Impact of Irrigation Infrastructure Development on Dynamics of Incomes and Poverty

Econometric Evidence Using Panel Data from Pakistan

Intizar Hussain,
Aamir Nazeer,
Ashfaq Muhammad, and
Waqar A. Jehangir

March 2003

Acknowledgements

This report is the outcome of the collaborative research project initiated by the JBIC Institute, the Japan Bank for International Cooperation and undertaken by the International Water Management Institute (IWMI). Several people have contributed, directly or indirectly, to the production of this output. First of all, we are thankful to our survey respondents who furnished information during the five household level surveys and whose cooperation made this study possible. We greatly acknowledge the hard work and active cooperation of field data enumerators and fieldwork supervisors, especially Mr. J.K. Somasiri. Special thanks to Mr. Izhar Hunzai for his contributions in the development of the proposal for the first phase of this project.

We are grateful to the JBIC Institute for providing the financial support as well as intellectual input for this project. Finally, we would like to thank our Director General, Professor Frank Rijsberman; Director Finance and Administration, Mr. Gerard O'Donoghue; and Director Asia, Mr. Ian Makin, and theme leader for WRIP theme, Dr. Madar Samad for their continuous support and encouragement for this project.

This study has been undertaken under the collaboration of following members

IWMI Team
Intizar Hussain
Senior Economist
Email: i.hussain@cgiar.org
Aamir Nazeer
Economist
Ashfaq Muhammad
Economist
Waqar Ahmed Jehangir
Senior Economist

JBIC Institute Team
Naoko Shinkai
Economist
E-mail: n-shinkai@jbic.go.jp
JBIC Institute, JBIC
Yasuyuki Sawada, and
Associate Professor
E-mail: sawada@stanfordalumni.org
Graduate School of Economics,
University of Tokyo

Table of Contents

List of Figures

List of Tables

Executive Summary

This report is the outcome of the collaborative research project initiated by the JBIC Institute, the Japan Bank for International Cooperation and undertaken by the International Water Management Institute (IWMI). The project was carried out in two phases. Phase - I commenced in April 2001 and ended in March 2001. Output of the first phase was based on analysis of data and information collected during first three household level surveys covering agricultural seasons during 2000-2001. The scope of the study was extended by initiating phase-II of the project in April 2002 for undertaking two additional household level surveys covering agricultural seasons in 2001-2002. This report analysis data and information for all five surveys covering the two year (2000-02) period, and further strengthened the empirical findings reported in the earlier companion report.

The overall goal of the study is to develop an in-depth understanding of income dynamics in relation to access to irrigation water and to comprehensively evaluate the impact of irrigation infrastructure on poverty. This study investigates the dynamic poverty reduction effect of irrigation infrastructure development by integrating field observations, economic theory, and econometric analysis. Irrigation systems in Pakistan, where JBIC has funded for development/improvements/rehabilitation were selected as study areas. This report provides output of the Pakistan component of the study.

Main activities of the study consisted of (1) selecting suitable study areas and specific study sites, (2) developing a detailed sampling framework, (3) developing a panel data base by undertaking household level surveys during the years (2000-02) to cover 'before', 'during', and 'after' situations both for the Rabi and Kharif seasons of the year, and (4) undertaking econometric analyses of the impacts of irrigation infrastructure on poverty.

The study uses primary data collected through household surveys conducted five times during the year 2000-2002, from a sample of 695 households, using a detailed multi-topic questionnaire. The selected study sites are located in district Mandi Bahauddin and Gujrat, and were divided into four strata based on several criteria including access to irrigation water (with/without irrigation infrastructure), nature of water supplies (perennial/non-perennial), state of irrigation infrastructure development (improved/un-improved), and cropping pattern. The study sites were selected in areas where JBIC has assisted, On-Farm Water Management (OFWM) projects, for the improvement of watercourses/channels, over past decades. A multistage sampling procedure was adopted for selecting the sample households in each stratum. The study employs a 'with' and 'without' approach by comparing sample areas with improved, unimproved and with no infrastructure and without irrigation to establish irrigation accessibility.

The study focuses on three key aspects of irrigation infrastructure – poverty nexus: (1) determine whether access to irrigation infrastructure raised household incomes and expenditures; (2) determine whether access to irrigation infrastructure affects

variability in household incomes and expenditures; and (3) determine consumption smoothing effects of household's access to irrigation infrastructure. Three major hypotheses tested in the study are (1) The incidence, depth and severity of poverty are lower in agricultural settings with irrigation infrastructure than in settings without infrastructure; (2) The variability in incomes and expenditures is less in agricultural settings with irrigation infrastructure than in settings without infrastructure or in other words irrigation infrastructure help smoothens incomes and expenditures; and (3) If incomes in agricultural settings with irrigation infrastructure are higher (than in settings without infrastructure), consumption expenditure may not track incomes during the year. Or if incomes in agricultural settings without irrigation infrastructure are lower (than in settings with infrastructure), consumption expenditure may track incomes during the year. Key approaches used for rigorously testing of these hypotheses in the study are: (1). Inter-strata comparisons - using quantitative values on various socio-economic (including household incomes and expenditures) indicators; (2) Inter-strata comparisons - using both monetary and qualitative indicators of poverty; (3) Econometric analyses - estimating household income/ consumption smoothing effects of irrigation infrastructure development on poverty; and (4) Econometric analyses - estimating key determinants of household incomes/ expenditures/poverty, including estimating the impacts of irrigation infrastructure development [It should be clear at the outset that the study is based on inter-household analysis and does not look into intra-household poverty structures].

This study departs from conventional irrigation-poverty related studies in two important aspects. First, it treats poverty as a dynamic concept and decomposes observable poverty into chronic and transitory components. Second, it considers both temporal and spatial dimensions while quantifying the impact of irrigation infrastructure development and rehabilitation on dynamic poverty. In so doing, the study develops household specific poverty profiles over the course of 24 months and trace out movements into and out of poverty during the period. Both income and non-income indicators of poverty are used to construct dynamic poverty profiles. This provides useful insight into the relative magnitude of chronic and transient poverty. The irrigation related poverty impacts are evaluated using an equity-efficiency-cost recovery-and sustainability framework (Sampath, 1988; 1992) that in turn is integrated into a dynamic poverty framework (Sawada, 2000). In addition, dominance analysis is used to establish the superiority of poverty profile over the other. The quantitative findings are validated by using qualitative perceptions of users regarding the benefits of irrigation infrastructure development and rehabilitation.

The results of this study provide strong quantitative evidence on the role of irrigation infrastructure development on poverty alleviation, particularly chronic poverty. Main findings of the study are as under:

Analysis of socio-economic and demographic characteristics of the households across various strata shows that the irrigated areas have relatively larger households, and greater number of earners, compared to the rainfed areas, while an average year of schooling of household head was higher in rain fed stratum as compared to irrigated strata. On average, household heads are in their early fifties with no significant

differences across rainfed and irrigated strata. The percentage of the households headed by females was very low (between 2 to 3%) in irrigated and rainfed areas.

Average farm size was higher in irrigated areas as compared to rain fed areas. On an overall basis, nearly 39 percent of sample households are landless. Landlessness is the highest in rainfed areas (over 44 percent) compared to irrigated strata, with only 5 percent of the households in rainfed area owned over 3 hectares, and about 25 percent owned less than 1 hectare. On an overall basis, 0.55 hectare was the average landholding size of households owning less than one hectare of land, whereas the corresponding figure for above 3 hectares category was 7.63 hectares.

Owner cultivators are in majority in all settings where as pure tenants are invariably in small numbers. The percentage of farms operated by tenants was higher in rainfed area as compared to irrigated strata. While, owner-cum-tenant households were, more or less, similar in rainfed and irrigated strata, whereas, owner cultivators were higher in irrigated area when compared with rainfed. Average landholding is relatively larger on improved watercourses than on un-improved watercourses. This indicates that watercourse improvements were undertaken mostly in areas where landholdings were relatively larger. Estimates of Gini Coefficient show that land distribution in the study area is highly inequitable.

Total labor usage is higher (almost double) in Kharif season compared to Rabi season. Most of the farm labor (both family and hired labor) comprised of male labor, with female and child labor constituting only a small part of the total labor used. There are no significant differences in labor usage among four strata, particularly in Kharif season. In both seasons most of the required farm labor is provided by family labor. Overall, there are no significant differences in labor use on farms located on improved and un-improved watercourses, despite relatively higher cropping intensity and crop productivity on improved watercourses.

On average, wage rate for hired labor in the study area is about Rs.114 per day. Wage rates are higher in rainfed as compared to irrigated areas. The wage rates are fairly similar across improved and un-improved areas.

About 50 percent of households derive incomes from crop production, 93 percent of households derive their incomes from non-crop sources, and, 26 percent and 7 percent also deriving their incomes from livestock and agricultural assets, respectively. Overall, non-crop sources account for 74 percent of average household income, and crop sources account for 21.6 percent. In irrigated areas, about 68 percent of household income originates from non-crop sources. In the rainfed areas, around 96 percent of the total income is derived from non-crop sources and only 4 percent from crop production. The share of crop income in the total income is, generally higher for households on improved watercourses than those located on un-improved watercourses.

Overall cropping intensity is higher in irrigated strata as compared to rainfed areas. Among irrigated strata, cropping intensity is generally higher in perennial systems on farms located on improved watercourses compared to those located on unimproved

watercourses. In rice-wheat perennial stratum, cropping intensity is 8.5 percent higher for farms located on improved watercourses compared to those on un-improved watercourses. In the non-perennial setting, differences in cropping intensity across farms on improved and unimproved farms are only marginal.

Cultivated area of almost all major crops is higher on improved watercourses compared to that with unimproved watercourses. Productivity of rice and wheat is higher in irrigated areas as compared to rainfed areas. Productivity of rice and wheat is the highest on farms in non-perennial stratum. Productivity of wheat is found to be higher on farms located on improved watercourses as compared to those located on un-improved watercourses, and this holds for all three strata. However, productivity of rice is almost the same on farms locates on improved and unimproved watercourses except rice-wheat perennial where rice productivity is significantly higher on unimproved watercourses.

The gross value of product (GVP) per hectare is high in irrigated areas as compared to rain fed areas. On average, GVP per hectare for farms located on improved watercourses is higher by Rs.775/ha and Rs.412/ha compared to those located on un-improved watercourses, in rice-wheat non-perennial, and rice-wheat perennial strata, respectively. However, in mixed wheat perennial strata GVP per hectare is slightly higher (Rs.211) on unimproved watercourses as compared to the improved watercourses.

Overall cost of production is higher among all strata during Kharif than in Rabi. In both seasons, major cost components were irrigation, fertilizer and machinery. Higher cost of production in the rainfed areas reflect significant cost incurred on groundwater irrigation. Estimates of average cost of production in Rabi and Kharif seasons for farms on improved and un-improved watercourses show that the cost of production on farms located on improved watercourses is relatively higher than those located on un-improved watercourses.

Shortage of irrigation water is the first major agricultural problems faced by the farmers, which reflect on current drought situation in the study area in particular, and the country in general. Second most commonly reported problem is escalating cost of farm inputs, and among these the most significant item is ever increasing price of diesel fuel, required for tubewell irrigation. The second highest cost concern items are fertilizer and chemical. Problems related to credit and output marketing is the third major problem. Problems in obtaining credit are encountered more frequently by the small farmers, who remain unable to access institutional credit due to the complex and cumbersome procedures. The crop damages by pests and diseases are also common agricultural problems, and more so in the irrigated than rainfed settings.

Average monthly and annual incomes in the study area are Rs. 6844 and Rs. 82132, respectively. Average monthly incomes in rainfed areas are lower (Rs. 6492), as compared to irrigated areas (Rs. 6959), while average monthly incomes are found to be higher in non-perennial areas (Rs. 7337) compared to perennial areas (Rs. 6765), probably reflecting high crop incomes. A comparison of farm and non-farm households indicates that average monthly income of farm households is almost double (Rs 8314)

that of non-farm households (Rs.4040). Estimates show that monthly income is higher in Kharif as compared to Rabi season. On an overall basis, average monthly income estimated for households on improved watercourses is higher by Rs. 1055 (estimated at Rs. 7485) compared to those located on un-improved watercourses (estimated at Rs. 6430), and the differences are more pronounced during crop harvest months, and incomes are much higher in Kharif season (November) than in Rabi season (May, June).

Decomposition of average monthly income into various components suggest that, on an overall bases, monthly farm income contributes around 40 percent of the total income, while 33 percent of the total income comes from non-farm income sources. Transfer income (assistance from government, relative etc.) contribute around 27 percent to the household average monthly income. In the irrigated area, household farm income and non-farm income contributed 46 percent and 27 percent, respectively, with transfer income contributing 27 percent, while in rainfed areas the situation is reverse: the share of non-farm income in the total income is the highest (50percent), followed by transfer income (30percent), and farm income is smallest (20percent). The share of farm income is higher (48percent) in improved areas than in un-improved areas (43percent), with the share of non-farm income is almost the same. However, proportion of transfer income is six percent higher in un-improved areas (30percent) as compared to un-improved areas (24percent).

On an overall basis, average expenditures are comparatively higher than average income of the households in all strata and for all categories except rainfed area where average household income is slightly higher as compared to average expenditure. Average monthly income and expenditure is higher in irrigated areas as compared to rainfed area, however average expenditures are higher than income in irrigated areas, as compared to the rainfed areas where average incomes are higher than expenditures. Estimates show that the trends of income and expenditure are almost the same on improved and un-improved watercourses, with the only exception of December. That is, income is higher over expenditure during May, June, November and December. However, a larger surplus of income over expenditure is exists for household located at improved watercourses than those on unimproved ones. This is mainly due to relatively efficient use of surface as well as groundwater on improved water courses and resulting higher productivity and incomes.

On an overall basis, the average monthly expenditure in all four strata is estimated at Rs. 7165, while in general, monthly expenditures are found to be higher for households in irrigated areas (Rs 7485) compared to rainfed areas (Rs 6187), higher for farm households (Rs 8295) than non-farmer households (Rs 5011). A comparison of improved and un-improved areas indicates that there are significant differences in average monthly expenditure, with a lower expenditure estimated at Rs 7220 (lower by Rs 527 per month) of the households located at un-improved watercourses as compared to the households on improved watercourses (Rs. 7747). On an overall basis, average monthly expenditures are found to be highest in the month of May followed by November, December and February, while it remains more or less similar during all the remaining months. Month-wise expenditure trends are more or less similar in all strata, as well as, improved

and un-improved watercourses. Monthly expenditure trends are more or less similar for improved and un-improved areas but expenditure in the months of October, November, February is higher in improved areas as compared to un-improved.

Monthly trends in food expenditure are more or less similar across strata. i.e. about Rs. 2000 per month, on an average basis. The average monthly food expenditure is higher in rainfed areas (Rs. 2133) compared to irrigated areas (Rs. 1990). Monthly food expenditures of non-farmers is lower as compared to farmers. There is no significant difference in average monthly food expenditures in improved and un-improved areas, although there is some intra-stratum differences are found.

Expenditure on category 1 items (basic food items) is generally higher than that of category 2 items in all strata. Comparing rainfed and irrigated areas, it is found that households in rainfed area spent more on category 1 items as compared to irrigated areas Non-farm households are found to spend more on category 1 items than on category 2 items compared to farm households. Differentials in expenditures category 1 and 2 items are more or less similar across improved and un-improved categories, however, the ratio of food to total expenditure on un-improved water courses is 2 percent higher than improved water courses, which implies that households lacking access to improved irrigation infrastructure spend a relatively higher share of their total expenditure on food items, or alternatively, the share of living expenses is lower for households on unimproved water course.

Analyses of estimates of incomes by source show that on an overall basis, average non-crop income (Rs.57070) is higher than average crop income (Rs. 17436). This holds for irrigated as well as for rainfed areas. Average non-crop income in rainfed areas is higher (Rs.69987) compared to irrigated areas (Rs. 52855), however, average crop income is significantly higher (Rs. 21984) in irrigated areas as compared to rainfed areas (Rs. 3504). Average crop incomes in improved areas are significantly higher compared to un-improved areas. There are significant differences in average non-crop incomes across improved and un-improved areas. Average income from agricultural assets (rent of farm machinery etc) is higher in improved areas, however, livestock income is observed lower for households located in improved areas as compared to un-improved areas.

On average bottom 40 percent and top 5 percent of households received 11 percent and 27 percent of the total income, respectively. About 40 percent of the total income is received by top 10 percent of the households, whereas 35 percent is received by the middle 40 percent of the households. Overall, there is significant inequality in distribution of income in all strata.

The estimated value of Gini Coefficient varies from 0.282 to 0.536 among all strata and farm household categories, with an average value of 0.468, reflecting high level of income inequality. Income inequality is relatively lower in rainfed areas compared to irrigated areas (basically reflecting disparities in size of landholding in the latter). A comparison of improved and un-improved areas indicate that in improved areas bottom 40 percent of population received lesser proportion of total income (compared to

un-improved areas), and top 10 percent or top 5 percent received greater proportion of total income (compared to un-improved areas). Further, Gini coefficient is also higher for improved areas compared to un-improved areas. Overall, it may be concluded that income inequality is higher in improved areas than in um-improved areas. This does not mean that improvement in infrastructure has led to such inequality, but rather the fact is that infrastructure is improvements have taken place in areas where inequality in resources distribution, particularly land is already higher.

Dynamic poverty estimates based on household incomes in various study settings show that on an overall basis, 89 percent of the sample households are found to be poor, about 47 percent of all the poor households are chronically poor, whereas 42 percent are observed to be transient poor and 11 percent of the households are found non-poor. In sum, transient poverty is a major contributor to total poverty. Chronic poverty is relatively higher among non-farm households, while transient poverty is relatively higher among farm households – using monthly incomes as well as monthly expenditures. Chronic poverty is higher in rainfed areas (without irrigation infrastructure) compared to areas with irrigation infrastructure. However, transient poverty is relatively higher in irrigated areas compared to rainfed areas. There are marginal differences in the incidence, depth and severity of poverty among households on improved and un-improved watercourses, and this is regardless of whether income or expenditure is used as a welfare measure. Incidence and severity of both chronic poverty and transient poverty is relatively lower in areas with infrastructure and with adequate water availability regardless of whether infrastructure is upgraded or not.

Dynamic poverty estimates for households on improved and unimproved watercourses suggests that there are marginal differences in the incidence of poverty among households in the two locations. Among strata, the incidence of poverty is low in rice-wheat non-perennial and high in rice-wheat perennial on improved watercourses as compared to un-improved, however, in mixed-wheat perennial no differences are found in the incidence of poverty. Except rice-wheat non-perennial, incidence of chronic poverty is higher among households on improved watercourses in the other two strata. Comparison of transient poverty shows that transient poverty is lower in rice-wheat non-perennial and mixed wheat perennial strata, while higher in rice-wheat perennial stratum on improved watercourses as compared to un-improved areas. Overall, it may be concluded from these comparisons that there are minor differences in the incidence of poverty among households on improved and unimproved watercourses. Furthermore, there are no significant differences in chronic and transient poverty gap in improved and un-improved areas, however, chronic squared poverty gap in improved areas is slightly lower on improved watercourses as compared to un-improved watercourses, suggesting that provision of irrigation infrastructure in irrigated areas has helped in reducing chronic poverty, although the majority of the households still remain transient poor.

Values of indices estimated using monthly expenditures; generally correspond to the values estimated using monthly incomes. The main differences are that the head count of the chronic poor is less using expenditures compared to using incomes. The proportion of non-poor remained almost same using incomes and expenditures. In the rainfed area,

the proportion of non-poor declined from over 20.5 percent to little over 10.5 percent. Chronic poverty gap and transient poverty gap estimated using expenditures is, generally lower compared to using incomes.

Poverty estimates based on quarterly analysis show that though the head count index of total and transient poverty is higher in irrigated areas, but the incidence of chronic poverty is more pronounced in rainfed areas and similarly, in terms of depth of poverty, chronic poor households in rainfed areas are deeper below the poverty line as compared to irrigated settings, however, squared poverty gap of chronic poor is slightly higher in irrigated areas; Incidence, depth and severity of poverty is, more or less, the same on improved and un-improved watercourses.

Poverty estimates based on annual data show that overall, 55 percent and 43 percent of the sample households are classified as poor using incomes and expenditures, respectively, showing that poverty head count index is higher for income based estimates. However, poverty gap and squared poverty gap indices are much lower when estimated using expenditures than incomes. The poverty head count based on annual income in irrigated strata is slightly higher (55 percent) than rainfed stratum (53 percent). However, poverty head count based on annual expenditures is, more or less, similar in all strata. Poverty indices are much higher for non-farm group (73 percent using incomes and 61 percent using expenditures) than for farming group (45 percent using incomes and 34 percent using expenditures).

A comparison of poverty head count index in areas with improved and un-improved infrastructure indicates a relatively greater incidence of poverty in areas with improved infrastructure (based on expenditure), while it is slightly lower when estimated on the basis of income. Overall, the impact of improvements in infrastructure on poverty is not very clear. It should be noted that mere improvements in infrastructure does not guarantee improved access to water – improvement in infrastructure may be a necessary condition for improved access to water, it is not a sufficient condition for improved access to water. An improvement in water distribution/management is important to enhance anti-poverty impacts of improved infrastructure.

The poverty indices are fairly high and similar from January through to April and again from July through to October for all strata and categories whereas, low in May, June, November, and December. A comparison of indices for improved and unimproved areas show that poverty head count index is lower in improved areas in all months except May and June where the value of head count is slightly higher as compared to un-improved areas. Poverty indices estimated using monthly expenditures follow the similar pattern as those estimated using incomes, except that magnitude of expenditure-based indices is lower than income-based indices. Monthly indices show that chronic poverty is higher among non-farm households, while the incidence of transient poverty is higher among farming households, however, there are marginal differences in monthly chronic poverty indices estimated for improved and un-improved areas. Farmers relying on seasonal agricultural income find themselves in a relatively better position after crop harvest: May and June for wheat and October and November for rice, and those with

lower incomes become vulnerable in other months – reflecting high level of transient poverty among farming group. Low income non-farmers, mostly relying on daily wage work, continue to remain vulnerable throughout the year – reflecting high level of chronic poverty among non-farm group.

Poverty estimates for various categories show that transient poverty is the highest (47.2 percent) among all categories, followed by semi chronic and chronic poverty. Transient and chronic poor are higher in rainfed area as compared to irrigated areas, whereas a comparatively large proportion of semi-chronic poor is found in irrigated areas as compared to rainfed setting. Among farmers and non-farmers, the incidence of chronic and transient poverty is much higher for non-farmer households as compared to farmers, while semi chronic poverty is higher for farmer households. Comparison of improved and un-improved watercourses suggest that on an average, there are marginal differences in the incidence of transient and semi chronic poverty categories but the proportion of chronic poor is relatively higher on un-improved watercourse as compared to improved areas. It is clear that the poverty and squared gap differences between the two areas are marginal in terms of transient and chronic poverty, but the mean distance of semi-chronic poor households in improved areas is relatively less.

Classification of household into various groups based on income poverty indices for alternative specification of lower and higher poverty lines relative to reference poverty line imply that on an overall basis, a large proportion (42 percent) of the total households lie 1.25 percent of the reference poverty line as compared to 13.7 percent households below 50 percent of the poverty line. Except last specification of 1.25 percent above the poverty line, incidence of poverty is lower among farmer households than non-farm households. However, non-farmers in the group of below 50 percent of poverty line are relatively poorer than farmers. Comparison of alternative specifications on improved and un-improved watercourses suggest that in almost all the categories, there are marginal differences in the incidence of poverty, except 50 percent below poverty line category where it is relatively less in improved areas as compared to un-improved ones , which implies that poor of the poorest are higher in areas with un-improved infrastructure.

Overall, the welfare cost of expenditure fluctuations is much less than that of income fluctuations, due to the high variations observed in income. The welfare cost to farm households is higher than non-farm households, and that of irrigated strata higher than the rainfed strata. The coefficient of variation and the certainty equivalent measures are, generally higher for improved areas compared to un-improved areas.

Analyses of qualitative measures of poverty reveals that average household size in the study area are 7 members, while maximum size of 24 members. Irrigated areas have relatively larger households, and larger number of earners compared to rainfed areas. The higher dependency ratio, which is the ratio of dependents to non-dependents, indicates greater poverty. The dependency ratio of the entire sample is 98 percent. Dependency ratio is relatively higher in rainfed areas compared to irrigated areas, although differences

are very small. There are no significant differences in dependency ratio between improved and un-improved areas.

Comparison between improved and un-improved areas shows that average land size, and productivity / gross value of product are generally higher in improved areas compared to un-improved areas. However, there are negligible differences in values of other indicators, including access to electricity, access to piped water, and access to credit.

On an overall basis, about 66 percent of the sample households reported borrowing money in Rabi, while 85 percent in Kharif. A higher proportion of households in borrowed irrigated areas as compared to rainfed areas. Over 25 percent of households in both rainfed as well as in irrigated areas borrowed for both consumption as well as production purposes. Average monthly borrowings are higher during pre-harvest months (i.e. February, March, August, September and October). Monthly borrowings are higher in Kharif months than in Rabi months. There is no significant difference in the proportion of households borrowing money in improved and un-improved areas. However, in unimproved areas, relatively higher proportion of households borrowed for consumption purposes, due to lower overall incomes in these areas.

A large majority of rural households derive income from agriculture and there is considerable variability in incomes and expenditures, which in turns exacts negative welfare costs on the households, and more so for the poor than non-poor. We undertook regression analysis to compare seasonal consumption patterns of different groups of households having different seasonal income patterns – based on a set of household characteristics that determine the timing of income receipts. In all samples, the effect of average monthly income in expenditures is positive and significant as expected. The magnitude of the coefficient of average monthly income varies from 0.238 to 0.383, indicating that 1 percent increase in average monthly incomes will increase monthly expenditure by 0.238 and 0.383 percent, respectively.

In all the samples, which compare two groups of households with different income patterns due to access to infrastructure, level of infrastructure development and occupations of households, null hypothesis of all the four tests are rejected. The results indicate that (i) there are month effects in expenditures in all strata and for all socio-economic categories considered in this study; (ii) there are differences in month effects in all strata and socio-economic categories, and (iii) differences in month effects between strata and between categories are not constant, indicating that the patterns of expenditures are not the same between the households compared.

Comparison of irrigated areas (strata with irrigation infrastructure) with rainfed (without infrastructure) suggests that in the rainfed areas, month effects in expenditures are significant for only three months: negative in January and June and positive in November. In irrigated areas, the additional month effects in expenditure are significant in February, May, June, August, and September except rice-wheat non-perennial in which additional month effects are significant only for November. In general, month effects in expenditures are lower in rainfed areas when compared with all other strata of

irrigated areas. Comparing the regression results of improved and unimproved areas indicate that there are month effects in both improved and unimproved areas. However, test 3 and 4 are rejected indicating that there are no differences in month effects in expenditures between improved and un-improved areas, and that the differences in month effects between the two areas are equal. Comparison of farm (all) and non-farm (all) categories suggest that there are differences in month effects in expenditures between farmers and non-farmers, and the month effects in expenditures are higher for farmers compared to non-farmers. The results from these comparisons imply that household groups, who have different income patterns, also have different expenditure patterns (although not in all months), suggesting that in addition to average monthly incomes and pure month effects (preferences, prices), timing of income receipts do influence monthly expenditures (the case of imperfect smoothing). Overall the results of this analysis imply that households generally smooth their consumption expenditures, and seasonal variations in expenditures are mainly due to non-income factors. Household access to infrastructure helps in improving average incomes and increasing monthly incomes depending on the availability of water. Therefore, households with access to irrigation infrastructure are in better position to smooth their expenditures compared to those without it.

We integrated our quantitative assessment of irrigation and poverty dynamics with quantitative assessment based on perception of communities in question. The sample households were posed various questions on how they perceived the impact of irrigation infrastructure development on poverty reduction. The results of the farmer's perception about the improvement in irrigation infrastructure and its impact on poverty are presented in Appendix G and briefly discussed below.

The results show that an overwhelming majority of the farmers (about 93%) believed that lining of watercourse is a good thing. About 79 percent of the farmers thought that water could be saved up to 25 percent if the infrastructure is improved. About 67 percent of the farmers in all 3 irrigated strata believed that improvement in the infrastructure had saved their labor up to 4.3 days on an average during Rabi and 2.4 days during Kharif season. Almost 28 percent farmers thought that improvement in infrastructure had increased their productivity, while 25 percent were of the view that due to watercourse improvement has increased a cropped area of 0.1 hectare on an average, during the study period. When inquired about the decrease in seepage and Water logging, majority of households were unaware about these changes, and only eight percent reported that seepage and water logging has reduced due to watercourse lining. Around 48 percent of the farmer's thought that access to water has been increased to tall -enders due to watercourse improvements and 41 percent believed that this was in the case of' poor farmers. Almost all farmers (84 percent) reported the need for further improvement of their Irrigation facilities. On the question of reliability of irrigation water, 64 percent of the farmers reported to receive water in time, while only six percent received the required amount of canal water.

These qualitative assessments of benefits by the users support our quantitative estimates of benefits of system rehabilitation. The qualitative perceptions of the benefits

of infrastructure rehabilitations provide insider support to our quantitative findings as the users themselves perceive that canal lining has promoted efficiency and equity in the use of scarce irrigation supplies, improved land productivity, and therefore increased incomes, while averting potential negative environmental externalities. Improved water use efficiency should result in higher productivity and higher incomes.

The overall conclusions of this study are that (1) access to irrigation infrastructure, regardless of whether it is improved or un -improved, helps keep the incidence of chronic poverty at lower levels; (2) improvements/watercourse lining/upgrading helps in saving water, resulting in higher cropping intensity, higher crop productivity and improved crop incomes, with impacts on incomes also depending on the types cropping patterns adopted by farmers. However, the overall impact of infrastructure improvements on poverty is marginal, although there is some evidence to suggest that severity of chronic poverty is lower in areas with improved infrastructure compared to areas with unimproved infrastructure. Thus, infrastructure improvements help to reduce poverty in its worst forms by reducing severity of chronic poverty, as measured by squared poverty gap. The reasons for insignificant impact of infrastructure improvements on poverty are many, including poor governance (poor infrastructure condition, including of the improved infrastructure, resulting from inadequate maintenance, un -reliable water supplies resulting from lack of proper planning, water theft), inequitable water allocation, huge inequity in land distribution, and therefore access to irrigation water, poor access to complimentary inputs and other related services, which cumulatively tend to outweigh anti-poverty impacts of infrastructure improvements. Also, a large percentage of total poverty consists of transient poverty; therefore large reductions in total poverty are possible by targeting transient poverty first. Cost-absorbing income/expenditure smoothing interventions and instruments may, therefore be particularly desirable for cutting a large part of total poverty in the irrigated areas.

For any questions, clarifications, comments and suggestions on the contents of this report, please contact the project leaders at the following addresses:

IWMI Team
Intizar Hussain, Ph.D.
Senior Economist
International Water Management Institute (IWMI)
P.O.Box 2075, Colombo, Sri Lanka
Email: i.hussain@cgiar.org
Phone: 94-1-787404 (Extension 2204)
Fax: 94-1-786854