) the complex nature of the water resource itself due to complicated hydrological interactions and flow paths of water; b) a multitude of uses (and abuses) of water; c) a multitude of direct and indirect beneficial and adverse impacts both physical and economic externality effects (positive and negative); d) the variations in value of water across time, space and use patterns; e) the insufficient information and difficulty in quantifying some of the uses and their impacts that underpin the values generated by water; f) the difficulty in putting monetary or dollar values to some of the complex uses and impacts; and g) the lack of data, information and tools required for quantification and valuation of impacts.

Given such complexities, it may be virtually impossible to precisely account for and assess all possible impacts of irrigation on poverty. No matter how rigorously the impact estimates are derived, they represent only crude measures of the true values, and this is how they should be seen, interpreted and used. In designing impact assessment, it is important to consider the following two principles: a) *optimal ignorance*—how much do we need to know to reach meaningful conclusions? and b) *appropriate imprecision*—there is no need to know everything exactly. For practical purposes, what we need is some sort of close proxies or indicative estimates to provide guidance in irrigation-related policy decisions. Also, the cost of determining even the proxy estimates of impacts are often too high (in terms of required expertise, time, finance and, importantly, reliable

[2] This is a shorter version of the longer paper prepared for the workshop. For more detailed discussions on any of the aspects discussed in this paper, refer to the longer version (i.hussain@cgiar.org)

data) to prohibit more in-depth inquiries (and in some cases, marginal gains from such in-depth inquiries may be so low that they may not justify spending of any additional resources). However, the indicative estimates should be robust and meaningful in guiding decision making, but simple enough to be derived and they should accommodate resource and data limitations. A sound design and framework of assessments that comprehensively cover the major dimensions of impacts are key to deriving meaningful estimates.

Table 1 outlines some of the key aspects that should be considered in designing an assessment framework. As indicated in this table, the impact of irrigation on poverty would vary by the type of irrigation intervention, and by source and methods of irrigation application. Magnitude of antipoverty impacts of irrigation would depend upon the use and value dimension of irrigation and on their spatial and temporal scales. Similarly, irrigation-poverty impacts would also depend on the nature and type of poverty. For example, irrigation may be more effective in reducing permanent poverty than temporary poverty. Finally, impact estimates may be influenced by approaches, methods and indicators employed for assessment.

Table 1. Dimensions and aspects to be considered for assessment of irrigation-poverty-alleviation impacts.

A. Dimensions of irrigation	Main aspects	Comments
Types of irrigation interventions	? New irrigation development ? Irrigation infrastructural improvement /rehabilitation ? Performance improvement of existing irrigation systems ? Irrigation system rehabilitation ? Irrigation management/institutional intervention	The impact of each of these interventions on poverty would vary significantly; research design would also differ; therefore, these aspects must be clarified before initiating an impact assessment.
Irrigation source, distribution and application methods	? Canal/surface water irrigation ? Tank/surface water irrigation ? Small-scale vs. large-scale irrigation ? Tube well/groundwater irrigation ? Conjunctive use systems ? Irrigation distribution methods (continuous, rotational/*warabandi*) ? Irrigation application methods such as flooding, sprinkler, drip and bucket irrigation	The impact of irrigation on poverty would vary by characteristics of delivery systems and by irrigation application methods. These aspects should be accounted for at the design stage.
Use dimension of irrigation	? Crop production ? Noncrop farm enterprises ? Nonfarm uses of water ? Other multiple uses	Impacts of irrigation on poverty would vary by type and multiplicity of uses of irrigation

		water; therefore, the scope of assessment in terms of uses of irrigation should be defined at the design stage.
Space dimension—geographic scale	? Macro/country level ? Meso/state/provincial level ? Intermediate/community level ? Micro/household level	Similarly, the impact of irrigation on poverty would vary by geographic scale; therefore, the scope in terms of spatial coverage should be clearly defined at the design stage.
Temporal dimension—length of time run	? Short term vs. long term ? Static vs. dynamic impacts	The impact of irrigation on poverty would also vary over time; therefore, the scope of assessment in terms of temporal scale should be clearly defined at the design stage.
Value dimension of irrigation	? Material (economic/financial) benefits/costs ? Nonmaterial aspects ? Externalities—positive and negative	Impacts of irrigation on poverty would vary depending on the net value of irrigation water; therefore, the scope in terms of value of irrigation water should be defined at the design stage of assessment.
B. Dimensions of poverty		
B. Poverty types	? Absolute vs. relative poverty ? Temporary vs. permanent poverty ? Static vs. dynamic impacts ? Material (income, assets, etc.) vs. nonmaterial dimension (health, education, out-migration, institutions, and caste system). ? Other classifications (food poverty, income/expenditure poverty, human poverty—longevity, knowledge, economic provisioning and social inclusion—resource/asset poverty,	Impact of irrigation on poverty would differ by nature and type of poverty. For example, irrigation might be more effective in reducing permanent poverty than temporary poverty, and it may be more effective in

	economic and social well-being, etc.)	reducing economic poverty than social or human poverty. In impact assessments, such differences should be clearly accounted for.
C. Approaches to impact assessment		
Broad approaches and methods	? Qualitative vs. quantitative approaches - "Before and after" intervention comparisons - "With and without" intervention comparisons - "More with less" or differential access comparisons ? "Average vs. marginal" impacts approaches ? Choice of key and indicators. Indicators may be classified as a) the process or intermediate indicators that give an indication of the status, situation and the process that lead to some outcomes or impacts, and b) outcome indicators that give an indication of the consequence of achieving or failing to achieve a particular outcome. Most commonly used indicators may be broadly classified into the following five categories: *Endowment of natural resources* (land, water, productivity, etc.). *Asset ownership* (per capita land, per capita irrigated land, ownership of house, quality of house, room space per family member, and household assets). *Economic opportunities* (income sources, average income, average expenditure, ratio of food to nonfood expenditure, occupation, (un)employment, wages, access to markets, access to credit, gender-specific labor force participation rate, etc.). *Social services and opportunities* (access to information, access to services, such as school, hospital, post office, telephone, electricity, gas, safe drinking water, etc.). and basic social indicators—health-related	Resource requirement (in terms of time, cost and expertise), rigorousness, reliability and usefulness of impact assessments would vary by the type of assessment approach adopted. The choice of a particular assessment approach would depend on the above dimensions of irrigation and poverty, and should be defined at the design stage, with flexibility for necessary adjustments/ improvements.

	basic indicators, such as per capita calorie intake, under-five mortality rate, child malnutrition, child stunting, access to sanitation, life expectancy, etc.; and education-related indicators, such as adult literacy rates, enrolment in primary education, school dropout rate, school absenteeism rates (for those attending school), ratio of girls to boys in schools, distance to school, per capita educational expenditure, etc. and other social indicators (such as participation in decisions making, etc.) *Demographic indicators* (location, family size, dependency ratio, etc.)	

Irrigation-Poverty Impacts: Empirical Evidence

In 2002-2003, IWMI carried out detailed case studies on assessing impacts of irrigation on poverty alleviation in 26 selected canal irrigation systems in Bangladesh, China, India, Indonesia, Pakistan and Vietnam. These are among the top few countries where substantial investments have been made in the development of large- and medium-scale canal irrigation systems; where irrigated agriculture provides livelihoods to hundreds of millions of rural people. These countries together account for over 51 percent of global net irrigated area and over 73 percent of net irrigated area in Asia, with most of this area located in China, India and Pakistan. The systems selected for the study varied in terms of size, water supply and distribution, irrigation infrastructural condition, irrigation management, cropping patterns, crop productivity, level of crop diversification, size of landholdings, and demographic and social characteristics.

The case studies used both qualitative and quantitative approaches for impact assessments, which were largely based on primary field-level data. The studies were initiated by undertaking a broader-level assessment of each system for understanding their characteristics: technical/hydrological, agricultural, socioeconomic and institutional/management. These assessments were largely based on qualitative and participatory approaches using tools such as quick field surveys, focus group discussions and short interviews with semi-structured questionnaires. The initial fieldwork and participatory assessments provided an important foundation for designing sampling framework, data collection and for carrying out detailed assessments. Primary data were collected from within the systems and from adjoining rain-fed areas through household surveys. Consistent procedures were adopted for establishing reference areas and for developing a sampling framework and sample selection across selected systems in the six countries. For each irrigation system, a sample was drawn using a multistage sampling method. In the first stage, each selected irrigation system was purposively divided into three strata (e.g., head, middle and tail parts) to account for potential differences in the availability and access to water across reaches. In stage two, each stratum was divided into a number of clusters (in irrigated areas, a distributary canal was taken as a cluster and in rain-fed areas a village was defined as a cluster). One to two representative clusters were selected along each of the three reaches—head, middle and tail—of a system. Each of the reaches represented zones where agricultural activity was influenced by irrigation. The adjoining rain-fed areas were taken as reference zones. In stage three, a sample of households was selected from each cluster. Given the differences and complexity of systems across countries, there were some minor variations in procedures adopted in each of the locations according to local conditions; however, overall sampling procedures were fairly consistent across systems. The total sample size for surveys consisted of 5,408 households in the 26 selected systems. The sampled households were interviewed with pretested structured questionnaire for gathering data and information on various aspects of household economies including demographics, landholdings and agriculture, irrigation, cost and returns of crop cultivation, household assets, employment and earnings from the nonagriculture sector, credit, household total incomes and expenditures, and other related variables. The survey covered all cropping seasons during the 2001-2002 agricultural year (for more details on data-collection procedures see Hussain 2004).

Assessment was undertaken in a comparative framework where comparisons were made: a) between irrigated systems and adjoining unirrigated settings; across reaches within a system (head, middle and tail); and b) across systems (within and across countries). Impacts were assessed in both average and marginal terms. Econometric techniques were applied for assessing marginal impacts. The study used a range of process and outcome indicators classified into the following five categories:

Agriculture and water. Cropping pattern, crop diversification, cropping intensity, irrigation intensity, productivity/value of productivity/ha, net monetary benefit of irrigation/ha.

Resource endowments and assets. Land tenure, average landholding size, land distribution pattern, landlessness, household non-land agricultural assets, household nonagricultural assets.

Incomes, expenditures and employment. Household average income per year, ratio of crop income to total income, ratio of noncrop farm income to total income, ratio of nonfarm income to total income, average expenditure per year on food and nonfood items, ratio of food expenditure to total expenditure, and occupation.

Geographic, demographic and social indicators. Household location, family size, dependency ratio, education level, caste.

Income or expenditure poverty indices. Headcount index, poverty gap index, squared poverty gap index.

In addition to undertaking comparative analyses with the above indicators, the study employed an econometric framework using these indicators to evaluate their relative significance. The case studies focused on assessing mainly direct localized impacts of canal irrigation on poverty.

The following five points summarize some of the key findings and conclusions from the country case studies:

1. Irrigation has a strong land augmenting impact; the value of per hectare crop production under irrigated settings is about twice that under rain-fed settings. Quantitative evidence shows that household income and consumption are much higher in irrigated settings than in rain-fed settings, and a 50 percent point gap is not uncommon. In most settings, poverty incidence is 20-30 percent higher in rain-fed settings than in irrigated settings; irrigated systems have a much lower chronic poverty than rain-fed settings; the study suggests that irrigation significantly contributes to reducing the worst kind of poverty, i.e., chronic poverty.

2. Indirect impacts of irrigation on incomes and poverty are much larger than direct impacts. Even at the local level, direct productivity-related antipoverty impacts of irrigation are only one-third of total impacts in the command areas, and the impacts are much higher when economy-wide multiplier impacts are also accounted for. Further, there are complementarities between public-sector investments in canal irrigation and private-sector investments in irrigation and other related sectors by farmers such as investments in groundwater development.

3. The study finds that there are indicative patterns of poverty in large and medium-scale canal systems, where, in general, poverty is significantly lower at middle reaches than that at head and tail reaches; poverty is high where availability and access to surface water is low, groundwater quality is poor, agricultural productivity is low and opportunities in the nonfarm sector are limited.

4. In areas where communities and households depend to a great extent on agriculture for their livelihoods, access to irrigation is a necessary, but not a sufficient condition for poverty alleviation; access to other production inputs and services by the poor small and marginal farmers is also important to enhance benefits of irrigation for poverty alleviation.

5. Overall, the study findings suggest that irrigation reduces poverty significantly; however, the antipoverty impacts of irrigation vary across and within irrigation systems and depend on a number of factors, which include: a) condition of the irrigation infrastructure and its management, b) irrigation water allocation and distribution procedures and practices, c) irrigation and production technologies/methods, cropping patterns and crop diversification, d) support measures, e.g., information, input and output marketing, and e) structure of land distribution—(in) equity in land distribution—and land quality. Analyses from the country studies provide evidence that incidence and severity of poverty are significantly high in those settings where land and irrigation water

distribution is inequitable, irrigation infrastructure is poorly managed, and farmers' access to production-enhancing technologies and support measures is limited. Where these factors are favorable, the incidence of poverty is relatively low. Also, the studies indicate that poverty may be adversely affected where irrigation is mismanaged leading to land degradation problems, such as waterlogging and salinity, and abandoning of lands in the long term.

The overall conclusion of these studies is that irrigation investments, whether in the development of irrigation or in the performance improvement of existing systems, should not always be assumed to be poverty-reducing and that irrigation can be strongly pro-poor, neutral or even anti-poor depending on the above and the other related conditions.

References

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