Pro-poor Intervention Strategies in Irrigated Agriculture in Asia

Poverty in Irrigated Agriculture: Issues and Options

PAKISTAN

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0.1 STUDY BACKGROUND

Agriculture in the developing countries of Asia has made significant progress over the past three decades. Between 1970 and 1995, cereal production in these countries increased from over 300 to 650 million metric tons. This growth in food production was mostly attributed to growth in irrigated agriculture, together with the use of high-yielding varieties of crops and the application of fertilizers and pesticides. At present, in Pakistan, about 80 percent of the cropland is irrigated and accounts for about 69 percent of the total cereal production (GoP 2001). Irrigation has greatly improved the incomes of farmers who had access to fertile and well-drained lands, reliable water supplies, yield-enhancing inputs, and credit as well as other supportive services. It has also assisted the overall population by providing more food at reduced prices.

Despite these achievements, the productivity of a large part of irrigation systems remains severely constrained by the insufficiency of some or all of these inputs. Large areas within the irrigation schemes especially the tail-end reaches, suffer from chronic and severe water shortages. In some parts, the water logging problems have also been reported. A number of factors contribute to poverty in the low-productivity irrigated areas including: (i) physical factors (poor design of irrigation systems, unsuitable topography of agricultural lands, poor drainage, poor soil conditions); (ii) economic constraints (smaller landholdings, lack of financial resources and credit, lack of key inputs and marketing outlets); and (iii) socio-cultural problems (tenure arrangements resulting in insecure rights). It is now widely understood that institutional and managerial factors, poor governance, and lack of funds for maintenance largely cause water shortages, which could be addressed without large physical interventions with greater cost-effectiveness benefiting the poor.

The Government of Pakistan has made attempts to improve the productivity of irrigated areas, but the effort to address the irrigation related constraints have been minimal and largely ineffective. In Pakistan, there has been a lack of proactive policies, effective institutions, and actions to this end. Moreover, the previous irrigation-related research studies in the country focused on increasing the general agricultural productivity under the overall goal of enhancing food security. In this respect, the studies have been conducted on the needs for improving the irrigation systems performance but the research efforts have not gone much beyond technical and physical interventions and the general irrigation management transfer to farmer organizations at large. Little scientific knowledge exists on how a range of non-technical interventions such as economic, financial, institutional, and governance measures has most effectively contributed to reduce poverty in the low-productivity areas of the country.

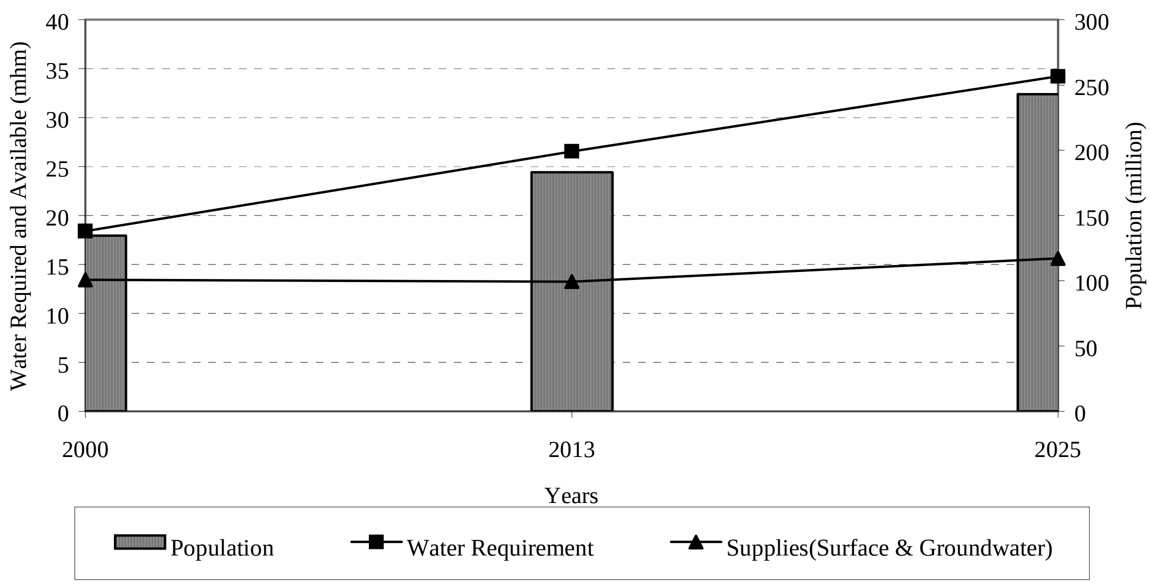
The agriculture sector in the country is now facing the dual challenge of increasing food demand and looming water scarcity. The population of Pakistan is reported to be 146 million in 2002 (GoP, 2002), and is projected to be 183 and 243 million in 2013 and 2025, respectively. The widespread growth in the human numbers and the required magnitude of food production for the projected population has been determined and is given in Table-0.1. The corresponding irrigation requirements for the year 2013 and 2025 would be 26.53 and 34.21 Million Hectare Meter respectively (Figure 0.1.).

Table 0.1. Projected production, requirements and shortfall (Million Tons).

Year	2013			2025		
Population	183 Millions			243 Millions		
Crops	Requirement	Production	Shortfall	Requirement	Production	Shortfall
Food-Grains	28.4	22.0	6.4	39.0	27.0	12.0
Sugarcane	47.2	37.9	9.3	66.0	42.3	23.7
Cotton (Lint)	2.0	1.7	0.3	2.9	2.2	0.8
Pulses	1.1	0.8	0.2	1.4	1.1	0.3
Oilseed (Ex. Cotton)	1.9	0.7	1.2	2.8	1.1	1.7
Vegetables	8.2	5.6	2.6	10.5	7.4	3.1
Fruit	9.2	5.5	3.5	14.3	7.3	7.0
Total	98	74.2	23.5	136.9	88.4	48.6

Source: Water Sector Investment Planning (WSIP) 1990.

Figure 0.1 Population, water requirement and availability up to year 2025.



It is becoming increasingly difficult to expand irrigated areas, as most accessible water resources have already been developed. The study conducted by the Asian Development Bank (ADB) during 1999 showed that the cost of investment in new irrigation schemes has increased substantially. As the single most dominant user of available water resources, irrigated agriculture in Pakistan is facing increasing pressure to produce more food with less water through significant improvements in water use efficiency at the farm and system levels. Low-productivity irrigated areas, in particular, are in stress, as resource-poor farmers in such areas are most vulnerable to water shortages, while there is also a significant need to enhance food production to ensure food security for the growing population.

If we analyze the latest poverty situation in the irrigated agricultural areas of Pakistan, we see a very gloomy picture. According to the Government of Pakistan (2002), about 28 percent of the total population is currently living below the poverty line. The incidence of poverty is higher in rural areas (32 percent) as compared with that in urban areas (19 percent). The quality of life of the poorer segments of society continues to deteriorate. Not only income poverty has been on the rise in the country but the other dimensions of poverty also present an equally dismal picture. Strong rural-urban differences in the extent of poverty is observed among households living in the rural areas that are likely to be poorer than those living in the urban areas. A comparison of incidence of poverty across irrigated regions of the country leads to some interesting observations. The poor generally live in areas that have a high percentage of poor quality lands and scarcity of irrigation water (Pieri et al. 1995).

As mentioned earlier, Pakistan's agriculture depends solely on irrigation. In the Indus irrigation system, waters flow from rivers to farm gate, through a complex irrigation network in the country, which links barrages and weirs to main canals, and subsequently, to branch canals, distributaries and minors, and watercourses. There is inequity in the distribution of water at all levels of the systems; within the watercourse command, irrigation water delivered to the farm households located at the tail reaches is usually less than that delivered to the farm households at the head, and the outlets on a minor receive a different quantity of water than the outlets on a distributary. In addition to this, there are substantial losses of water in the system. Water use efficiency is reported to be low and most of the losses are reported at watercourse level. These conditions aggravated the problems in the form of water logging and salinity in the country. In order to mitigate the menace of water logging and salinity, the government of Pakistan introduced interventions in the form of programs such as Salinity Control and Reclamation Projects (SCARPs), On Farm Water Management (OFWM) Program, Irrigation Systems Rehabilitation Project (ISRP), and National Drainage Program (NDP). Some of these projects partially achieved their objectives at least on pilot area basis. During 1990s, the government of Pakistan started the program of irrigation reforms. The proposed reforms included handing over of the irrigation system to the Farmers' Organizations, and converting the Provincial Irrigation Departments (PIDs) into Provincial Irrigation and Drainage Authorities (PIDAs). These interventions will be discussed in detail in part-2 of this report.

Besides other deficiencies, ills and failures/inefficiencies, poverty considerations were not given a high priority in these projects. These projects were not only poverty neutral; rather they effected large and excessive transfers of public resources to the rural elites. Even some of the desperately poor areas and communities remained outside the domain of these projects due to politicized selection. Consequently, the most hit and the disadvantaged sections of the rural communities in the irrigated areas of Pakistan became the poorest of the poor. This indiscriminately included both small landowners and landless in terms of depressed agricultural productivity and vulnerability to diseases, which were undoubtedly correlated with the irrigation developments.

Objectives and Scope

The overall objective of the study is to determine what could realistically be done to improve the returns to poor farmers in the low-productivity irrigated areas within the context of improving the overall performance and sustainability of the established irrigation systems. The study focused on selected representative low-productivity irrigated areas and their peripheries with a large number of people under persistent poverty in irrigated areas of Punjab, Pakistan. The emphasis was on identifying and assessing a set of appropriate economic, financial, institutional governance, and technical interventions at field and system levels, and changes in overall policy and institutional frameworks as far as they affect access to water resources for the poor.

The scope of the study is as follows:

- analysis and field research on the impacts of current policy and institutional framework, and the impacts of underlying physical, economic and socio-cultural conditions on the selected areas in particular and on the overall irrigation systems at large, including the assessment of opportunities for and constraints on improving productivity in the sample areas through improved access to irrigation water;
- identification and evaluation of a range of potential pro-poor economic, financial, institutional governance, and technical interventions at various levels against a set of criteria under which such interventions could most effectively address poverty reduction in the study areas; and
- formulation of a set of appropriate interventions and the policy and institutional frameworks, including adequate support systems, required to ensure large-scale uptake, replicability, and higher impacts within and between different irrigated command areas of the country.

Research Hypotheses

The study tested the following hypotheses:

1. Command areas of specific canal reaches receiving less irrigation water per hectare have lower productivity and a higher incidence of poverty;

2. Under existing conditions small, marginal and poor farmers receive less benefits from irrigation than large and non-poor farmers;

3. The greater the degree of O&M cost recovery the better the performance of irrigation management;

4. Effective implementation of PIM/IMT leads to improved irrigation system performance which in turn reduces poverty; and

5. There is a scope for improving performance of irrigation systems under existing conditions, with effective and improved institutional arrangements.

Research Questions

The study addressed the following research questions explicitly:

1. What are the poverty situations in the study areas?

2. Where are the poor people located along irrigation systems, and are there any geographic patterns of poverty within an irrigation system?

3. What are the poverty prevalence, its depths, trends, main causes, and its relation with income/ asset distribution pattern, key issues, and strategies to reduce poverty (including those not related to irrigation)?

4. What are the benefits of surface irrigation to the poor and to what extent, including indirect benefits to small farmers and landless?

5. What is the level of irrigation system performance in the study area?

6. What are the major irrigation-related constraints to productivity?

7. What are the causes of unsatisfactory performance of irrigation system?

8. To what extent is the poor irrigation system performance related to technical (farm water use, distribution pattern among canals or at higher levels), institutional, economic/ financial and regulatory aspects of system management?

9. To what extent does improved system performance benefit the poor and what are the opportunities to reduce poverty by improving performance of irrigation systems?

10. What are the impacts of irrigation-related institutions, laws, and policies on overall system performance, including impacts on productivity, and equity in access to irrigation water?

11. What were the various interventions and innovations, which had been adopted for improving irrigation system performance and what was their effectiveness and implications for the poor?

12. Are there any measures to provide discretionary benefits to the poor while improving system performance?

Organization of the Report

This report is divided into three parts. Part 1 provides an overview of irrigation development and poverty trends in Pakistan, and highlights key poverty alleviation initiatives in the country. Part 2 is divided into three sections and presents an overview of (i) institutional arrangements for irrigation management in Pakistan; (ii) major legal interventions for irrigation management; and (iii) recent technological innovations in irrigated agriculture in the country. Part 3 is based on primary research in selected irrigation systems in the upper Indus basin, and consists of 10 sections. After a brief introduction, section 2 gives details on study settings, data collection procedures and sample characteristics. Approaches and methodological framework employed in the study is elaborated in Appendix-1. Section 2 and 3 provide analyses of poverty, including spatial dimensions of poverty, characteristics of the poor and key determinants of poverty in irrigated areas. Section 4 assesses performance of selected irrigation systems and associated impacts on poverty. Section 5 identifies key constraints on enhancing crop productivity in the studied systems. Productivity and poverty impacts of recent institutional interventions are assessed in section 6. Based on the above, section 7 presents a detailed analysis of constraints and opportunities for reducing poverty in irrigated agriculture. Last section provides a summary of key study findings, main conclusions and recommendations.

References

Government of Pakistan. 2001. *Agricultural Statistics of Pakistan 2001*. Islamabad, Pakistan: Economic Adviser's Wing, Ministry of Food Agriculture and Livestock.

Government of Pakistan. 2002. *Pakistan Economic Survey 2001-2002*. Islamabad, Pakistan: Finance Division, Economic Adviser's Wing.

Pier, C.; J. Dumanski; A. Hamblin; and A. Young. 1995. *Land Quality Indicators.* World Bank, Discussion Paper No. 315, Washington, DC.

WSIP (1990) *Water Sector Investment Plan*. National Engineering Services, Lahore, Pakistan

Part—1

Irrigation and Poverty in Pakistan – An Overview

Irrigation and Poverty in Pakistan- An overview

1. INTRODUCTION

Pakistan's agriculture depends mainly on irrigation, as the annual precipitation in major areas of the country does not exceed 10 inches with heavy concentration in the monsoonal months of July-August. Realizing the significance of irrigation water, Pakistan has built a huge irrigation system comprising 3 earth-fill dams for storage of water, 19 barrages, 12 link canals, 43 irrigation canals extending over a length of 58,500 km and nearly 100,000 watercourses with a total length of 1,621,000 km (Gill 1996). In addition, more than 530,000 tube wells are also currently pumping groundwater for irrigation. In spite of all this, the available water supplies fall much short of Pakistan's crop-water requirements. According to the required delta of water only about 75 percent is available from various sources of irrigation and the situation is likely to worsen by 2010 when Pakistan will be able to meet only 55 percent of its requirements (WAPDA 1997). This state of affairs has tended to constrain Pakistan in terms of scarcity of water, inability to expand the irrigation frontier, low agricultural production high unemployment rates and endemic rural poverty. If the situation is allowed to persist indefinitely, Pakistan will soon be caught up in a grave economic crisis. To overcome these problems, Pakistan must either increase the available supply of irrigation water or raise its use efficiency. While there is large scope for the latter, little can be accomplished through the former option. This is because sustainable use of water is governed by the fact that withdrawal of water from reservoirs, barrages or other sources cannot be achieved faster than it is replenished through the natural hydrological cycle (Bhatti et al. 1997).

2. HISTORY OF IRRIGATION IN PAKISTAN

The history of Pakistan's irrigation system spans over many centuries. The use of floodwater for crop production involves the entire history of the human race. The new era of irrigation development began under the British rule with the construction of the Bari Doab canal (now in India) as the first canal having permanent masonry head-works. This was followed by the construction of a number of weir-controlled canals in the Punjab and the North-West Frontier Province (NWFP). These included the Sidhnai canal, the Lower Chenab canal, the Lower Jhelum canal in the Punjab and Kabul and Swat canals in NWFP.

The program of irrigation development was sharply expanded beginning with the twentieth century. The major canals built in the Punjab included triple canals, Sutlej Valley canals, Thal canal, Taunsa barrage and a number of link canals. The triple canals involved the construction of the upper Jhelum, the upper Chenab and the lower Bari Doab canals. The Sutlej Valley canals now falling in Pakistan territories involved such canals as Fordwah, Pakpattan, Bahawal, Quimpur, Mailsi, Panjnad and Abbasia. The Thal canal from Kalabagh on the Indus river and the Haveli canal from the Trimmu head-works at the confluence of the Chenab and Jhelum rivers also went through the completion process. In addition, three link canals, namely Bambanwala-Ravi-Bedian-Dipalpur (BRBD), Balloki-Suleimanki (BS) and Marala-Ravi (MR), were also undertaken for the improvement of supplies to various areas (West Pakistan 1963). In NWFP, a multi-purpose (irrigation and power generation) canal was taken out from the Swat river to irrigate the plains of Dergai and Mardan districts. The Paharpur canal was constructed to irrigate parts of the D. I. Khan division. Until 1920, the province of Sindh depended on inundation canals for irrigation. To bring it at par with other provinces, it was necessary to start a more vigorous program and consequently, the construction of the Sukkur barrage and seven canals followed.

The canals that originate from the Right Bank are Northwest, Rice and Dadu canals, and those originating from the Left Bank are Rohri, Easter Nara, Khairpur West feeder and Khairpur East feeder canals (West Pakistan 1963).

In the period following Pakistan's independence, irrigation development was pursued even with more vigor than it was under the British rule. Right at the time of independence in 1947, Pakistan decided to take up the construction of the Kotri barrage for the irrigation of lower Sindh. This barrage involved the construction of the Katri Beghar feeder, Panyari, Fuleli and Akram Wah (lined channel) canals. As work on this barrage reached its final stage in 1955, all formalities on the initiation of the Guddu barrage were in order. The project involved digging of three canals, namely Begari Sindh feeder, Desert feeder and Ghotki feeder to be completed by 1963. Beginning in 1954, a weir across the Kurram river was constructed for the irrigation canals of the Kurrum upper main canal, the Kurram lower main canal and the Marwat canal (Ahmad and Chaudhry 1988).

Under the Indus Water Treaty signed in 1960 with India, huge replacement works were carried out in major irrigated areas of Pakistan. They mainly centered on link canals, barrages, siphons and earth-fill dams, and the Rasul-Qadirabad link, the Qadirabad-Bulloki link, the Bulloki-Suleimanki link, the Taunsa-Panjnad link and the Chashma-Jhelum link came into existence. Chashma, Rasul Qadirabad and Sidhnai along with the Mailsi siphon were the new barrages.Mangla and Turbella (world's largest earth-fill dam) were part of replacement works under the Indus Water Treaty. More recently, the Chashma and Hab dams have also been converted into earth-fill multipurpose dams. Apart from regulating irrigation water supplies, these dams also provide secondary benefits of power generation and flood protection. Although it is difficult to extend irrigation water to major areas of Baluchistan, part of the Hab dam water has been used for irrigation in the Bela district. Canals have been dug to supply irrigation to the Nasirabad district from the Indus river.

While wells and Persian wheels have been historically used for tapping groundwater resources for irrigation purposes, the full potential of these resources could not be exploited using manually or animal-operated systems. With the availability of motorized power in the 1960s, tube wells revolutionized the entire system, which began to increase at a rapid pace. Within a decade and by 1970–71, the number of tube wells had reached 98,000. The number rose to 200,000 by 1980–81, to 340,000 by 1990–91 and exceeded half a million in 1999–2000. As the number of public tube wells has been on the decline since 1989–90, the increase in the total number of tube wells in the 1990s must be largely attributed to the private tube well development (Pakistan 1975, 2000).

With the passage of time, the development of irrigation has significantly changed the status of agriculture. Although historical data beyond Pakistan's history are not available, farm-gate supply of irrigation water has increased from 58.74 million acre-feet in 1960–61 to 133.28 million acre-feet in 1999–2000. This, in other words, implies that the total increase over the 39-year period was nearly 127 percent, which would correspond to an annual growth rate of 2.04 percent in irrigation water resources. As a result of expanding irrigation supplies, Pakistan's agriculture has become increasingly irrigated both in terms of total and proportionate irrigated area. The expansion of irrigated areas shows that only about 22.6 million acres were irrigated during 1950–51, which rose to 26.0 million acres in 1960–61, and further to 32.0 million acres in 1970–71 and to 38.8 million acres in 1980–81. The values for 1990–91 and 1999–2000 corresponded with 41.4 and 44.7 million acres, respectively. In terms of the irrigated area as a proportion of the total cropped area, there was a stagnation of the ratio at 71.0 percent between 1950–51 and 1960–61. It rose to 77.9 percent in 1970–71 and to 81.2 percent in 1980–81. However, the percentage dropped to 76.8 and 79.5 percent for 1990–91 and 1999–2000, respectively (Pakistan 1975, 2000). In spite of these positive developments, Pakistan's agriculture continues to suffer from low productivity relative to world levels (Pakistan 2000). Agricultural growth rates have dwindled down to 2–3 percent per annum from 1994–95 to 1999–2000, which fell further to minus 2.5 percent during 2000–2001 (Pakistan 2001). Poverty in agricultural/rural areas has been on the increase as a consequence of adverse trends in rural employment and income distribution. Although these adverse trends may be attributed to a large number of factors including low fertilizer-application rates, high incidence of pest attacks and inclement weather conditions, many of them may be associated with uncertain supply of irrigation water or management of the irrigation system as follows.

First, it has been pointed out that groundwater has been a major factor in agricultural production over the last 40 years. Because of the ability of tube-well water to match crop water requirements, the resource perhaps stands overexploited posing the threat of excessive lowering of the water table and the intrusion of saline water into the freshwater aquifer (Bhatti et al. 1997). Second, due to age, overuse and poor maintenance, the Indus Basin Irrigation System has developed into a low-delivery and use-efficiency system. For example, the delivery efficiency of the canal system ranges between 35 and 40 percent from the canal head to the crop-root zone. Thus, in practical terms, this means that most of the surface water is currently lost en route. Third, the canal water supplies are highly inequitably distributed between canals, watercourses and head- and tail-end users. The situation is worsened by frequent thefts of water by influential farmers in collusion with irrigation officials. This inequitable distribution results not only in inefficient use but also in reduced agricultural production. Last, the prices of surface irrigation water in Pakistan are kept low and have no relationship to the amount of water supplied. The low water prices have contributed to poor maintenance of the irrigation system and deteriorating canal water supplies. The water supplies to a farmer are determined by his canal command area but the charges are levied on the basis of cropland. The farmers, especially the large ones, have a tendency to minimize their water bills by cropping the minimum possible area with available supplies. It is such practices that, in quick succession, have often led to the twin menace of water logging and salinity. Several interventions have been done to address these problems. These and other interventions in irrigation sector will be reviewed in part 2 of the report.

The overall objective of irrigation development has been to increase farm-gate water supplies, raise agricultural productivity and enable small farmers to have better access to canal water supplies at fair prices. All these novel objectives are intimately and positively related to raising the standard of living of the poor or to poverty reduction in agriculture and elsewhere in the economy. While it is clear that irrigation development and its improved management have the potential to contribute to poverty alleviation, the key question is how to exploit this potential to enhance the role of irrigation for poverty alleviation. It is well documented that input subsidies and price support worked more to the advantage of large and well-off farmers, and the overall institutional support in the past had benefited the minority of these well off farmers. This has contributed to worsen the highly skewed resource distribution pattern in the country. The current situation in irrigated agriculture in Pakistan may be characterized by (a) highly skewed land distribution; (b) high population growth, and increasing number of smallholdings; (c) high illiteracy rate; (d) low crop yields; (e) lack of information sharing; (f) centralized bureaucracies, political interference; (g) lack of transparency and accountability of officials; (h) inequity in the distribution of water; and (i) inadequate maintenance of irrigation infrastructure, and lack of effective implementation of operational rules. All these factors have contributed to worsening the poverty situation in rural Pakistan during late 1990s, substantially reducing antipoverty impacts of irrigation.

New National Water Policy

In 2002, the Government of Pakistan formulated a new National Water Policy (NWP). The draft NWP report discusses key issues in water resources development, management and proposed policy statements. The issues raised in the draft report include: inefficient water-saving irrigation practices, reduction in the availability of surface water due to silting of dams, lack of proper maintenance of the canal system which led to unsatisfactory irrigation services, water logging and salinization of areas in various canal commands, lack of commitment by various organizations, over exploitation of groundwater resources, and the accelerated deterioration of top soils. The report also gives an account of issues related to pollution of aquifers, disposal of saline effluent, contamination of river water, inadequate participation of stakeholders in the system management and inadequate cost recovery. The report provides a review of national water resources, their temporal and spatial distribution/variations and the future water requirements up to the year 2025. The document recommends adopting policies, which ensure sufficient food production in order to meet growing food requirements and food security of the nation. Improving the productivity per unit of water by targeting the production of higher value export crops without sacrificing the wheat crop is greatly emphasized. The report recommends promotion of and support for higher efficiency in the conveyance of irrigation water and ensuring sustainability of irrigation infrastructure through (a) awareness of farmers and government service delivery personnel, (b) increasing the level of cost sharing and (c) increasing community and farmer participation in the management decisions related to infrastructure. The draft document also suggests (1) modernizing irrigation network by enforcing high maintenance standards for irrigation infrastructure to avoid system deterioration; (2) ensuring equity in water distribution mainly for tail-end farmers through institutional support; (3) encouraging and supporting the development of additional storages to meet demand-based needs of crops; (4) promoting the transfer of the management of irrigation schemes to AWBs and FOs, with prior infrastructure rehabilitation, and the establishment of independent regulators to ensure equitable water distribution while facilitating conflict resolution; and (5) promoting empowerment of FOs to collect O&M charges and to impose fines for non-payment.

Regarding water rights and water allocation between the provinces, the draft national policy document lays emphasis on ensuring water rights of the provinces in accordance with the 1991 Water Accord. In addition, improvement of the functioning of Indus River System Authority (IRSA) to harness and develop more water resources in economically and socially desirable ways to reduce water shortages, especially during the critical periods of crop growth is emphasized in the report. With respect to the economic and financial issues in irrigation management, the draft report endorses the concept of realistic pricing of water in all sub-sectors, and the promotion of appropriate water charging systems that would ensure the collection of O&M costs and an increasing portion of the capital costs. Regarding groundwater use, the draft NWP recommends developing a groundwater regulatory framework to control groundwater over-exploitation. In the case of institutional and legal aspects of irrigation water management, draft NWP suggests the creation of a high level inter-provincial permanent body at the federal level, composed of part-time members, to be responsible for all water-resource matters. The proposed Council would be composed of concerned Ministers/Secretaries of Federal Governments, Provincial Representatives and Stakeholder's representatives as Members, and may be headed preferably by the Prime Minister or his nominee.

3. POVERTY TRENDS IN PAKISTAN

Poverty in Pakistan, having dropped to the lowest levels in the 1980s, was on the increase throughout the 1990s in the urban and the rural areas. Poverty is a multidimensional complex phenomenon with many underlying causes including the macro-economic policies. Poverty figures in Table 1.3.1 show that there was consistent improvement in poverty between 1969–70 and 1987–88 on a country-wide scale in Pakistan both in the rural and urban areas. The trend, however, was reversed since 1987–88 as the proportion of the poor population below the poverty line continued to rise throughout the 1990s. To be more specific, 46.5 percent of Pakistan's total population was poor in 1969–70, which in a decade's time fell to 30.7 percent. The proportion was reduced to 24.6 percent by 1984–85 and only 17.5 percent of the people were poor in 1987–88. These drastic improvements in poverty levels, however, could not be upheld in the 1990s as the percentage of the poor rose to 22.1 percent as early as 1990–91. The incidence of poverty registered a sharp increase between 1990–91 and 1996–97 to lie at 31.0 percent during the latter period. It continued its upward trend, in a gradual manner, during the rest of the 1990s as poverty rose to 32.6 percent in 1998–99 and to 33.5 percent in 1999–2000. Although the trend in rural and urban poverty was the same as in total poverty, the levels of poverty were somewhat higher in the rural areas relative to those in urban and total poverty.

The changes in growth, employment, income distribution, and inflation as reported in Table 1.3.2 are the trendsetters in poverty. The improvement in poverty was associated with high growth rates exceeding a threshold level of 6.0 percent per year. By contrast the degree of poverty accentuation varied with the level of downward deviation from this growth rate. For example, the slower the growth rate of a year the higher its poverty level. The slowdown in growth was caused by generally falling or stagnating investment rates of nearly 20 percent in the late 1980s to 16 percent in 1999–2000 (Pakistan 2001). Similarly, the unemployment rates, which did not exceed 2–3 percent during the 1960s, 1970s and 1980s, gradually rose to 5–6 percent levels, respectively, during the early and later part of the 1990s. The recessionary situation of the 1990s created by near stagnation in per capita incomes and growing unemployment rates was bound to result in deteriorating income distribution. Although the Gini coefficients improved consistently through the 1980s and were never in excess of 0.37, they began to assume values greater than 0.40 beginning in 1990–91. These values are historically the highest in Pakistan, they point to the fact that income inequalities in the 1990s have peaked at the worst possible level. Finally, inflationary tendencies affect the poor more adversely and determine the prevailing poverty levels. As the 1990s, in general, were characterized by double-digit inflation, high and rising poverty levels would be a normal expectation.

Table 1.3.1. Poverty incidence (head count ratios) in rural/urban Pakistan for selected years since 1969–70.

Year	Total	Rural	Urban
1969–1970	46.53	49.11	38.76
1979–1980	30.68	32.51	25.94
1984–1985	24.57	25.87	21.17
1987–1988	17.32	18.32	14.99
1990–1991	22.11	23.59	18.64
1992–1993	22.40	23.35	15.50
1996–1997	31.00	32.00	27.00
1998–1999*	32.60	34.80	25.90
1999–2000*	33.50	NA	NA

Sources: Amjad and Kemal 1997; Qureshi and Arif 1999.
*Social Policy and Development Center (SPDC) 2000.

At the macro level, key public sector interventions included price controls, procurement and food subsidies, public investment and extension of credit to raise investment for accelerated growth, public works programs for employment generation, the Zakat system for improvements in income distribution and restriction on trade, foreign exchange and exchange rate for control on balance of payments and trade. More recently, the Khushal Pakistan Program, cash support for a nutritionally vulnerable, micro-credit scheme and social-sector spending have emerged as leading direct interventions by the government. It may be noted that the impact of these approaches may be highly limited in view of the growing worldwide emphasis on deregulation, privatization and liberalization. In fact, the government has been forced to curtail public-sector employment and, since 1988, a ban has been in force on fresh employment. In addition, it is also questionable if the resource-constrained government made worse by the prevailing credit crunch, would allow expanded government expenditure for direct intervention. Already, the government-development expenditure has fallen to less than 3.0 percent in 1999–2000 against 9.3 percent in 1980.

Like direct interventions, even monetary and fiscal policies had perverse effects on poverty. For example, the monetary policy during the 1990s was increasingly used for financing budgetary deficits and, as noted above, it has contributed heavily to inflation with regressive impact for the poor. In view of high tax-evasion rates, poor tax compliance and weak tax administration, heavy reliance on indirect taxes has been a cornerstone of Pakistan's tax policy. Being regressive in its incidence, high tax burdens of the poor were a natural phenomenon. The free-float exchange rate policy has resulted in continuous depreciation of the Pak. Rupee, which promotes inflationary tendencies in an import-dependent and trade liberalizing economy.

Table 1.3.2. Growth, unemployment, Gini ratios and inflation rates 1969–70 to 1999–2000 period. Annual Unemployment Gini Inflation.

Period	Growth rate	Unemployment	Gini ratio	Inflation rate
1969–1970	9.5	1.9	0.386	4.1
1978–1979	5.5	3.55	0.376	6.6
1984–1985	8.7	3.72	0.369	5.7
1987–1988	6.4	3.13	0.348	6.3
1990–1991	5.6	6.22	0.407	12.7
1992–1993	2.3	4.73	0.410	9.8
1996–1997	1.9	6.12	0.400	11.8
1998–1999	4.2	6.12	5.7	
1999–2000	3.9	6.00	3.6	

In addition to the above, policies pursued in agriculture have even more adverse effects on poverty. First, there has been, and continues to be, considerable under pricing of domestic (support prices) agricultural commodities relative to world levels (farm-gate parity price), causing immense resource transfers from the relatively poorer agriculture sector to the urban consumers, middlemen and industrialists with incomes four to five times as those in agriculture (Chaudhry 2000). It is a fact that agricultural commodity markets often fail and prices that farmers receive are generally lower than government-fixed support/procurement prices. Second, a policy of subsidy withdrawal has been in vogue. The implementation of the policy is likely to discourage modern input use, intensive land cultivation, technological breakthroughs and, above all, employment, productivity and output growth in agriculture. It will also hurt the finance-constrained small farmers more than the large rich farmers. Third, in view of steeper increases in input prices when compared with those of agricultural commodities, farmers have to face lower profits than elsewhere in the economy. This induces receding investment incentives in agriculture and outflow of investable resources to other more profitable sectors. Fourth, the imperfections in input and output markets place agriculture in a highly vulnerable position. It often faces rent-seeking in the disposal of commodities and black marketing, adulteration and under-weighing in the purchase of agricultural inputs. Fifth, despite attempts at reforms, Pakistan's agricultural tax system remains oppressive and highly regressive in its incidence. Last, Pakistan has made three serious attempts at land reforms but without any success. To the extent that poverty levels may be associated with land distribution, failure of land reforms in Pakistan may have been a reason for the high incidence of rural poverty.

4. OVERVIEW OF POVERTY ALLEVIATION INITIATIVES

The Government of Pakistan, over the last fifty-two years, has launched various programs to increase the pace of development in rural areas and to reduce poverty in the country. During 1952-61, under Village-Aid program, the Government developed the physical base in rural areas by developing infrastructure (roads, culverts, irrigation works and community buildings). The program could not achieve all its objectives due to lack of inter-agency coordination. Later on, Rural Works Program (1963-72) was started with support from the U.S. Food for Peace Program. It was designed to utilize the potential surplus manpower in building and improving rural infrastructure. This program created job opportunities for the rural poor and made a positive impact on income distribution in rural areas. Afterwards, a special program called People's Works Program was started by the Government in 1972 for providing infrastructure in rural areas, which replaced the Rural Works Program. The main objective of the program was to improve socio-economic conditions of the rural people through providing infrastructure like schools, link roads, low cost housing, drainage water supply, industrial homes, etc. The program ended in 1982. Later on, a special development program known as Five-point Program commenced in 1985 and lasted for three years. This program supported rural development, shantytowns and mass literacy projects. Then People's Program (1989-90) provided funds for the development of infrastructure like water supply schemes and farm to market roads, schools and health facilities. The program was again started in 1994 and ended in 1996. During this period, Rs. 9684 million was utilized for various kinds of infrastructure development programs. In July 1991, the Government launched a development program called Tameer-e-Watan program to provide drinking water in the rural areas and effect the construction of rural roads and rural buildings, electrification of villages, provision of schools, supply of natural gas to urban and rural areas and establishment of public call offices. The program was stopped due to political interference and exploitation. All the above discussed development efforts have not been of much success in bringing significant improvements in the living conditions of the rural poor.

Recently,the government has implemented various welfare programs. These include Khushaal Pakistan Program, Food Support Program, Zakat Rehabilitation Grant, and Micro-credit program. Another major program is the Social Action Program with four target areas – elementary education, basic healthcare, family planning, and rural water supply and sanitation. Also, the government has recently reinvigorated its efforts to provide irrigation facilities to marginal areas, not yet served by the canal network. Priority areas in water resources development over the next decade include: (a) raising of Mangla dam, construction of Mirani dam, Gomal zam dam, Thal canal and other small and medium reservoirs; and (b) efficient use of stored water through construction of new irrigation schemes like Rainee/Thar canals, Kachi canal, greater Thal canal, and modernization of barrages in Punjab. According to the estimates in the government's 10 year perspective plan (2001-2011), these developments would augment irrigation water by 6 million acre feet by 2011. These initiatives are expected to contribute to at least partially addressing the problem of growing water scarcity in the country.

The government of Pakistan (2001) had devised a three-year plan for poverty reduction. The plan identified the extent, nature and profile of the current poverty and the response of the government to reduce it. The plan sought to fight against poverty through the four fold process of (a) increasing economic opportunities for the poor; (b) increasing their empowerment; (c) increasing their access to physical and social assets; and (d) increasing their access to welfare and support through the development of social safety nets. These are to be achieved through: (a) economic reforms; (b) physical assets creation for the poor; (c) social assets creation for the poor; (d) social safety net mechanism; and (e) food governance.

Over time, various studies estimated poverty, and assessed impacts of various policies and interventions. These included Naseem (1973, 1977, 1979), Wasey (1977), Mujahid (1978), Irfan and anjad (1984), Kruik and Leeuwen (1985), Malik (1988), Akhtar (1988), Ahmad and Ludlow (1989), Havinga et al. (1989), Mahmood et al. (1989), Ercelawn (1990), Malik (1991 and 1994), Gazdar et al. (1994), Jafri and Khattak (1995), Anwar (1996, 1997 and 1998), Amjad and Kemal (1997), Baluch and McCulloch (1998), Ali and Tahir (1999), Bhatti et al. (1999), Goheer (1999), Jafri (1999), Arif (2000), and FBS (2001). Recent studies evaluating impact of various policies and programs include Kamal (1994), Malik et al. (1994), Anwar (1996) and Qureshi (2001). A brief review and key conclusions are presented below.

Kemal (1994) examined the structural adjustment program of the International Monetory Fund and the World Bank in realizing the intended objectives and their impact on employment, income distribution and poverty in Pakistan. The study revealed that freezing of wages and low employment opportunities had led to deterioration in the personal income distribution. The Gini Coefficient increased from 0.35 in 1987-88 to 0.41 in 1990-91. The income inequality in rural areas was the outcome of the elimination of subsidies on inputs. The policy lowered the incomes of both the poor and the rich but the increase in output prices benefited the richer farmers relatively more than the poor farmers. The author concluded that the structural adjustment program had adverse implication for employment and equity; therefore, it was recommended that the program must be accompanied with the targeted welfare programs. Similarly, Anwar (1996) estimated the impacts of structural adjustment program on poverty in Pakistan. The author used current consumption expenditure for the measurement of living standard and welfare. The FGT index measures indicated that poverty in Pakistan had increased during the structural adjustment period. The incidence of poverty increased from 13.81 percent to 17.26 percent between 1987-88 and 1990-91. The changes in intensity and severity of poverty were also pronounced in both rural and urban areas. The author suggested that there should be targeting programs to assist the poor and alleviate the adjustment cost.

Malik et al. (1994) estimated the effects of Infaq (i.e. all Zakat, Ushr, Sadaqat gifts and other assistance transfers to the poor) on poverty alleviation in Pakistan. The authors used the household income and expenditure survey data for the year 1987-88. Foster, Greer and Thorbecke (FGT) poverty measures were estimated for before and after Infaq receipts. It was found that Infaq had reduced the poverty level by 2.4 percent in Pakistan. The most important impact of Infaq was on the reduction in poverty gap and severity of poverty. The overall poverty gap was reduced by 4.93 percent, i.e. 8.7 percent in the urban areas and 3.5 percent in the rural areas. Qureshi (2001) reviewed various policies, programs and schemes, which had been introduced and implemented by different governments in Pakistan over the time. The author stated that economic growth since the early 1990s slowed down considerably at around 4.5 percent, and thus, poverty had increased during the last ten years. The government with the help of NGOs had also executed many Social Welfare Programmes. Similarly, targeted Income Transfer Schemes introduced by the government included Zakat and Ushr Programme, the Baitul Maal and Food Stamp Scheme. These programs basically pooled resources from the population at large and the public sector, and redistributed them to the needy throughout the country. The schemes proved to be of great benefit to the poor.

References

Ahmad, Nazir; and Ghulam Rasul Chaudhry. 1988. *Irrigated agriculture of Pakistan.* Lahore: Mirajuddin Press.

Amjad, Rashid; and A. R. Kemal. 1997. Microeconomic policies and their impact on poverty alleviation in Pakistan. *Pakistan Development Review Vol. 38* (Spring).

Chaudhry, M. Ghaffar. 1982. Green revolution and redistribution of rural incomes: Pakistan's experience. *Pakistan Development Review* 21 (3) (Autumn).

Chaudhry, M. Ghaffar; Syed Abdul Majid; and Ghulam Mustafa Chaudhry. 1993. The Policy of irrigation water pricing in Pakistan: Aims, assessment and needed redirections. *The Pakistan Development Review* 32 (4) (Winter).

Chaudhry, M. Ghaffar. 1996. Abolishing poverty and hunger: A South Asian perspective. *Contemporary South Asia* 5 (3).

Chaudhry, M. Ghaffar. 2000. *Agriculture sector performance and policies*. A consultancy report for the Asian Development Bank. Manila: Asian Development Bank.

Gill, Mushtaq Ahmad. 1996. *Participatory irrigation management: Pakistan's experience.* Paper presented at International Seminar on Participatory Irrigation Management held in Turkey, April 10-17.

Habib, Irfan. 1963. *Irrigation system of Mughal India 1556–1707*. Bombay: G. S. Pressn. IWMI (International Water Management Institute). n.d. *Publications catalogue 1995–2000.* Lahore: IWMI.

Johnston, B. F.; and Peter Kilby. 1975. *Agriculture and structural transformation: economic strategies in late developing countries.* New York: Oxford University Press.

Keneda, M.; and M. Ghaffar. 1970. Output effects of tube wells on the agriculture of Pakistan. *Pakistan Development Review* 10 (1) (Spring).

Khan, Dilawar Ali. 1978. Employment and Occupational Change in the Rural Punjab: Consequences of Green Revolution. In *Employment planning and basic needs in Pakistan: Report of a national conference.* Islamabad, Pakistan Manpower Institute and Bangkok: Asian Regional Team for Employment Promotion.

Mellor, John W. 1988. *Lectures on agricultural growth and employment.* Islamabad: Pakistan Institute of Development Economics.

Pakistan. 1975. *Agricultural statistics of Pakistan 1975.* Islamabad: Food and Agriculture Division.

Pakistan. 2000. *Agricultural statistics of Pakistan 1999–2000.* Islamabad: Food, Agriculture and Livestock Division.

Pakistan. 2001. *Economic survey 2000–2001*. Islamabad: Finance Division.

Qureshi, S. K.; and G. M. Arif. 1999. *Profile of poverty in Pakistan. 1998–99.* Pakistan, islamabad: Institute of Development Economics, Islamabad.

Rosegrant, Mark W.; and B. R. Hazell. 2001. *Transforming the rural Asian economy: The unfinished revolution*. Washington. D.C.: International Food policy research Institute.

SPDC (Social Policy and Development Center). *2000. Annual review*.

Tabatabai, H. 1995. Poverty and inequalities in developing countries: A review of evidence. In *The poverty agenda: trends and policy options*, ed. G. Roger and R. Van Der Hoeven. Geneva: International Institute for Labour Studies.

WAPDA (Water and Power Development Authority). 1997. *Ninth five-year plan 1998–2003*. Lahore: Water Resource Development.

West Pakistan. 1963. *Hundred years of P.W.D.* Lahore: Public Works Department.

World Bank. 1990. *World Bank report 1990: Poverty*. New York: Oxford University Press.

Action-Aid Pakistan. 1997. *Gender and poverty in Pakistan: A background paper*. Action Aid Pakistan.

Adams, J.J.; and R.H. He. 1995. *Sources of income inequality and poverty in rural Pakistan.* http://www.ifpri.cgiar.org/pubs/obstract/abstr/oz/htm.

Ahmad, E and C. Allison. 1990. *Poverty, growth and public policy in Pakistan.* Draft Paper.

Ahmad, N. 1998. Poverty in Pakistan. Pakistan Journal of Applied Economics, Vol. 14 (1 &2), 1-26.

Ahmad, E and S. Ludlow. 1989. Poverty inequality and growth in Pakistan. The Pakistan Development Review, 28(4): Pp. 831-850.

Akhtar, S. 1988. *Poverty in Pakistan*. Draft Mimeo. World Bank: Islamabad, Pakistan.

Alderman, H.; and M. Garcia. 1993. *Poverty, household food security and nutrition in rural Pakistan.* Research Report 96. IFPRI: Washington, D.C.

Ali, S. M. 2001. *Poverty and child mortality in Pakistan.* MIMAP Technical Paper Series 6. PIDE: Islamabad, Pakistan.

Ali, S.S.; and S. Tahir. *1999. Dynamics of growth, poverty and inequality in Pakistan.*

Alexandridis, T. S. Asif and S. Ali. 1999. *Water performance indicators using satellite imagery for the Fordwah Eastern Sadiqia (South) Irrigation and Drainage Project.* IIMI-Pakistan Research Report No.R-87. Lahore, Pakistan: International Irrigation Management Institute.

Anwar, T. 1996. Structural adjustment and poverty: The case of Pakistan. *The Pakistan Development Review, 35 (4): Pp9ll-926.*

Anwar, T. 1997. Incidence of relative poverty in Pakistan: Evidence from household survey. Journal of Rural Development & Administration, Vol. XXIX: Peshawar, Pakistan.

Arif, G.M. 2000, Recent rise in poverty and its implication for poor households in Pakistan, The Pakistan Development Review, 39 (4), 1153-1170.

Arif, G.M.; H. Nazli;and R. Haq.2001. *Rural non-agriculture employment and poverty in Pakistan.* Islamabad, Pakistan: Pakistan Institute of Development Economics.

Bhatti, M.A. R. Haq and T. Javed. 1999 A sectoral analysis of poverty in Pakistan. *The Pakistan Development Review* 38(4): Pp. 859-872.

Bastiaanssen, W.G.M.; D.J. Molden; S. Thiruvengadachari; A.A.M.F.R. Smit; L. Mutuwatte and G. Jayasinghe. 1999. *Remote sensing and hydrologic models for performance assessment in Sirsa Irrigation Circle, India.* Research Report No. 27. Colombo, Sri Lanka: International Water Management Institute.

Baulch, B.; and N. McCulloch. 1998. *Being poor and becoming poor: Poverty status and poverty transition in rural Pakistan.* Working Paper No. 79. Institute of Development Studies, University of Surrex, UK.

Ercelawn, A. 1984. Income inequality in rural Pakistan: A study of sample villages. *Pakistan Journal of Applied Economics, Vol. III (I)*, 1-26.

Ercelawn, A. 1988. *Tables presented at World Bank Seminar*. Islamabad.

Ercelawn, A. 1989. *Poverty in Pakistan: Choice of poverty criteria*. Draft Paper.

Gazdar, H. S.; Howes; and S. Zaidi. 1994. *Poverty in Pakistan: Measurement trends and patterns.* STICRD, ISE, London, UK.

Grimard, F. 1996. Does the poor's consumption of calories respond to changes in income? Evidence from Pakistan. The *Pakistan Development Review*, 35(3): Pp. 257-283.

Goheer, N.A. 1999. Poverty in Pakistan: Increasing incidence, chronic gender preponderance and the plausibility of Grameen-type intermediation. *The Pakistan Development Review*, 38 (4): Pp. 373-894.

Government of Pakistan. 2001. *Three year poverty reduction programm 2001-04.* Islamabad, Pakistan:Planning Commission.

Harris, G.; S. Howes; and S. Zaidi. 1994. *A profile of poverty: Some insights from the Pakistan Integrated Household Survey 1991*. London School of Economics, 51994.

Havinga, I.C., F.W. Haanappel; A.S. Louterand; and W.A. Andel. 1989. Poverty in Pakistan 1984-1985. *The Pakistan Development Review*, 28 (4): Pp. 851-869.

Hussain, A. 1997. *Overcoming poverty*. A Report published by The Task Force on Poverty Eradication, Overcoming Poverty, Government of Pakistan. Islamabad, Pakistan: Pp. 69.

Irfan, M. and R. Amjad. 1984. Poverty in rural Pakistan. In *Poverty in Rural Asia*. ed. A.R. Khan and E. Lee. ILO/ARIEP.

Jafri, S.M.Y.; and A. Khattak. 1995. Income inequality and poverty in Pakistan. *Pakistan Economic and Social Review, Vol. XXXIII*. Lahore, Pakistan.

Kemal, A.R. 1994. Structural adjustment, employment, income distribution and poverty. *The Pakistan Development Review*, 33(4). Pp: 901-914.

Kruijk, H. D. and M.V. Leeuwen. 1985. Changes in poverty and income inequality in Pakistan during the 1970s. *The Pakistan Development Review,* XXIV Q & 4.

Mahbub-ul-Haq Centre for Human Development and UNDP. 1999. A profile of poverty in Pakistan. Islamabad, Pakistan.

Mahmood, S.;H.S. Khalid and T. Malunood. 1989. The food poverty and its causes in Pakistan. *The Pakistan Development Review, Vol. XXX*. Islamabad, Pakistan.

Malik, M.H. 1988. Some new evidence on the incidence of poverty in Pakistan. The Pakistan Development Review, 27 (4), winter.

Malik, S. J. 1991. Poverty in Pakistan 1984/85 and 1987/88. In *Including the Poor*.ed. M. Lipton, and J. Van Gaag The World Bank. Washington, D.C.

Malik, S. 1996. Determinants of rural poverty in Pakistan: A micro study. *The Pakistan Development Review,* 3 5(2): Pp. 171-187.

Malik, S.J. and H. Nazli. 1999. Rural poverty credit use: Evidence from Pakistan. Paper presented in *15th AGM of Pakistan Society of Development Economics*. 5-8 November. Islamabad, Pakistan.

Malik, S.J., M. Hussain and N.S. Sherazi. 1994. Role of Infaq in poverty alleviation in Pakistan. *The Pakistan Development Review*, 33(4): Pp. 935-952.

Molden, D; R. Sakthivadival; C.J. Perry; C. Fraiture; and W.H. Kloezen. 1998*. Indicators for* comparing performance of irrigated agricultural systems. IWMI Research Report No. 20. Colombo, Sri Lanka: International Water Management Institute.

Mujahid, G.B.S. 1978. A note of measurement of poverty and income inequalities in Pakistan: Some observations on methodology. *The Pakistan Development Review, Vol. XVII*, No. 3. Autumn.

Mustafa, K.; Z.A. Gill; and T. Azid 2001. NGO's *micro finance and poverty alleviation: Experience of the rural poor in Pakistan.* Proceedings of the 16th Annual General Meeting 2001. The Pakistan Institute of Development Economics, Islamabad, Pakistan.

Naseem, S.M. 1977. Rural poverty and landlessness in Pakistan. In *Poverty and Landlessness in Asia*. Report. Geneva: ILO.

Nasir, Z.M. 2001. *Poverty and labor market linkages in Pakistan.* MIMAP Technical Paper Series.7, PIDE. Islamabad, Pakistan.

Qureshi, S.K. 2001. *An overview of Government's poverty alleviation policies and programs.* MIMAP Technical Paper Series No. 12, PIDE. Islamabad, Pakistan.

Wasey, A. 1977. Urban poverty line estimates. *The Pakistan Development Review, Vol. XVI,* Islamabad, Pakistan.

Zaidi, M.A.and K. De Vos. 1994. Trend analysis of relative poverty in Pakistan (1984-85-1987-88). *The Pakistan Development Review*, 33 (4): Pp: 915-934.

Zaman, W. 1998. *Impact of farmers' participation for water resources management in the Punjab province, Pakistan.* Lahore, Pakistan: International Water Management Institute

Part—2

Institutional and Technological Interventions for Irrigation Management in Pakistan – An Overview

1. Institutional Arrangements for Irrigation Management
   in Pakistan –An Overview
2. Government Interventions in Irrigated Areas – An Overview
3. Technological Innovations in Irrigated Agriculture – An Overview

Institutional and Technological Interventions for Irrigation Management in Pakistan- An Overview

1. INSTITUTIONAL ARRANGEMENTS FOR IRRIGATION MANAGEMENT IN PAKISTAN – AN OVERVIEW

The term "institutions" is vague and means different things to different people. In sociology, the concept of institution is defined as "an organized, established procedure" (Bandaragoda 2000). In institutional economics, the term "institutions" is defined as "the rules of the game in a society or more formally the humanly devised constraints that shape human actions (North 1990). In that sense, institutions are frameworks within which human interactions take place. The institutions set the ground rules for resource use and establish the incentives, information and compulsions that guide economic outcomes. The main purpose of the creation of institutions is to reduce uncertainty in society by establishing stable structures for human interactions. Generally, institutions may be considered as combinations of policies and objectives, laws and regulations, organizations and their core values, operational plans and procedures, incentive mechanisms, accountability mechanisms, norms, traditions, practices and customs (Bandaragoda 2000). The main irrigation-related institutions include legal, social, political, economic and organizational components and can be divided into three categories, i.e., formal rules, informal rules and organizational structures. This section will focus on the institutions that influence irrigation management at the primary, secondary and tertiary levels.

Formal Laws and Rules

The irrigation-related formal laws and rules in Pakistan were devised to allocate and distribute water on an equitable basis to irrigated areas with a minimum maintenance burden. The first irrigation and drainage law, The Canal Irrigation and Drainage Act, was enacted in 1873 and was amended and extended occasionally to meet the emerging needs. Derived from the provisions of this law, various management procedures were devised to operate and maintain canals, allocate and distribute water and resolve the conflicts. According to this law, the provincial government was the owner and manager of the canal water and drainage infrastructure at the primary and secondary level. The farmers were considered as "beneficiaries" and had responsibilities of distributing and using water supplies at the farm level. The management at the tertiary level was the responsibility of the farmers and the state could only intervene if asked to do so.

Canal and Drainage Act of 1873

The Canal and Drainage Act of 1873 is the main legislation relating to the irrigation and drainage system at the provincial level. Under this Act almost the entire irrigation network is entrusted to the provincial government through the officials of the irrigation and revenue departments and the judicial officers. Several amendments to the 1873 Act have been made to deal with the specific requirements, but the Act remained the major law throughout the irrigation history of Pakistan. Subsidiary legislation provided room for various operating rules, manuals of procedure and water rates. These manuals form the second component of the formal rules. Under the law, the management of the system is centralized, with no user involvement. The multiplicity and complexity of the formal procedures makes their implementation in the field quite difficult and impractical. The system of detailed record keeping provides several opportunities to the lower staff to indulge in rent-seeking practices. Therefore, the law has lost its relevance with the changed sociopolitical and water scarcity conditions. For groundwater management, the Punjab Soil Reclamation Act was enacted in 1952. The objective of the law was speedy reclamation and improvement of waterlogged and saline areas and to prevent further damage in order to maximize agricultural production.

Water Users's Association Ordinance of 1981

The Punjab Water User's Association Ordinance was promulgated in 1981. The Ordinance provides room for the involvement of irrigators in water management at watercourse level through the WUAs. Under the law, the field officer, i.e., the Director, On-Farm Water Management (OFWM), has control over the WUAs. He has the authority to register or refuse to register WUAs. Under the Ordinance, more than 50 percent of the water users of a watercourse may form an association and apply to the field officer for registration. The WUA does not have any management powers related to canal water. The field officer may entrust the maintenance of a watercourse to the association but this must be carried out to the satisfaction of the field officer. Under the law, WUAs are subsidy-oriented entities. There is no provision for continuous maintenance of infrastructure and resolution of disputes. Since the field officer is given the power to form WUAs basically to carry out maintenance work, the WUA members remain unable to internalize the essence of collective action for water management. As a result, most WUAs formed are defunct now.

The Punjab Irrigation and Drainage Authority Act (1997)

The Government of Pakistan is in the process of implementing the institutional reforms in its irrigation and drainage sector. In 1997, the Provincial Assemblies passed the Provincial Irrigation and Drainage Authority (PIDA) bills in all the four provinces. The reforms aim at decentralizing the irrigation management system through public and private partnership, farmer's participation and resource governance. The new institutional framework consists of three entities with restructured roles: Provincial Irrigation and Drainage Authority (PIDA), Area Water Boards (AWBs) at the canal command level, and Farmer Organizations (FOs) at the distributary level. The framework is to be tested in one pilot canal command initially. PIDA has defined the functions of AWBs and FOs, though these are only meant for managing surface water. The rules, which regulate formation and functioning of FOs, are listed as follows: (a) Irrigation and Drainage Authority Pilot Farmers' Organization Rules, 1999; (b) Punjab Irrigation and Drainage Authority Farmers' Organization Registration Regulation, 1999; (c) Punjab Irrigation and Drainage Authority Pilot Farmers' Organization Election Regulations 1999; (d) Punjab Irrigation and Drainage Authority Pilot Farmers' Organization Financial Regulations; (e) Farmers Organizations Conduct of Business Regulation 1999; (f) Irrigation Management Transfer Agreement; and (g) Scheme for Transfer of Irrigation Management: Farmer Organizations in Punjab.

Informal Rules

In irrigated areas of Pakistan, the informal norms, values and practices form a strong institutional basis for organizational and social behavior at the grassroots level. The *biradri* (caste and kinship systems), landholding and farm sizes, tenancy, etc., determine the rural power structures, which influence water management at the tertiary level. Occasionally, these variables also influence the management of canals at the secondary level. The level of collective action for effective water management depends on the relative power structure, and the caste considerations. The informal rules of society and the irrigation management go hand in hand in terms of various forms of w*arabandi* at the tertiary level of the irrigation system in the canal command areas. Various forms of water distribution practices adopted about a century ago with the common understanding of the irrigators have evolved in today's warabandi System.

Evolution of Warabandi

Water distribution at the tertiary level was primarily the responsibility of farmer beneficiaries at the watercourse level. Irrigation communities experienced social organization processes and established their own water distribution arrangements among users. Water distribution took place through warabandi or an irrigation roster, primarily determined by the amount of irrigated land owned by each member. The farmer-managed warabandi was called *kachcha* (flexible, informal) warabandi. Later, the government had to intervene due to the increasing number of water disputes, or when farmers requested additional water for increased intensities, particularly to nurture their fruit orchards in arable land. Warabandi refers to the irrigation roster, a system of fixed water turns proportionate to the area of each user. For a comprehensive account, see Bandaragoda and Rehman 1995.

State intervention increased when farmers were exposed to new opportunities to acquire more water. Special allowances for orchards and other nontraditional needs were often misused. Sometimes, when a special allowance had been sanctioned, farmers exceeded the limit several times over to get more water. At other times, farmers obtained special allowances without actually owning an orchard. This flexibility was often the result of an alliance between lower cadre staff of ID and more influential farmers. Invariably, such instances were unacceptable to the other, less-privileged water users. Disgruntled farmers either approached higher officials for some redress, or sought mitigation of these disputes through the judicial system. Successful settlement of disputes through this process encouraged more farmers to lodge complaints with the authorities. Apart from these allocation-related disputes, farmer-managed water distribution at the watercourse level often resulted in conflicts among farmers, which sometimes culminated in violence. The main origins of these disputes were two interrelated social factors. The first was the existence of a number of heterogeneous groups in terms of caste, baradari, or kinship, political affiliation, etc., along the same watercourse command. The coalition and conflict of interests of various subgroups in the community fostered inequity in water distribution. The second was the kachcha practice, which became prone to manipulation by the more influential water users. Confronted with growing problems of disputes, and inequity in water distribution caused by kachcha warabandi, some aggrieved water users expressed their preference for a fixed irrigation roster. Leading petitioners in such cases were mostly from the tail or middle reaches of the watercourses (Mirza 1975) who were more affected by actions of upstream users. Other affected water users usually agreed to sign the petition to formalize the irrigation roster. In the Punjab province, ID's interventions in water distribution, by fixing formal water schedules (*pakka* warabandi), started somewhere during the 1960s. By now, most of the watercourses in the area have switched over to pakka warabandi, and have discarded the flexible form of kachcha warabandi. This widespread phenomenon of switching over from the kachcha to pakka warabandi reflects the limited formation of social capital among the farming communities in Pakistan.

Types of Warabandi

The term *warabandi* is derived from two local words *wahr* and *bandi,* meaning "turn" and "fixed," respectively (Bandaragoda and Rehman 1995). Thus, this term translates into fixation of irrigation turns for the landowners along a particular watercourse. Essentially, warabandi is a rotational method to equitably distribute available water supplies in an irrigation system. Turns are fixed according to a predetermined schedule specifying the day, time and duration of supply to each irrigator, in proportion to the size of his landholding in the outlet command (Singh 1981; Malhotra 1982). In consideration of "fixing" water turns, this definition seems to apply only to the officially sanctioned pakka warabandi schedule, which is determined and "fixed" by ID.

Pakka Warabandi

A pakka warabandi generally follows a cycle of one week, or 10 1/2 days. Furthermore, the 12-hour pakka warabandi rotation is alternated every year, generally after the annual canal closure in December-January, so that farmers who had been irrigating at night during the previous year will irrigate during daytime hours during the next year. This warabandi is sanctioned by respective Executive Engineers of ID, and also serves as proof of water rights for shareholders along the watercourse (Bandaragoda and Rehman 1995).

Kachcha Warabandi

Unlike pakka warabandi, farmers distribute water entering their watercourse by following an agreed irrigation roster without the formal involvement of the governmental agency. This type of warabandi is generally referred to as kachcha (ordinary, unregulated, informal) warabandi (Bandaragoda and Rehman 1995). This type of warabandi provides turns that are generally fixed and predetermined, but the day and timing of each turn is flexible and depends on the availability of water in the watercourse.

Water Management Organizations

There are several agencies involved in managing the irrigation supplies and drainage in the irrigated areas of Pakistan. These include:

- Water and Power Development Authority (WAPDA).
- Punjab Irrigation Department (PID).
- On-Farm Water Management Directorate (OFWMD).
- Salinity Control and Reclamation Projects (SCARP) staff.
- Punjab Private Sector Ground Water Project (PPSGWP).
- Agricultural Development Bank (ADBP), etc.

Water and Power Development Authority (WAPDA)

WAPDA, linked with the Federal Ministry of Water and Power, was created in 1958 as an autonomous agency to supervise the construction of large-scale infrastructure in the Indus Basin Project. It remains as an agency responsible for the dams and interprovincial link canals, and operates these facilities with the consultation of PIDs according to water rights and the seasonal allocation of the provinces. In the irrigated areas of Pakistan, WAPDA was responsible for the planning and installation of tube wells for the SCARP and for the tile drainage projects.

The Provincial Irrigation and Drainage Authorities (PIDAs)

PIDAs, transformed from PIDs are autonomous bodies responsible for policy formulation, legal enactment and overseeing the overall management of the irrigation and drainage systems in the respective provinces. PIDAs are responsible for the O&M of the irrigation systems extending from the headworks to the main canals, distributaries, to the outlets in the watercourses in the provinces. The role of a PIDA is defined in the already mentioned different Acts, rules and manuals. Currently PIDA is in transitional stage and, ultimately, it will be a financially autonomous body with independent revenue collection and spending authority with proper accountability. Below PIDA in each province, financially self-accounting AWBs are to be created on an experimental basis. And below AWB, FOs will be formed, again on a pilot basis,along the distributary level (secondary level). AWB will receive water from PIDA and deliver it to FOs and the latter operate and maintain the distribution channel with financial autonomy and management. An FO is formed and owned by the farmers of the command area of the distributary. PIDA manages primary and secondary network of canals, drains, and public tube wells through its irrigation circles, divisions and subdivisions. The main responsibility of O&M lies with the Executive Engineers, Subdivisional Officers, and the Subengineers. Most of the maintenance is undertaken through contracts. The revenue assessment is carried out through *Patwaris* and *Zilladars*. The collection is the responsibility of the Revenue Department that collects the water charges through village-based *Lumberdards*. The revenue and spending on irrigation and drainage are not linked to each other.

The Area Water Board (AWB)

An Area Water Board was supposed to cover about 0.4 million hectares, and FO 400 to 4000 hectares. Each canal command would have one AWB, which included about 120 to 140 distributary systems. In Pakistan, there are 43 canal commands and altogether 43 AWBs would be established. Area Water Boards would have function similar to that of a utility company. AWB would be incharge of a particular area.It would be composed of the representatives from farm households' organizations, PIDA, the Agriculture Department, WAPDA, etc. According to the PIDA Act, the farm households' representatives should include the head and the tail end farm households, as well as large and smallholding farm households. One FO represents one distributary and one WUA represents the farm households below the mohga (outlet) and along a watercourse.

Farmer Organizations (FOs)

FOs are being established at the distributary canal command level. They will receive water from the AWBs and distribute the same to various watercourse farmers and other users. FOs will operate and maintain distributary canals and assess and collect revenue. About 40 percent of the collected revenue will be given to FOs for O&M of the channels. FOs will have to sign an Irrigation Management Transfer (IMT) Agreement with PIDA to take over management. So far, some 20 FOs have been established but the management is yet to be transferred. However, in the southern Punjab, IMT Agreements have taken place between three FOs and PIDA.

Planning and Scheduling of Water Deliveries in the Irrigation Command Areas

Planning and scheduling of the water deliveries in the main canals and the secondary canals are PIDA's responsibility. Planning is done for each cropping season (kharif and rabi). The PIDA staff schedules water for a particular subdivision based on the culturable command area and is responsible for delivering the scheduled water to the main canals and to the secondary canals in that subdivision, subject to the availability of water in the upstream system. The supplies depend on the release of water from the storage reservoirs by WAPDA. At the tertiary level the farmers manage the distribution of water through the weekly warabandi system. The water users are also responsible for the maintenance of the watercourse and for implementation of warabandi but, if there is some dispute, PIDA intervenes at the farmers' requests to resolve the problem.

Resolution of Water Disputes

As mentioned earlier, under the Canal and Drainage Act of 1873, there is provision to resolve the disputes among water users. The Subdivisional Canal Officer (SDCO) is responsible for allocating the warabandi and to resolve warabandi-related disputes. He is also responsible for implementing the orders of the Divisional Canal Officer regarding new sanctioned watercourses and to adjust the claims from the joint users. Under the PIDA Act of 1997, there is a built-in mechanism to resolve the disputes. The responsibility for resolving disputes regarding the formation of the association, election of office bearers, framing of bylaws, etc., is entrusted to FOs. In case of any dispute of this kind an appeal can be made against the decision to the "Appel1ate Board" of the WUA. In case of disputes relating to the operational aspects of irrigation they are referred to AWB and PIDA and are settled under the laws relating to irrigation.

References

ACE-NESPAK-NDC. 1997. *Hydrogeological studies, final report, second SCARP transition project.* Lahore: Irrigation and Power Department, Government of Punjab.

Bandaragoda, D. J. 2000. *A framework for analysis of institutions for water resources management in a river basin context*. IWMI Working Paper 5. Colombo, Sri Lanka: International Water Management Institute.

Bandaragoda, D. J.; and G. R. Firdousi. 1992. *Institutional factors affecting irrigation performance in Pakistan: Research and policy priorities.* IIMI-Country Paper. Colombo, Sri Lanka: International Irrigation Management Institute.

Bandaragoda, D. J.; and S. U. Rehman. 1995. *Warabandi in Pakistan's canal irrigation systems: Widening gap between theory and practice.* Country Paper No. 7. Colombo, Sri Lanka: International Irrigation Management Institute.

Cernea, M. 1987. *Farmer organization and institution building for sustainable development.* Regional Development Dialogue, 8 (2). Nagoya, Japan: United Nations Center for Regional Development.

Khan, M. A. 1978. *Hydrological data, Rechna Doab, Vol. I, Lithology, mechanical analysis and water quality data of testholes/testwells.* Publication No. 25. Lahore, Pakistan: Project Planning Organization (NZ), Water and Power Development Authority.

Malhotra, S. P.; S. K. Raheja; and David Seckler. 1984. A performance monitoring study of the warabandi system of irrigation management. In *Productivity and equity in irrigation systems,* ed. Niranjan Pant. Delhi: Ashish Publishing House.

Mirza, A. H. 1975. *A study of village organizational factors affecting water management decision-making in Pakistan.* Water Management Technical Report No. 34. Fort Collins, USA: Colorado State University.

North, Douglass C. 1990. *Institutions, institutional change and economic performance.* USA: Cambridge University Press.

PGC-Punjab Private Sector Groundwater Development Project Consultants. 1999. *Guideline for the modification of STWs as CTWs in PPSGDP.* Technical Report No. 28. Government of Pakistan: Project Management Unit, Planning and Development Department.

Singh, K. K. Ed. 1981. *Warabandi for irrigated agriculture in India.* Publication No. 146. New Delhi: Central Board of Irrigation and Power, India.

2. GOVERNMENT INTERVENTIONS IN THE IRRIGATED AREAS – AN OVERVIEW

Prior to the canal construction in the Chaj and the Rechna Doabs, the watertable was reported to be more than ten meters, and in the center of the Doabs it was reported to be more than 30 meters. Because of the relatively flat topography, low hydraulic gradient, and generally poor drainage conditions, the watertable started to rise due to increased recharge through the unlined irrigation channel and deep percolation from croplands. Simultaneously, with the rise of watertable, the hydraulic gradient and consequent movement of groundwater towards the center of the Doabs decreased annually. By 1930, the depth of watertable in the center of the Doabs rose above the altitude of the adjacent rivers, thereby reversing the hydraulic gradient and direction of the groundwater flow. By 1960, the watertable rose up to as much as 3 meters in the southeast area of Faisalabad (Rechna Doab), and in many other areas of the Chaj Doab, it reached the land surface. With the rise in watertable, the secondary salinization of cultureable lands started rendering precious land waste. The government intervened from time to time to reclaim the land resources for continued irrigated agriculture in the area. Seven types of major interventions have been introduced in these areas at different times. Table 2.2.1 presents a summary of these interventions that took place in different time periods in the study areas. These interventions comprised both hardware and software type of interventions including:

(i) Introduction of surface irrigation network
(ii) Introduction of tubewells
(iii) Drainage-related interventions
(iv) SCARPS projects
(v) SCARP Transition Projects/ community tubewells
(vi) Lining of the watercourses through On Farm Water Management Projects
(vii) Introduction of the participatory irrigation management through water users associations

Pre-SCARPs Interventions (Pre-1960s)

Waterlogging was first noticed in the upper region of the Rechna Doab and middle region of Chaj Doab, a few years after the opening of the Lower Chenab Canal in 1892 and Lower Jehlum Canal. At that time, the watertables in other parts of the Doabs were fairly deep and irrigation applications were quite adequate for crops and leaching requirements of the soil. During the period of 1912-1952, the watertable started rising in the Doabs. Attempts to control the watertable by intercepting seepage from canals through tubewells and drains parallel to canals were also made. However, these measures were not effective in controlling the rising water levels. The tubewell pumping schemes implemented by the Punjab Irrigation Department between 1945-1951 to eradicate waterlogging and supplement the irrigation water were mostly based on inadequate data. They were not commensurate with the magnitude of the problem, with the result that they had no significant effect. The first such project was the Rasul Tubewell Scheme with 1,526 units installed in the Chaj Doab. The Soil Reclamation Board also implemented reclamation schemes from 1954 to 1960 and installed 190 tubewells to operate in Chuharkana, Jaranwala, Chichoki Mallian and Pindi Bhattian for a total area of 48,000 hectares in the Rechna Doab. On a large scale, the construction of storm water drains was carried out during 1933-47 and 3,700 kilometers of surface drains were laid out mostly in the Rechna and Chaj Doabs. Ahmadpur and Kot Nikka open drains were the first in a series of open drains constructed for

Table 2.2.1. Summary of government interventions in the irrigated areas of Pakistan.

Type of intervention		Upper Jehlum Canal System (UJC)				Gujrat System		Lower Jehlum Canal System (LJC)		Lower Chenab Canal System (LCC)	Hakra Canal System
		Name of Distributary									
		9-R	10-R	13-R	14-R	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R
Canal and Drainage Act, 1873		X	X	X	X	X	X	X	X	X	X
Punjab Soil Reclamation Act, 1952		X	X	X	X	X	X	X	X	X	X
Punjab Water Users' Association Ordinance, 1981	Formation of Water Users' Associations (WUA)	X	X	X	X	X	X	X	X	X	X
On-Farm Water Management (1976)	Lining of Watercourses	X	X	X	X	X	X	X	X	X	X
SCARP (1960s-80s)	Installation of Public Tubewells	X	X	X	X	X	X	X	X	X	
SCARP Transition Project (1980-2001)	Installation of Private Tubewells	X	X	X	X	X	X	X	X		
Punjab Irrigation and Drainage Authority Act, 1997	Area Water Board (AWB)									X	
	Farmers' Organization (FO)										X

the Rechna Doab to complement the surface irrigation network under the Upper Chenab (UC) and Lower Chenab (LC) canals. The Upper Chenab Canal (UCC) had 611,500 hectares of land drained by 1,217 kilometers of drains and LCC had 1,500,000 hectares drained by 1,329 kilo meters of drains.

Lack of maintenance placed a damper on drain construction, thus the lining of existing canals was initiated to reduce the seepage. In 1943, lining a portion of the Jhang Branch Canal was undertaken. This presented many difficulties and did not prove to be very successful. The further lining of existing canals was not undertaken. However, many new canals were lined such as the Bumbanwala Ravi Baidian Depalpur (BRBD) link and Haveli Link canals.

Salinity Control and Reclamation Projects (SCARPs) (1960s to 1980s) and their Achievements

In order to get rid of waterlogging and salinity problems, the Government of Pakistan also started the vertical drainage scheme in terms of the SCARP projects during 1960s. The basic aim of the salinity control and reclamation program was to reduce the culturable areas that had gone waste due to the problem of waterlogging and salinity. The scheme was thought to be beneficial in two regards, i.e., by providing vertical drainage to waterlogged areas and by augmenting the water supplies through deep tubewells available for use along with the surface supplies. About six different SCARP schemes were introduced and implemented in the Rechna and Chaj Doabs.

SCARP I

The SCARP-1 project was primarily a vertical subsurface drainage scheme anticipated for about 0.492 million hectares of gross area in the Chaj and Rechna Doabs. The project comprised twelve schemes: Beranwala, Chichoki Mallian, Chuharkana, Hafizabad, Harse Sheikh, Jaranwala, Khanqah Dogran, Pindi Bhatian, Sangla Hill, Shahkot, Shadman, and Zafarwal. The objective of the scheme was to reduce the watertable and utilize the fresh groundwater (FGW) pumpage as an additional source of irrigation supplies in the Rechna Doab. About 2,069 tubewells of varying capacity were installed during the early 1960s for a cumulative discharge volume of 0.2 million hectare meters per year. Investigations made by the USGS (Malmberg 1968) in SCARP-1 indicated that pumping had more than doubled the irrigation supply and lowered the watertable to a depth of more than three meters across much of the project area. As a result, more than 66 percent of the 162,000 ha of land damaged by waterlogging and salinity was wholly or partially reclaimed. The cropping intensity was reported to increase from about 77 percent in 1962 to 101 percent in 1968.

SCARP II

The SCARP-II was launched in Upper Chaj Doab (area between the rivers of Chenab and Jhelum). It covered a gross area of about 0.8094 million hectares. Under this project, about 2207 public tubewells were drilled and operations began in various schemes (11 in total) in Lalian, Mona, Khadir, Upper Jhelum subproject, Phalia, Sohawa, Busal, Lower Hujjan Schemes, and Kot Moman. In June 1971, the watertable was at a depth greater than five feet in all but one percent of the SCARP-II area. Relatively high depth of watertable was recorded in areas where SCARP-II had started working earlier. The average decrease in discharge across various parts of SCARP-II was not as serious as in SCARP-I (Mundorff et al. 1976).

SCARP III

The SCARP-III included three schemes in Lower Thal Doab. It covered a gross area of 0.518 million hectares and about 1635 public tubewells were installed in this phase. As of June 1969, the watertable was within five feet of the land surface in about 40 percent of the area covered under SCARP III (Mundorff et al. 1976).

SCARP IV (Mangtanwala and Muridke)

Executed under SCARP IV was the construction of 935 fiberglass tubewells in the fresh groundwater areas of the Rechna Doab along the Ravi River with a total discharge capacity of nearly 62 cumecs in order to alleviate waterlogging, control salinity and augment additional irrigation supplies in Mangtanwala and Muridke areas. The total area of the Mangtanwala and Muridke units was 225,652 hectares. About 37 percent of the tubewells in the Muridke unit were of lower capacity (57 and 85 lps) when compared to the earlier installations of less than 22 percent in the Mangtanwala unit, where the emphasis was more on high capacity wells. Interestingly, there was no tubewell discharging at 0.5-cusec (14 lps) incremental intervals in either of the two schemes, which was one-third the preference under SCARP-1. Based on the data, for the number of operational wells remaining after successive time intervals, the fiberglass tubewells of SCARP IV were reported to outlast the mild steel versions under SCARP-I tubewells, especially during the early years of operation. SCARP-I had over 47 percent of the tubewells operating under 3 cusecs (85 lps) capacity when compared to the nearly 32 percent for SCARP-IV. Those higher capacity wells were known to suffer from greater loss in specific capacity over time (Memon and Arif 1993).

SCARP V (Lower Rechna Area)

The original reclamation program planned by the WAPDA consultants, M/s. Tipton and Kalambach, during 1966 for the SCARP V (LRR) project comprised 1.1 million hectares of culturable area. The Jhang, Rakh, Lower Gugera and Brula branches of the LCC command provided irrigation to this area. The Haveli Canal and Koranga Feeder of the Central Bari Doab Canal irrigated the remaining areas. This project could not materialize. Subsequently, on the recommendations of the World Bank, the project as a whole was deferred and its lower parts under the commands of Haveli, Koranga Feeder, and the tail reaches of the LCC system were renamed and planned as Shorkot-Kamalia Unit of SCARP-V comprising 0.172 million hectares. As an early action plan during 1974, the consultants proposed a project covering a gross area of 68,400 ha termed as the pilot project. About 101 tubewells were installed in this SCARP-V area to alleviate the problem of waterlogging and salinity. The overall cropping intensity in SCARP-V area increased from 114 percent to 135 percent.

The remaining part of the SCARP-V was assigned to the Project Planning Organization (PPO), North Zone (NZ), during 1974 for the preparation of the revised plan. In view of the severity of the drainage problem, the PPO (NZ) developed a scheme for the construction of 71 drainage tubewells under Satiana Pilot Project as a part of the overall plan to provide a relief to the waterlogged areas of about 73,650 ha in Satiana. The PPO (NZ) also proposed the Gojra Khewra, the Khairwala Surface Drainage System and Fourth Drainage projects. The Fourth Drainage Project was launched during 1983 to reclaim water from about 119,000 hectares of land. During 1993 after the completion of these projects, the watertable depths across much of the project areas decreased considerably.

Upper Rechna Remaining (URR)

The gross area of the Upper Rechna Remaining Project is about 0.47million hectares. This area is served by three canal systems (LCC, UCC and MR Link Canal, all of which derive their supplies from the Chenab River). Historic data (1966-75 average) on canal diversions indicate that due to non-perennial irrigation supplies in the commands of the LCC and MR Link Canals, these areas experience an acute deficit of irrigation supplies during most part of the year, except for the months of May and June. These shortages are reported to be more acute from November to March. The area located in the fresh groundwater zone has exploitation opportunities. The cropping intensity is reported to be in excess of 140 percent. The project area has three main drainage basins, namely Deg Nala, Q-B Link and Ahmedpur Vagh. The first two basins drain to the Ravi River while Ahmedpur Vagh drains to the Chenab River. The Q-B Link and Ahmedpur Vagh basins have most of the drains artificial and do not efficiently drain the area during the monsoon season. In the Deg Nala Basin, about 60 drains equivalent to 393 kilometers have been constructed to bring the drainage effluent to the Deg Nala in the Upper Rechna, which ultimately disposes the drainage water to the Deg Diversion Channel, finally discharging into the Ravi River upstream of the Balloki Headwork.

Drainage channels in the Deg Nala Basin are primarily to transmit surface runoff received from across the MR and BRBD Link canals. For the protection of these canals, cross drainage works have been provided and an additional 183 kilometers of artificial drains cover sheet-runoff from damaging the UCC; collectively, these discharge into the Nikki Deg Natural Drainage Channel. However, still at many places, the embankments of roads and canals block the path of drainage. For overflows resulting from storms of higher intensity than designed for the cross drainage structures, the damage to the rice crop is substantial. It was found that the top soil (0-18 cm) non-saline land increased from 78-88 percent while other soils like saline-alkali and non-saline alkali also showed improvements (Rehman et al. 1997).

Post-SCARP Interventions (1980s to 2001)

SCARPs had been useful in eliminating waterlogging, controlling salinity and for providing additional irrigation water to increase cropping intensities and yields. However in mid eighties, the following problems were identified to be resolved through the SCARPs transition and improvement projects (ACE 1985):

I. With the deterioration of the operational efficiency of SCARP tubewells over the time and consequent reduction in pumpage, the watertable had started showing a rising trend in most parts of the area.
II. With increasingly high power tariff, rapid depreciation of tubewells and low water rate for tubewell supply, the O&M cost of SCARP tubewells was becoming high and unsustainable by the public sector.
III. With the passage of time, replacement of a large number of aging tubewells was needed.
IV. With frequent repairs and fault removals needed by aging tubewells, the Irrigation Department had limited capacity to manage and operate SCARP tubewells.

SCARPs Transition Pilot Project

Launched in the late 1980s was a pilot project for the transition of SCARP tubewells in the Khanqah Dogran scheme of the First SCARP. The basic concept tested was the involvement of private sector pumping for irrigation from shallow groundwater, generally falling within fresh water limits, in order to balance the drainage requirement of the pilot project area where public sector operation of SCARP tubewells was terminated.

The objectives of transferring fresh groundwater pumpage were to meet irrigation and drainage requirements more effectively and increase agricultural production and farm incomes through conjunctive use of water. These objectives were envisaged to be achieved by electrification and installation of private tubewells, irrigation/drainage improvement works (e.g. lining of minors and watercourses), and institutional developments. Under the pilot project, 213 SCARP tubewells were transferred and replaced by 2,100 private tubewells with necessary financial incentive and technical guidance provided to the farm households (ACE-NESPAK-NDC 1997).

Second SCARP Transition Project

The successful implementation and enthusiastic response from the farm households of the SCARP Transition Pilot Project led to the development and execution of Second SCARP Transition Project. The transition activities were expanded to the remaining schemes of the first SCARP by closing 1,353 SCARP tubewells and replacing them with the installation of 4,700, comparatively shallow private/community tubewells to be operated by farm households/groups of farm households (ACE-NESPAK-NDC, 1997). Included in the project was a hydrogeological study to collect and update necessary data to form a basis for the analysis of long-term sustainability of groundwater withdrawals and its utilization in the project area without causing any undesirable effects on hydro-geologic regime and environment. The study, interalia, concluded that existing distribution and pattern of pumping did not indicate significant vertical or lateral movement of groundwater of undesirable quality in future in at large scale, and recommended to regulate the number and distribution of tubewells in the project area by public agency.

Punjab Private Sector Groundwater Development Program (PPSGDP)

On the successful culmination and enthusiastic reception by farm households of SCARP transition projects, the Government of the Punjab executed and co-financed along with the World Bank the PPSGD project in the province for a five-year period (1997-2002). The project activities were spread over an area of 1.455 million hectares (3.59 million acres) containing an estimated 5266 watercourses. The project area comprises fresh groundwater areas of Second SCARP (including Shahpur), Third SCARP (Rangpur Unit) and remaining SCARPs within the Rechna Doab (Fourth; Muridke Mangtanwala: and Fifth; Shorkot Kamalia). The PPSGD Project also covers saline groundwater areas of the Second SCARP and saline groundwater pockets within and at the boundaries of fresh groundwater areas (PPSGDP 1998). The project envisages: the disinvestments of 4,230 SCARP tubewells and establishment of 6,360 private tubewells owned by farm households/groups of farm households; lining of distributaries, minors and watercourses; installation of drainage tubewells in saline areas; prevention of saline groundwater intrusion; establishment of groundwater management areas using groundwater models; preparation of groundwater regulatory framework; and institutional development. The main objective of this project was to increase the scope and productivity of Punjab's irrigated areas as well as to increase the farmer's income in order to alleviate poverty.

Impact of PPSGDP

- Till 2002, more than 550,000 private tubewells were operating mainly for agriculture, and as a result of this development the cropping intensity has increased from 80 percent in 1947 to more than 150 percent in some of the areas of the Punjab province.
- Investment on these tubewells was about Rs. 25 billion while the annual benefits in the form of agricultural production were estimated to be Rs. 150 billion.
- High pumping through private tubewells and uneven groundwater development resulted in the deterioration of soil quality and lowered groundwater table in some areas of the Punjab.
- Tubewells, which were installed at shallow depth, stopped working due to the lowering of watertable.
- In some parts of the project area, with excessive pumping, the groundwater table lowered abnormally which made tubewell water use more expensive, depriving small farmers of the supplementary source of canal water.
- In some saline groundwater areas, the intrusion of saline groundwater occurred from saline groundwater zones to the fresh groundwater zones.

On-Farm Water Management (OFWM) Program

The On-Farm Water Management (OFWM) program, started in 1976, has so far accumulated 26 years' experience. The Agriculture Department has been in charge of the program i.e. primarily, construction works such as land leveling and watercourse lining. Farm households' participation is an important element of the program since farm households gain a sense of ownership and better quality works. The OFWM involved farm households' contributions of 50 percent of the cost in terms of their own resources such as physical and financial contributions. The department provided subsidies as well as training for farm households in technical aspects of OFWM. To implement farm households' participation, the department assisted organizing farm households' groups, namely Water Users' Associations (WUAs). After informal activities of WUAs from 1976 to 1981, the WUA Act was enacted in 1981, after which the WUA became a formal group. The On-Farm Water Management (OFWM) and Water Users' Association Ordinance (1981) provide room for the involvement of irrigators in water management at the watercourse level through the Water Users' Association (WUA). Under this law, the Field Officer (Director, OFWM) has a substantial control over WUAs. He has the authority to register or refuse registration to the WUA. Under this ordinance, more than 50 percent of the water users of a watercourse may form an association and apply to the Field Officer for registration. WUA does not have any management power relating to canal water under this ordinance. The Field Officer may entrust the maintenance of a watercourse to the association but this must be carried out to his satisfaction. The high O&M cost, low recovery of Abiana along with the efficiency issues in the Irrigation Department led the government to decide in favour of participatory irrigation management and irrigation transfer to the FOs through the PIDA Act.

4. TECHNOLOGICAL INNOVATIONS IN IRRIGATED AGRICULTURE – AN OVERVIEW

Over the time, various innovations have been introduced in irrigated agriculture of Pakistan, leaving different impacts on saving water, reduction in the cost of production, increase in the production, and ultimately the profit margins. Some of the important innovations introduced in irrigated agriculture are discussed below.

Bed and furrow irrigation method

In this method, furrows are made at 75 cm space intervals, where a bed remains between the furrows. In these dimensions, the wheels of the tractor match the furrows. The dimensions could be different for different systems. Seed is sown in two rows near the edge of the bed. The bed and furrow irrigation method is suitable for crops like cotton, vegetables, maize and sugarcane. This irrigation method is considered as a new technology or innovation.

Kalwij et al. (1999) determined comparative and quantitative assessment for irrigation frequency and water application between the basin and bed and furrow irrigation methods. The sample comprised 32 farmers located in 7 watercourse command areas, scattered in 5 sub-systems of Hakra 4-R distributary. The results showed that the number of irrigation applications for cotton was increased by two, with average values of 7 and 5 for the bed and furrow and basin fields, respectively. The average cotton production was reported to be 15 percent higher for bed and furrow irrigation method. Gill et al. (2002) also reported the following important advantages of bed and furrow irrigation methods.

i. Saving of about 30 percent of irrigation water
ii. More suitability for saline and sodic soils
iii. Less damage to crops due to excessive rain or over-irrigation
iv. Adaptability for various crops
v. Reduction of the chances of crop lodging
vi. Enhanced fertilizer use efficiency

Skimming wells technique

The extraction of groundwater by partially penetrating a tubewell between the fresh and salty groundwater layers is called skimming of fresh groundwater. For increasing the fresh water discharge, the radius of a well is a choice variable. The maximum discharge of fresh water increases, as the difference between fresh and salty groundwater densities increases. Asghar et al. (1999) argued that under shallow watertable areas, the Radial wells for skimming fresh water seems an attractive option, provided the social, economic and environmental constraints allow the skimming. The authors were also of the view that by introducing adequate interventions in design and operational management strategies of skimming wells, higher discharges were also feasible. It is also reported that the design and installation of a skimming well, considering the aquifer characteristics and the operation management strategies, could control the salty water upconing.

Groundwater without compromising the quality was still lacking due to hydro-geologic conditions in the Indus basin. The authors had stated that many people in the rural areas of the Indus basin use canal water, which contains biological and industrial waste that cause medical problems. Skimming wells can also provide an alternative source of water for domestic supply.

Resource conservation technologies

The development of resource conservation technologies in Pakistan started in 1960s. Water and Power Development Authority (WAPDA) and Colorado State University (CSU) of USA developed a technological package of resource conservation technologies after a long period of research.

The package comprised

i. Conservation tillage practices
ii. Watercourse improvements
iii. Precision land leveling
iv. Improved irrigation and agronomic practices

The package was implemented in various agro-climatic zones of the country during the period of 1976-80. Gill et al. (2002) reported that watercourse improvement showed that it could achieve saving in irrigation time by 28 percent, labor saving by 50 percent, and the increase of cropping intensity by 23 percent, cropped area by 17 percent, crop yield by 16-37 percent and farm income by 20 percent.

The various benefits of precision land leveling as reported by Sattar et al. (2001) are given below.

a. Reduction in irrigation application losses up to 25 percent.
b. Saving of labor for irrigation by about 35 percent.
c. Increase in the irrigated area by 2 percent due to bringing the field ditches under cultivation.
d. Increase in crop yields by about 20 percent.

Adoption of improved water management practices is an important element of conservation agricultural practices. Following are the technologies used for this purpose.

Zero tillage technology

Gill et al. (2002) reported that a survey was conducted to evaluate farmers' experiences with zero tillage technology. Total wheat farms selected were 98 with an area of 1326 ha. The results showed that there was a 14.8 percent increase in wheat yield over conventional method, and a saving of 81 percent in cultivation cost. The energy requirement from diesel was reduced by 81 percent, and irrigation water requirement reduced by 20 percent. The authors argued that if the technique was adopted in the rice-wheat zone of the Punjab, there would be a saving of about one billion rupees to farmers, including half a billion rupees in the form of diesel fuel to Pakistan.

Groundwater management by use of sulfurous acid

Use of sulfurous acid is an innovation for the treatment of brackish water. In the Punjab, sulfurous acid treated groundwater is being pilot tested for rice, wheat and sugarcane crops. The initial result showed the following benefits:

i. Reduces pH of irrigation water and soil
ii. Decreases the sodicity of irrigation water
iii. Reduces the build up of salts in soil
iv. Improves physical condition of soil
v. Replaces sodium with calcium by activating the later
vi. Makes calcium available as nutrient
vii. Increases infiltration rate of soil

Water storage tanks

Water storage tanks have been successfully tested in rain fed areas to help the poor farm households. In mountainous areas the tubewells often have small discharges and the direct application of irrigation causes higher conveyance and application losses. The water storage tanks can increase the volume of flow through the timely release of water. OFWM has observed and reported the following benefits from 156 water storage tanks constructed in the rain fed areas:

i. An increase in the reliability of irrigation water
ii. A decrease in the conveyance and application losses
iii. Use of small turbine pumps, dug wells, and natural spring for irrigation purposes

Rainwater harvesting

The term rainwater harvesting refers to a number of activities including the reception of rainfall, proper infiltration in the field, control over flow from the fields, and finally, safe disposal to the rivers. The annual rainfall in rain fed areas is enough but the precipitation is concentrated in the monsoon season. The rainwater could be conserved to improve the moisture condition of soil as well as to check the run-off by using the deep ploughing. OFWM reported the following benefits of rainwater harvesting:

i. Control over soil erosion
ii. Water control by using pipes outlets/Nakkas with cemented structure
iii. Conservation of moisture by increased infiltration
iv. Improvement in fertility level of soils
v. Tree cultivation of waste lands
vi. Crop production increase by 70 percent
vii. Conversion of eroded gullies into productive fields
viii. Possibility to grow horticultural crops, especially fruit trees
ix. Possibility of raising livestock, dairies, poultry, bee keeping due to crops and water availability.

Lessons Learned/Policy Implications

- In the past, both hardware and soft ware types of interventions took place in the irrigated areas of Pakistan. These interventions were having varying degree of impact on the poor farmers.

- The SCARPs programs were thought to be beneficial in eliminating water logging, controlling salinity and for providing additional irrigation water to increase cropping intensities and yield. The program was neutral to scale in nature. In the future if any intervention is required it should be either neutral to scale or pro-poor.

- SCARPs were ended due to high power tariffs, rapid depreciation of tube wells and high cost of O&M that caused high and unsustainable financial burden for the public sector. For a successful program, community participation is very essential.

- Various innovations took place in irrigated areas of Pakistan, including bed and furrow irrigation methods, skimming wells technique and resource conservation technologies etc. The innovations could be replicated in those areas with similar conditions to where these innovations proved fruitful.

References

Jehangir, W. A.; and M. Mudasser. 1998**.** *Participatory Irrigation Management and its Financial Viability (A case study of Hakra 4-R Distributary*). Paper presented in Workshop on Developing Guidelines for Technology Transfer/Farmers Participation in Irrigation and Drainage and Associated Rural Development, sponsored by International Waterlogging and Salinity Research Institute (IWASRI) and Cranfield University on October 13, 1997. Publication No. 188.

Kalwij, I. M.; Z. I. Mirza; M. A. Amin; and A. Hamid. 1999. *Disseminating the Bed and Furrow Irrigation Method for Cotton Cultivation in the Hakra 4-R Distributary in Collaboration With the Water Users Federation"*. Lahore, Pakistan: International Water Management Institute.

Gill, M. A.; C. M. Ashrafi; and M. Ahmad. 2002. *Resource Conservation Technologies for Combating Drought*. Proceedings of Regional Workshop on Drought and Water Management Strategies, held from 16-18 Sept. 2002, Lahore, Pakistan.

Asghar, M. N.; M. Aslam; M. S. Shafique; and M. Ashraf. 2000. *Options for Skimming Relatively-Fresh Groundwater Lenses in the Indus Basin of Pakistan-A Review.*

Sattar, A.; A. R. Tahir; F. H. Khan. 2001. *Impact of Precision Land Leveling on Water Saving and Drainage Requirements*. Proceedings of the Second National Seminar on "Drainage in Pakistan" held in University of Agriculture, Faisalabad on April 18-19, 2001.

ACE-Associate Consultant Engineers (Pvt) Ltd. 1985. *SCARPs transition Pilot Project*, *Khanka Dogran Unit of SCARP-1*. PC-I, Performa, Government of Pakistan.

ACE-NESPAK-NDC. 1997. *Hydrogeological Studies, Final Report, Second SCARP Transition Project*. Irrigation and Power Department, Government of Punjab, Lahore.

Aslam, M. 1997. *Predicting Future Tubewell Salinity Discharges: Salinity Management Alternatives for the Rechna Doab, Punjab, Pakistan. Volume V.* Research Report No. R-21.5, Pakistan National Program, International Irrigation Management Institute, Lahore.

Government of Pakistan. 1994. *Census of Agriculture 1990*. Province Report, Economic Affair and Statistics Division, Agricultural Census Organization, Pakistan.

Government of Pakistan. 1998. *Crops, Area and Production (By Districts).* Economic Advisors' Wing, Ministry of Food Agriculture and Livestock, B-Block, Pakistan Secretariat Islamabad.

Government of Pakistan. 2002. *Economic Survey of Pakistan 2001-02*. Islamabad, Pakistan: Economic Advisors' Wing, Finance Division.

Malmberg, G. T. 1968. *Reclamation by Tubewell Drainage in the Rechna Doab and Adjacent Areas, Punjab Region, Pakistan*. USGS Water Supply Paper, 1608-O. Washington D.C.

Memon, M.; and P. Arif. 1993. *Factors Associated with SCARP Tubewells*. ISMR Symposium Proceedings, Vol VI, Lahore.

Pieri, C.; J. Dumanski; A. Hamblin; and A. Young. 1995. *Land Quality Indicators*. World Bank, Discussion Paper No. 315.Washington, DC.

PPSGDP-Punjab Private Sector Groundwater Development Project Consultants. 1998. *Guidelines for the modification of STWs as CTWs in PPSGDP*. Technical Report No. 28. Project Management Unit, Planning and Development Department, Government of Pakistan.

Rehman, G.; H. Zia; and H. Hussain. 1997. *Salinity Management Alternatives in the Rechna Doab, Punjab, Pakistan*. IIMI-Pakistan Research Report No. 21, Vol. 2, 1997. IIMI-Pakistan, 12 km Multan Road, Lahore, Pakistan.

WAPDA. 1979. *Revised Action Plan for Irrigated Agriculture*. Main Report, Vol. 1, Master Planning and Review Division, WAPDA, Lahore.

Part—3

Poverty in Irrigation Systems : An Analysis for Strategic Interventions

1. Introduction
2. Study Settings, Data and Sample Characteristics
3. Poverty in Irrigated Agriculture : Spatial Dimension
4. Determinants of Poverty in Irrigated Agriculture
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Appendix - I
Appendix - II
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Poverty in Irrigation Systems:
An Analysis of Strategic Interventions

1. INTRODUCTION

As explained in part one of the report, the overall goal of the study is to promote and catalyze equitable economic growth in rural areas through pro-poor irrigation interventions. The immediate objective is to determine what could realistically be done to improve the returns to poor farm households in the low-productivity irrigated areas. The study focused on selected representative irrigation systems in Chaj Doab, Rechna Doab and Hakra area and their peripheries in Punjab, Pakistan, with a large number of people under persistent poverty. The emphasis is on identifying and assessing a set of appropriate economic, financial, institutional and technical interventions at field and system levels, and changes in overall policy and institutional framework as far as they affect access to water resources and the productivity levels of the poor. The study is based on primary data the collected at the system and household levels, supplemented with secondary data where necessary.

This part of the report provides details on selected study areas, data, analysis, results, findings and conclusions of the study and is divided into 10 sections. Section 1 presents details on study settings, data collection procedures, and characteristics of selected systems and sample households. Section 2 and 3 provide analyses of poverty, including spatial dimensions of poverty, characteristics of the poor and key determinants of poverty in irrigated areas. Section 4 assesses the performance of selected irrigation systems and associated impacts on poverty. Section 5 identifies key constraints to enhancing crop productivity in the studied systems. Productivity and poverty impacts of recent institutional interventions are assessed in section 6. Based on the above, section 7 presents a detailed analysis of constraints and opportunities for reducing poverty in irrigated agriculture. Last section provides a summary of key study findings, main conclusions and recommendations.

2. STUDY SETTINGS, DATA AND SAMPLE CHARACTERISTICS

Study Area

The study was conducted in sample areas of the Upper Chaj Doab (comprising Gujrat and Mandi Bahauddin Districts) irrigated by Upper Jehlum Canal (UJC), Lower Chaj Doab (comprising Sargodha District) irrigated by Lower Jehlum Canal (LJC), Rechna Doab (comprising Jhang and Toba Tek Singh Districts) irrigated by the Lower Chenab Canal (LCC) East and tail part of the Hakra irrigation system (comprising Bahawalnagar District) irrigated by the Hakra canal system (Figure 3.2.1). The total geographic area of the Chaj Doab, Rechna Doab and Hakra system is reported to be 1.2 Mha, 2.98 Mha and 20,000 ha, respectively. The salient features of irrigation systems in the study area are presented in the Table 3.2.1.

Table 3.2.1. Salient Features of the Selected Irrigation Systems.

System	Name of distributary	Perennial/non perennial	GCA (100 ha)	CCA (100 ha)	Length (km)	Outlets	
						Number	Discharge (cusecs)
UJC system	9-R	P*	61.9	59.5	10.24	29	39
	10-R	P	45.3	43.7	11.05	23	25
	13-R	NP**	30.4	28.7	13.81	18	26
	14-R	NP	241.6	221.8	47.94	135	193
	Kakowal	P	97.9	92.7	38.68	50	84
	Phalia	NP	299.1	269.1	75.24	152	289
LJC system	Lalian	P	486.4	444.8	59.80	195	351
	Khadir	P	520.0	474.3	89.05	166	235
LCC system	Khikhi	P	419.7	329.4	53.30	158	341
Hakra system	Hakra 4-R	P	201.9	178.5	36.08	131	189

*P=Perennial GCA = Gross cultivated area
**NP=Non-perennial CCA = Cultivated command area

Sampling

A stratified random sampling design was used to select the sample households in the study areas. At the first stage, the irrigated areas were divided into four irrigation systems listed below:

I. UJC system
II. LJC system
III. LCC system
IV. Hakra system

These systems were irrigated through Upper Jehlum Canal (UJC), Gujrat system, Lower Jehlum Canal (LJC), Lower Chenab Canal (LCC) East and Hakra 4-R, respectively. Since there were variations in irrigation systems in terms of cropping patterns and nature of perennial and non-perennial irrigation water supplies, at the second stage, distributaries were selected considering

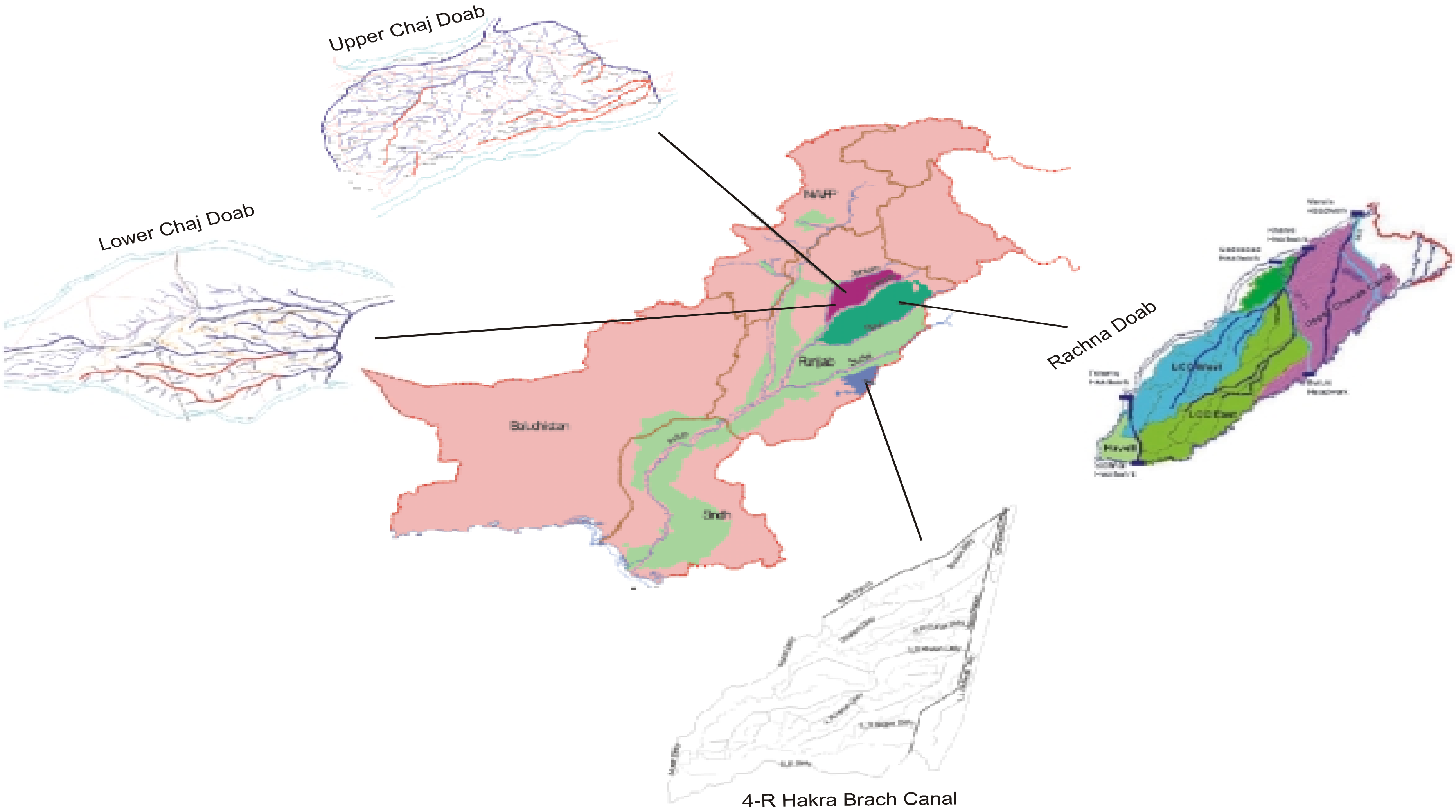


Figure 3.2.1. Location of Chaj Doab, Rechna Doab and Hakra area in Punjab, Pakistan.

the agro-ecological characteristics based on cropping patterns, nature of water supplies (perennial/non-perennial) and location of watercourses across head, middle and tail of a distributary.

According to this criteria the entire study area was divided into seven cropping zones and the following ten distributaries were selected:

1) 9-R and 10-R	characterized by rice-wheat crop rotation with perennial irrigation system located in Gujrat district;
2) 13-R and 14-R	characterized by rice-wheat crop rotation with non-perennial irrigation system located in Gujrat district;
3) Phalia	characterized by mixed-wheat crop rotation with non-perennial irrigation system located in Mandi Bahauddin district;
4) Kakowal	characterized by mixed-wheat rotation with perennial irrigation system located in Mandi Bahauddin district;
5) Lalian and Khadir	characterized by mixed-wheat rotation with perennial irrigation Khadirsystem located in Sargodha district;
6) Khikhi	characterized by mixed-wheat rotation with perennial irrigation system located in Toba Tek Singh/Jhang districts; and
7) Hakra 4-R	characterized by cotton-wheat rotation with perennial irrigation system located in Bahawalnagar district.

The areas of the selected distributaries were homogenous in terms of above characteristics. The Upper Jehlum Canal (UJC) sub-system was divided into six distributaries with two distributaries (9-R and 10-R) having rice-wheat cropping pattern with perennial irrigation supplies, and 13-R and 14-R having rice-wheat pattern with non-perennial supplies. Sugarcane, rice and wheat were the main crops grown in the command areas of Kakowal and Phalia distributaries. Irrigation supplies in these distributaries were perennial in nature. Lalian, Khadir and Khikhi had mixed wheat cropping pattern and got perennial irrigation supplies. The Hakra 4-R had cotton-wheat cropping pattern and has perennial irrigation supplies. While each distributary was fairly homogenous within its boundaries in terms of above characteristics, however, there could be intra-distributary variations especially in terms of access to water (at the head, middle and the tail) due to locational differences in the availability of water. These intra-distributary variations were captured through sampling across head, middle and tail reaches within a distributary.

At stage four, households from each of the selected watercourses were selected through systematic random sampling from a complete sampling frame for each watercourse (i.e. a list of all households on the watercourse). Landless households were drawn from the voters' list through systematic random sampling based on their proportion in total number of households on each selected watercourse. Equal allocation method was adopted for selecting watercourses across head, middle and tail reaches of the selected distributaries and the sample households across each of the selected watercourses.

Sample Size

A well-represented sample of 1224 farm households was selected for collecting data and information through a well-designed pre-tested questionnaire. In case of first 6 distributaries in Gujrat and Mandi Bahauddin, 540 households were selected along 36 watercourses located in the head, middle and the tail areas. In each of the first 6 distributaries in irrigated areas, about 90 households were selected so that an equal number (30 households) was available from each of the head, middle and tail reaches. For each of the last four distributaries (i.e. Lalian, Khadir, Khikhi and Hakra 4-R), about 171 households were selected in such a way that an equal number of households was interviewed from three watercourses from head, middle and tail reaches of the distributaries. Details of sample sizes are provided in Table 3.2.2.

Table 3.2.2. Number of watercourses and sample households in selected distributaries.

Distributaries	No. of watercourses	No. of households	Total number
9-R, Khoja Distributary	6	15	90
10-R, Dhupsari Distributary	6	15	90
13-R, Saroki Distributary	6	15	90
14-R, Maggowal Distributary	6	15	90
Phalia Distributary	6	15	90
Kakowal Distributary	6	15	90
Lalian Distributary	9	19	171
Khadir Distributary	9	19	171
Khikhi Distributary	9	19	171
Hakra 4-R Distributary	9	19	171
Total Sample	72	166	1224

Before initiating surveys, two teams of twelve members each were fully trained on various aspects of data collection. Each team consisted of ten male and two female enumerators and one field team leader. All the enumerators were well versed regarding the pros and cons of field data collection. They practiced the final questionnaire in field conditions near Lahore for pre-testing their skills as well as for necessary improvements in the questionnaire. All the primary data were organized in spreadsheet as well as in SPSS files for analysis purpose.

In addition to the questionnaire surveys, participatory rural appraisals were also conducted in selected areas. One PRA was conducted on the command area of each watercourse where 30-50 farmers and non-farmers participated. All information gathered was digitized and analyzed.

The study also used secondary data collected from PID and Farmer's Organizations. These data sets included design discharge of outlets, daily discharge data for the selected irrigation systems over the last few years at distributary heads, and official data on abiana assessment and collection.

Socio-Economic Profile of Sample Households

This section provides details on social, agricultural and economic characteristics of sample households.

Social Characteristics

Table 3.2.3 shows that average household size in the study area is about 8 members, although there is significant variation in household size across distributaries. The largest household size was reported for Khikhi Distributary as 9.8 while the lowest estimate was 6.49 for 9-R Khoja Distributary. Average number of dependents (with age less than 16 and above 60 years) for the households in the study area was 3.87. It ranged from 3.04 for Lalian Distributary to 5.42 for Khikhi Distributary. On an average, 2.07 persons per household were earning members with lower estimate of 1.66 for 9-R Khoja Distributary and higher estimate of 2.51 for Khikhi Distributary. Highest dependency ratio (defined as the ratio of family members below 16 and above 60 years to family size) was estimated as 0.52 for Phalia Distributary whereas the lowest was estimated as 0.35 for Lalian Distributary.

Average number of schooling years of household heads in the study area was 4.24. The estimate was significantly low for Phalia (1.93 years) and Khadir (2.99 years) distributaries while higher for Khikhi Distributary (5.58 years). A further decomposition showed that 48 percent of the household heads were illiterate in the study area. A higher percentage was seen in Phalia Distributary while the lowest was (32.75 percent) for Khikhi Distributary. Only 9 percent household heads in the study area had completed more than 10 years of schooling. In this category, the lowest estimate was for Phalia Distributary (2.33 percent) and the highest was for 10-R Dhup Sari (15 percent).

Table 3.2.3. Characteristics of household members in the study area.

Indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R	Total
Average household size (number)	6.49	6.71	7.06	7.52	7.37	7.48	7.92	7.84	9.8	8.28	7.87
Average number of dependents	3.53	3.57	3.79	3.74	3.97	3.84	3.04	3.11	5.42	4.31	3.87
Average number of working members	1.66	1.92	2.2	2.1	2.08	2.34	1.7	1.96	2.51	2.19	2.07
Dependency ratio (dependents /family size)	0.50	0.50	0.52	0.47	0.52	0.46	0.35	0.38	0.52	0.49	0.46
Dependency ratio (dependents/member between 16-60 years)	1.33	1.29	1.3	1.11	1.23	1.12	0.74	0.8	1.2	1.07	1.07
Education level of household head (years)	4.32	4.05	3.58	4.26	1.93	4.47	4.93	2.99	5.58	4.89	4.24
Educational status of head of household (percentage)											
No education (%)	47.78	55.17	52.81	50.00	74.42	48.86	40.36	57.74	32.75	40.00	47.97
Up to 5 years (%)	13.33	9.20	16.85	10.00	5.81	7.95	16.27	17.86	14.62	14.71	13.53
5-10 years (%)	28.89	20.69	20.22	25.56	17.44	31.82	31.93	19.64	45.03	37.65	29.46
More than 10 years (%)	10.00	14.94	10.11	14.44	2.33	11.36	11.45	4.76	7.60	7.65	9.05

Note: Dependents= Persons with age less than 16 years and above 60 years

Regarding access to different utilities, Table 3.2.4 shows that 73 percent of sample households used hand pumps (groundwater) for extraction of drinking water while additional 12 percent extracted groundwater through motor pumps. Only 11 percent of households had access to tap water. Tap water was available to households on four distributaries, mainly at Khikhi and Hakra 4-R, because the underground water was very saline and unfit for drinking purpose. Almost 83 percent of the households had access to electricity, with 47 percent at Khadir Distributary and 95 percent at 14-R Maggowal Distributary. Households at four out of 10 distributaries did not have access to fuel gas connection at home. Moreover, only 2.41 percent of sample households had home gas connection though fuel gas cylinders were available in the nearby town markets. About 42 percent of the households had toilet facility within household boundaries while 37 percent had flush system. At Khikhi Distributary, 80 percent of the households were fitted with flush system toilets while only 9 percent of the households in Khadir Distributary had access to this facility.

Table 3.2.4. Quality of housing in the study area.

Indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R	Total
Drinking Water Source (%)											
Tap water (%)	0.00	0.00	0.00	3.33	0.00	4.55	0.60	0.00	57.89	18.82	11.54
Hand pump (%)	90.00	87.36	92.13	91.11	93.02	89.77	81.33	96.43	2.92	52.94	72.37
Motor pump (%)	10.00	11.49	7.87	5.56	6.98	5.68	17.47	2.98	22.22	18.24	12.03
Other (%)	0.00	1.15	0.00	0.00	0.00	0.00	0.60	0.60	16.96	10.00	4.07
Total (%)	100	100	100	100	100	100	100	100	100	100	100
Electricity Connection (%)											
Yes	92.22	95.40	91.01	95.56	93.02	82.95	74.70	47.02	97.66	84.12	82.90
No	7.78	4.60	8.99	4.44	6.98	17.05	25.30	52.98	2.34	15.88	17.10
Home Gas facility (%)											
Yes	6.67	4.60	4.49	1.11	1.16	0.00	0.00	0.00	7.60	0.00	2.41
No	93.33	95.40	95.51	98.89	98.84	100.00	100.00	100.00	92.40	100.00	97.59
Toilet Facility											
Outside (%)	64.44	66.67	47.19	54.44	68.60	76.14	62.05	90.48	14.62	50.00	57.93
Flush (%)	27.78	26.44	37.08	35.56	23.26	17.05	37.35	8.93	79.53	48.24	36.76
Non-Flush (%)	7.78	6.90	15.73	10.00	8.14	6.82	0.60	0.60	5.85	1.76	5.31
Room Space											
Persons per Room (Average)	2.63	2.73	2.52	2.79	3.11	2.64	3.04	3.71	3.18	2.86	2.99
Up to 1 person per room (%)	15.56	14.94	14.61	12.22	3.49	10.23	7.83	6.55	2.92	6.47	8.55
1.01-2 persons per room (%)	36.67	31.03	33.71	27.78	25.58	40.91	30.12	19.05	24.56	32.35	29.21
2.01-3 persons per room (%)	22.22	29.89	32.58	27.78	31.40	23.86	25.30	25.60	33.33	33.53	28.80
More than 3 persons per room (%)	25.56	24.14	19.10	32.22	39.53	25.00	36.75	48.81	39.18	27.65	33.44
Total (%)	100	100	100	100	100	100	100	100	100	100	100.00

Availability of room space per person was a coarse but useful indicator of the affluence of a household. It was estimated that on an average, one room was available to 3 persons in the study area. Only 9 percent of the households had enough space to allocate one room per person and it varied significantly across distributaries. Only 2.92 percent of the households at Khikhi Distributary fell into this category while 15.56 percent households in 9-R Khoja Distributary enjoyed the same. On the other hand, more than three persons were sharing one room in 33 percent of the households of the study area. Almost 48 percent of the households at Khadir Distributary could spare one room for more than three persons.

Agricultural Characteristics

Land distribution varied significantly across distributaries. Average farm size of the study area was estimated at 4.68 hectares with as low as 2.49 hectares for 10-R Dhup Sari and as high as 6.54 hectares for Hakra 4-R Distributary. A significant proportion of farmers in the study area was operating less than 3 hectares of land. On an average, 50 percent of sample farmers were operating farms of more than 3 hectares with significant variation across distributaries. Overall, about 11 percent of the farmers were operating farm areas of less than 1 hectare with the highest proportion of 25 percent in 9-R Khoja Distributary and the lowest proportion of 4.48 percent in Hakra 4-R Distributary.

Irrigation water is the key agricultural production resource. It was found that around 5 percent of farmers were using canal water only for irrigation. None of the farmers solely depended on canal water in 10-R Dhup Sari, Phalia, and Kakowal Distributaries for irrigation purposes. The highest proportion of farmers fully dependent on canal irrigation water was 15 percent in Hakra 4-R Distributary. Only 12 percent of farmers were using tubewell water for irrigation purposes in the study area. It was found that majority of these farmers were located at tail reach areas. None of the farmers at Khikhi and Hakra 4-R Distributaries solely depended on groundwater indicating the poor quality of groundwater for irrigation purpose in these areas. As expected, about 83 percent of the farmers were utilizing both canal and groundwater for fulfilling their irrigation needs. This indicated that farmers were doing a few irrigations with canal and a few with tubewell water or mixed water from both sources due to the scarcity of canal water and relatively poor quality of groundwater for irrigation purposes.

Cropping intensity mainly depended on cropping pattern, operational farmland holdings and availability of surface water, though other factors like credit availability were also important. Overall, average cropping intensity was 148 percent, which was the lowest at Khadir Distributary (124 percent) and the highest at 13-R Saroki Distributary (183 percent). Figures 3.2.2. and 3.2.3 show the distribution of selected farmers according to the size of landholding and the source of irrigation used in the study area.

Table 3.2.5. Landholding and water resources distribution in the study area.

Indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R	Total
Land distribution in the sample areas											
Average farm size (ha)	2.83	2.49	3.62	3.38	4.84	3.44	4.96	5.66	5.16	6.54	4.68
Less than 1ha (%)	25.40	9.23	12.70	6.56	16.67	9.23	6.87	15.91	10.37	4.48	10.88
1.001 to 2ha (%)	20.63	27.69	12.70	21.31	14.29	21.54	16.79	17.42	19.26	12.69	17.96
2.001 to 3 ha (%)	22.22	40.00	30.16	26.23	19.05	26.15	14.50	15.15	17.78	20.90	21.44
Above 3 ha (%)	31.75	23.08	44.44	45.90	50.00	43.08	61.83	51.52	52.59	61.94	49.72
Cropping intensity (%)	151	161	183	164	170	153	138	124	137	153	148
Source of Irrigation											
Canal Irrigation (%)	6.35	0.00	4.76	4.92	0.00	0.00	3.82	5.30	0.74	14.93	4.83
Private tube well (%)	22.22	18.46	31.75	21.31	19.05	20.00	1.53	18.94	0.00	0.00	12.01
Canal and private tube well (%)	66.67	81.54	63.49	73.77	78.57	78.46	94.66	75.76	99.26	85.07	82.60
Others (%)	4.76	0.00	0.00	0.00	2.38	1.54	0.00	0.00	0.00	0.00	0.56

Note: Average farm size = Land owned + land rented in-land rented out

Figure 3.2.2. Distribution of farmers according to landholdings across selected distributaries in the study area.

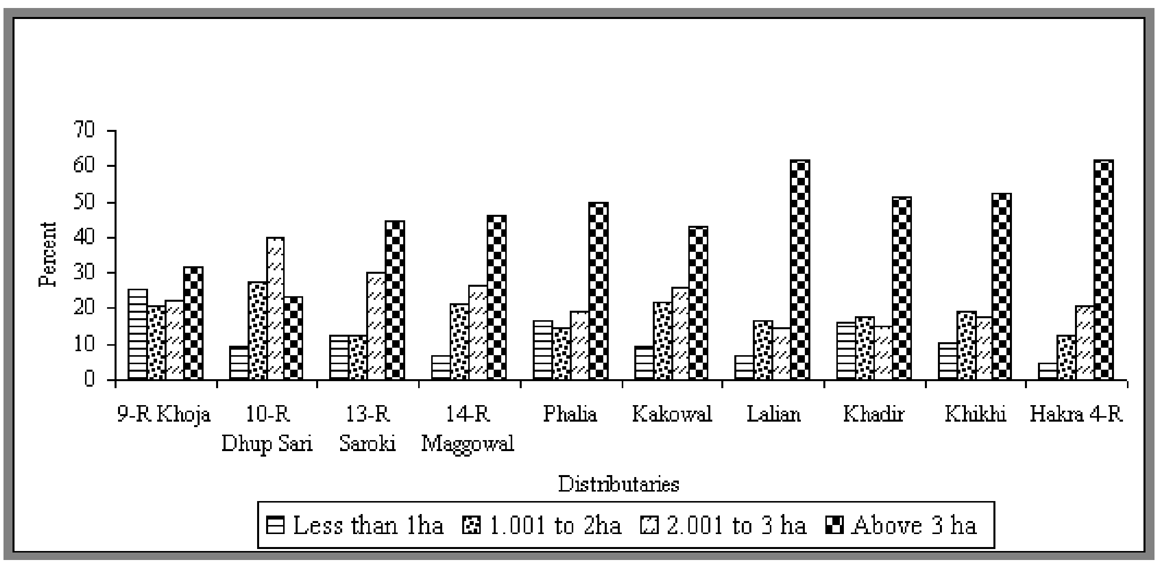


Figure 3.2.3. Distribution of farmers according to source of irrigation in selected households across selected distributaries in the study area.

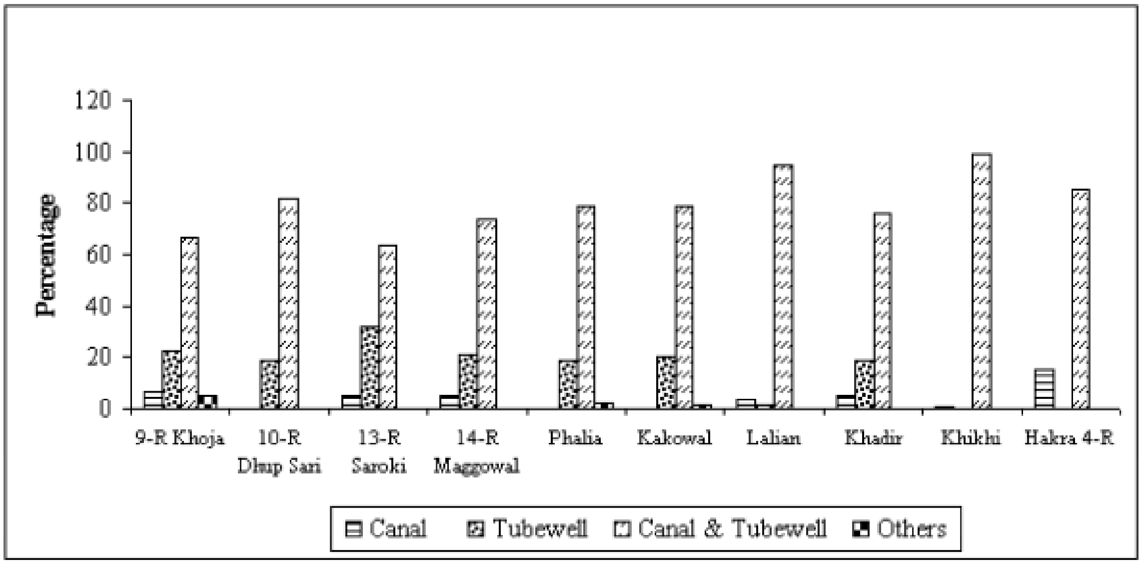


Table 3.2.6 shows that the average gross value of production (GVP) per hectare for major[1] crops in the study area was Rs. 21370. However, there was significant variation in GVP across distributaries, with the lowest value of Rs.11083 for 9-R Khoja Distributary and the highest value of Rs. 31986, for Khikhi Distributary. Average cost of production per hectare for major crops was Rs. 13086 with as low as Rs.7191 for 9-R Khoja Distributary and as high as Rs. 21838 for Hakra 4-R Distributary. Average gross margins per hectare was Rs. 8284 for the study area.

[1] Major crops stands for Wheat, Rice and Cotton, and Sugarcane

Table 3.2.6. Agricultural productivity and profitability in the study area.

Indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R	Total
Productivity (Averages)											
Sugarcane cultivated area (ha)	1.06	0.23		1.15	1.48	0.68	1.38	1.39	0.48	0.83	1.12
Sugarcane productivity (kg/ha)	26687	38776		26681	29100	15073	38952	37588	39790	28717	34581
Wheat cultivated area (ha)	1.8	1.52	2.21	1.94	2.36	1.63	2.5	2.48	3.3	4.02	2.61
Wheat productivity (kg/ha)	1822	2342	2493	2785	2588	2582	2881	2550	3471	2054	2611
Rice cultivated area (ha)	1.72	1.53	2.78	1.59	2.8	1.44	0.42	0.97	0.2	0.51	1.78
Rice productivity (kg/ha)	1435	1348	2778	1648	3278	1361	2535	2509	1779	2298	2028
Cotton cultivated area (ha)	-	-	-	-	-	-	0.61	2.83	2.31	4.01	3.14
Cotton productivity (kg/ha)	-	-	-	-	-	-	366	0	1033	889	927
Profitability (Rs/ha)											
Gross value of production for major crops	11083	13623	14393	15839	14129	15113	23461	21236	31986	28772	21370
Total cost of production for major crops*	7191	8063	7298	8755	7901	8652	11612	11708	20852	21838	13086
Gross value of production for all crops	15204	22699	32763	26936	25526	19106	21156	16600	25667	19695	21909
Total costs of Production for all crops	10163	14796	17401	16524	15598	13790	11698	10783	17660	15820	14273
Gross margin for all crops	5041	7903	15362	10412	9928	5316	9458	5817	8007	3875	7636

* Major crops are wheat, rice, cotton and sugarcane.

Table 3.2.7 indicates that overall, 27 percent of the farm households indicated that their major agricultural problem was water shortage. About 18 percent of farmers reported that expensive farm inputs were the second major problem faced by them. Another problem that is directly associated with high input cost was adulteration in farm inputs as was reported by 17 percent of the farmers. This was of high concern in four out of 10 distributaries and more specifically in Khikhi Distributary and Hakra 4-R Distributary areas. Lack of irrigation infrastructure/poor infrastructure, high diesel prices, and unavailability of inputs were other major problems faced by the farmers.

Table 3.2.7. Major problems faced by farmers (%).

	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R	Total
Water shortage	27.01	24.77	25.50	20.94	25.00	22.18	29.61	30.77	28.33	31.23	27.50
Expensive farm inputs	18.01	17.43	18.50	20.09	15.71	16.13	15.72	18.51	18.03	20.58	17.98
Other [2]agricultural problems	26.54	33.49	33.00	29.49	40.00	33.06	5.69	8.41	5.15	4.60	16.94
Low quality of farm inputs	0.00	0.00	0.00	0.00	0.00	0.00	9.11	6.97	22.75	27.60	9.66
Lack of irrigation infrastructure/ Poor infrastructure	16.11	7.80	6.00	8.97	5.00	7.66	12.30	7.69	4.29	2.91	7.60
High price of diesel/ electricity	0.00	0.00	0.00	0.00	0.00	0.00	12.76	18.75	8.58	5.33	6.56
Unavailability of farm inputs	3.32	3.67	5.50	6.41	4.29	6.45	4.10	1.92	4.94	2.91	4.15
Low output price/ delayed payment of output	2.37	3.67	3.50	4.27	5.00	4.84	5.24	4.33	4.08	2.18	3.94
Lack of credit	3.79	3.21	3.50	4.70	3.57	4.84	1.82	1.92	1.72	1.45	2.69
Salinity and waterlogging	2.84	5.96	4.50	5.13	1.43	4.84	1.82	0.48	1.29	0.97	2.50
Groundwater problem	0.00	0.00	0.00	0.00	0.00	0.00	1.82	0.00	0.86	0.00	0.41

Economic Characteristics

Generally, two-thirds of the household heads were primarily engaged in agriculture sector as shown by Table 4.8. However, there was significant variation across distributaries. Agriucltural laborers/workers comprised 7.47 percent of household heads. About 7 percent of the household heads were engaged in non-agricultural business/enterprises while only 2.4 percent were in the services sector and about 5 percent of the household heads were living in retirement. In addition to their primary job, 16 percent of household heads were engaged in secondary jobs for earning additional income; of these about 5.5 percent were employed in the agriculture sector as farmers or agricultural worker/laborer and 8 percent were engaged in non-business/enterprises and service sectors.

[2] Drainage problem; damage by pests, animals, and disease, weeds; labor shortage; lack of farm roads, storage facilities; low yield of crop; difficult leveling of field; lack of drying facility for paddy, rice, and load shedding of electricity.

Table 3.2.8. Sources of employment with respect to head of household.

Percentage	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R	Total
Primary employment of household head											
Agriculture (%)	45.56	56.32	58.43	54.44	38.37	59.09	78.92	78.57	78.95	78.82	67.05
Agriculture worker / labor (%)	3.33	1.15	2.25	6.67	12.79	4.55	8.43	13.69	5.26	10.00	7.47
Non-agricultural business/entrepreneurship (%)	18.89	11.49	5.62	7.78	9.30	7.95	6.63	2.98	7.60	3.53	7.39
Services (%)	2.22	5.75	5.62	4.44	2.33	1.14	0.60	1.19	1.17	2.94	2.41
Others[3] (%)	17.78	13.79	17.98	16.67	25.58	17.05	5.42	3.57	7.02	4.71	10.87
No Job (%)	12.22	11.49	10.11	10.00	11.63	10.23	0.00	0.00	0.00	0.00	4.81
Secondary employment of household head											
Agriculture (%)	6.67	3.45	0.00	2.22	0.00	3.41	0.00	0.00	0.00	0.00	1.16
agriculture worker / labor (%)	3.33	3.45	4.49	0.00	0.00	1.14	7.83	9.52	4.09	3.53	4.40
Non-agricultural business/entrepreneurship (%)	3.33	1.15	2.25	2.22	2.33	0.00	7.23	9.52	9.36	10.00	5.89
Services (%)	2.22	0.00	0.00	1.11	0.00	2.27	1.20	3.57	4.68	3.53	2.24
Others (%)	6.67	1.15	0.00	2.22	8.14	4.55	0.60	2.98	0.00	0.00	2.16
No job (%)	77.78	90.80	93.26	92.22	89.53	88.64	83.13	74.40	81.87	82.94	84.15

Table 3.2.9 shows that average annual income (crop income + non crop income + livestock income + Income from agricultural assets) of households was around Rs. 79000 with significant variation across distributaries. Highest average annual income was about Rs. 100000 estimated for households at Khikhi Distributary while the lowest was Rs. 54400 for households at Kakowal Distributary. Further decomposition of annual income showed that average proportion of crop income (net crop income (all crops) + land rent received - land rent paid + share of income from shared out land - share of income for shared in land) was 32 percent for the study area, with the highest of 47 percent for Lalian Distributary and the lowest of 14 percent for households at 9-R Khoja Distributary. Overall, income from sale of animals (Income from selling animals - the cost of buying animals) comprised about 5.5 percent of annual income for sample households with a range of –0.6 percent at Phalia Distributary to 8 percent at 14-R Maggowal Distributary. Negative livestock income indicated more animal purchases than sales during the study period. Around 60 percent of the household income comprised non-crop income (income from artisan + repair work + other enterprises + interest from household savings + pensions + remittances from relatives inside the country + remittances from outside the country + gifts/transfer payments + animal products + poultry products + fish + lottery + other non crop items + handicrafts + salaries + others) though this proportion varied significantly across distributaries. It ranged from as low as 45 percent for Lalian Distributary to as high as 84 percent for 9-R Khoja Distributary. Overall, 18 percent of the annual income was from remittances from relative/family members within country or abroad. About 12 percent of annual income was offered by the foreign links of the households, with 0.6 percent for households at Khadir Distributary and 40 percent at 9-R Khoja Distributary.

[3] Includes Housekeeping, other personal services, Begging, and schooling

Average total value of agricultural assets was Rs. 50000 for the study area, with the lowest value of Rs. 16500 for households at 9-R Khoja Distributary and the highest of Rs. 73500 at Hakra 4-R Distributary. Average annual income of landless households was Rs. 41500 while that of owner cum tenant households was Rs.106000. Average annual income of landowners and owner cum tenant farmers was around 20 percent higher than overall average annual income (Rs.79108) of all households. The situation was reverse for landless households and tenants whose average annual income was around 52 percent and 57 percent less than the overall average annual income. This clearly indicated that a significant effect on average annual incomes was due to variation in agricultural land ownership. Figure 3.2.4 shows the different sources of income with their proportional share in annual income of households in the study area. Moreover, Figure 3.2.5 shows the average annual income of selected households according to tenancy status in the study area.

Table 3.2.9. Sources of household income across selected distributaries.

	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R	Total
Income											
Annual crop income (ave.)	8011	13215	35147	21821	26700	10852	42050	30912	29803	21125	25788
annual non-crop income (ave.)	48504	47759	50319	40917	40936	39792	40202	37798	64805	55200	47463
Income from selling of animals(ave.)	857	1039	4483	5601	-420	2815	5613	8251	3248	6271	4333
Annual income (ave.)	57722	62235	90513	70412	68731	54396	89670	77545	100394	85556	79108
Annual crop income (%)	13.88	21.23	38.83	30.99	38.85	19.95	46.89	39.86	29.69	24.69	32.60
Annual non-crop income (%)	84.03	76.74	55.59	58.11	59.56	73.15	44.83	48.74	64.55	64.52	60.00
Income from selling of animals (%)	1.48	1.67	4.95	7.95	-0.61	5.17	6.26	10.64	3.23	7.33	5.48
Annual income (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100
In country remittances (% of annual income)	5.64	8.52	9.17	5.15	0.93	5.30	3.51	0.91	11.16	4.67	5.63
Out country remittances (% of annual Income)	39.88	21.83	11.23	13.11	15.85	23.96	1.98	0.60	13.81	12.97	12.28
Annual income (Rs.)											
Landless	38247	41470	52305	52349	36475	31974	37188	35329	58079	33061	41475
Landowners	78953	71552	103687	81518	87007	56826	103850	138749	113501	118518	98479
Tenants	42159	25651	46850		-1890	-36801	61357	40016	69192	20659	45209
Owner cum tenant	34966	67992	138717	76223	284783	106938	124604	64918	128087	101245	105752
Total value of agricultural Assets (ave.)	16519	25566	48676	64197	37667	36774	56337	42087	66645	73521	50302

Figure 3.2.4. Sources of income and their share in annual income across distributaries in the study area.

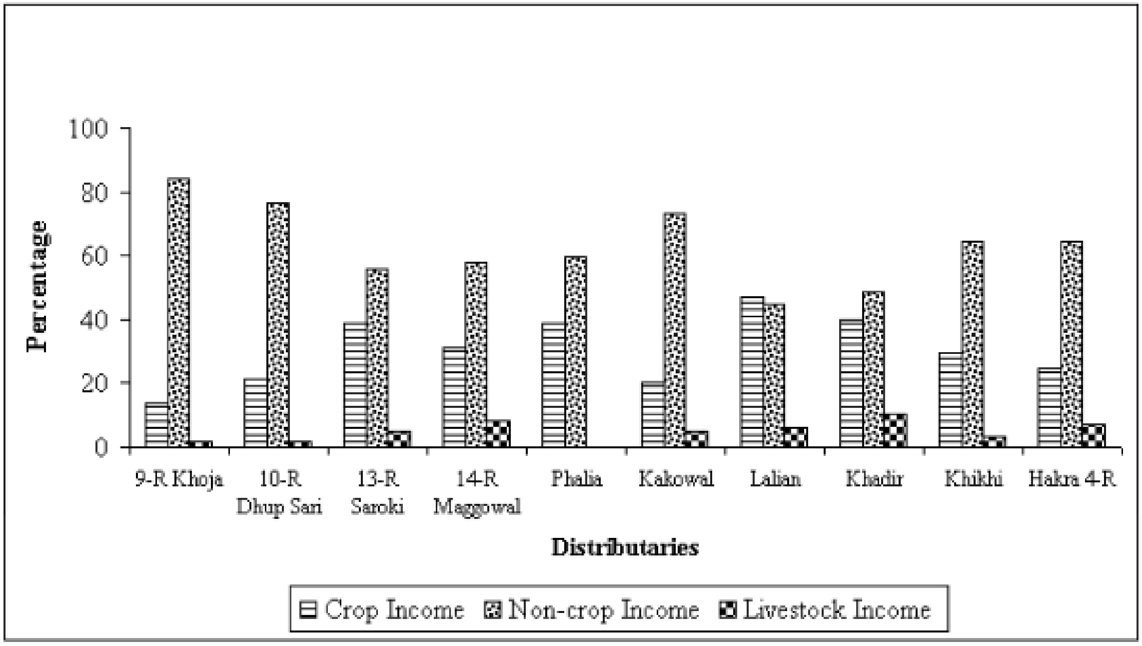
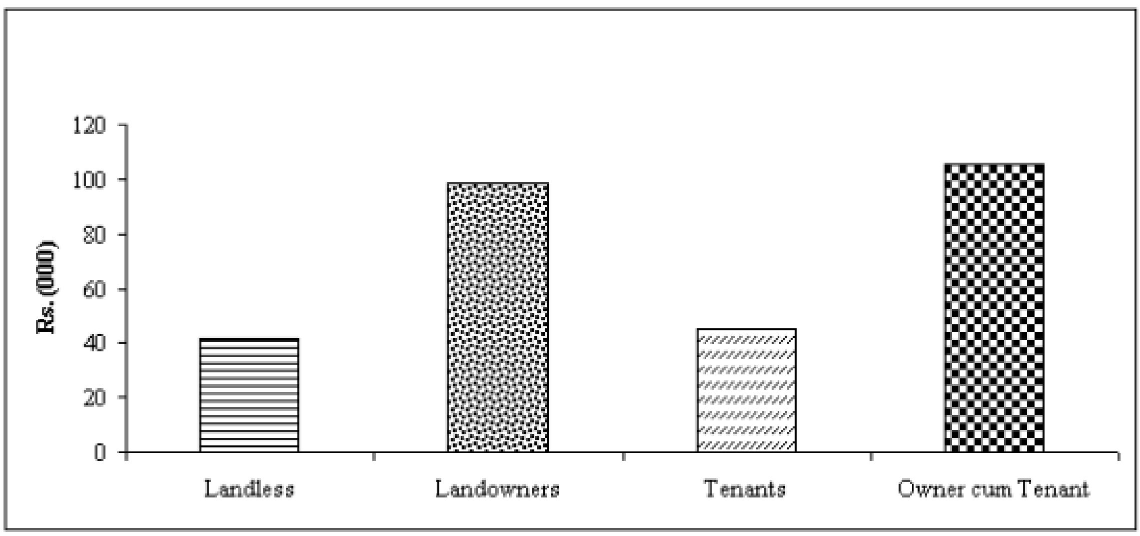


Figure 3.2.5. Average annual income according to tenancy status for selected households in the study area.



Average annual food expenditure was estimated at Rs.23000 per household (Table 3.2.10), with the lowest estimate of Rs.16500 for households at Khadir Distributary and the highest of Rs. 27000 for 9-R Khoja Distributary. On an average, a household was spending around 40 percent of its total expenditure on various food items. Average per capita income of the households in the study area was estimated at Rs.11218. It was found that per capita income at five out of 10 distributaries was less than overall average with the lowest estimate for Kakowal Distributary (Rs. 8293) and the highest of Rs. 13900 for 13-R Saroki Distributary. Average per capita expenditures was Rs. 9990 while estimates for four out of 10 distributaries were less than the overall average of the sample population. The highest estimate was Rs. 13618 for 9-R Khoja Distributary and the lowest was for Hakra 4-R Distributary. At 5 out of 10 distributaries, average per capita expenditure was higher than average per capita income. Average total credit borrowed per household was about Rs. 30433 and two third of this was borrowed from non-institutional sources while one-third was from institutional sources. For all those distributaries where per capita expenditure was higher than per capita income, the amount of credit borrowed was also greater than for other distributaries.

Table 3.2.10. Annual expenditure of household and sources of borrowing in the study area.

Indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R	Total
Average annual food expenditures (Rs.)	27029	23348	24285	24533	25634	26535	22006	16534	25560	19350	22792
Ratio of food to total expenditures	0.40	0.38	0.37	0.37	0.39	0.40	0.43	0.41	0.45	0.43	0.41
Annual expenditures	74165	70923	73903	77162	74310	71819	67217	53087	71502	57525	67353
Per capita annual expenses (Rs.)	13618	11970	11602	11371	11664	11136	9526	8482	8409	7577	9990
Per capita food expenses (Rs.)	4860	3823	3687	3554	3931	3939	3081	2397	2856	2652	3283
Per capita annual income (Rs.)	11663	10055	13898	10148	9631	8293	12216	11942	11594	10990	11218
Credit											
Institutional credits (Rs.)	1833	16862	6955	11378	20967	10184	12006	7817	4820	11341	9986
Non-institutional credits (Rs.)	30563	21621	38005	31396	20951	31271	10937	11372	20556	11791	20447
Total credit (Rs.)	32397	38483	44960	42774	41919	41455	22943	19189	25376	23133	30433

3. POVERTY IN IRRIGATED AGRICULTURE: SPATIAL DIMENSIONS

Introduction

Monetary measures of poverty were estimated for each of the ten distributaries spread over five different districts of Punjab, representing different physical, hydrological, agricultural, socio-economic and institutional characteristics. Poverty headcount, poverty gap and squared poverty gap estimates were used in order to analyze the current status, depth and the severity of poverty. Two different poverty lines were used in estimating poverty indices, i.e. Rs.730 per capita per month (PL-I) and Rs.530 per capita per month (PL-II). Poverty estimates were computed on the basis of household expenditure instead of income due to the generally accepted opinion that expenditure is a better reflector of the household financial and economic position than income. The household expenditure approach is also used to bypass the under-reporting problem of income, which raises more concerns than exaggeration in reporting expenditures.

Head Count Index

The head count index provides an estimate of the number of people living below the poverty line and measures the incidence of poverty. The poverty lines based on Basic Needs Approach was used in this study. The poverty line-I was adapted from Qureshi and Arif (1999). A poverty line of Rs. 730 per capita per month expenditure (PL-I) was used primarily for computation of poverty indices while a second poverty line of Rs. 530 per capita per month expenditure (PL-II) was employed for sensitivity analysis. Estimates of three poverty indices for each irrigation system are presented in Table 3.3.1.

The head count index based on poverty line I shows that about 59 percent of the sample households were living below the poverty line. The highest proportion of poor households was in Hakra 4-R system (Bahawalnagar District) while the lowest was in the command area of upper Jhelum Canal in Gujrat District. Similarly, the highest incidence of poverty across distributaries was estimated (77 percent) for Khadir Distributary while the lowest count (40 percent) was for 10-R Dhup Sari Distributary.

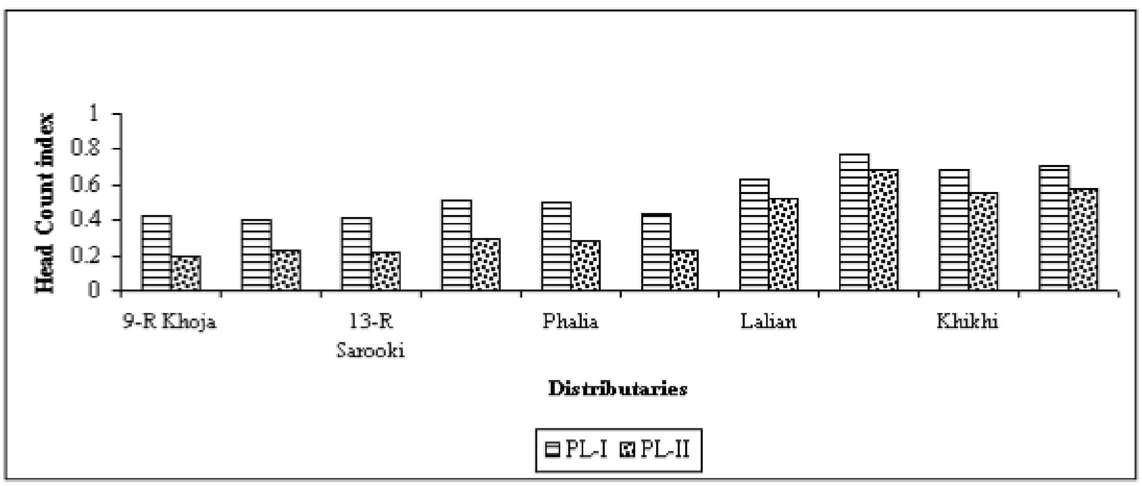
Sensitivity analyses show that at lower poverty line (PL-II), 43 percent of the households were poor indicating a sharp decrease of 16 percent in total poor households from PL-I estimates. These estimates indicate that about 43 percent of the households were chronically poor whereas about 16 percent were on the verge of poverty line waiting for a productive push up to become non-poor. However, the highest proportion of the poor (60 percent) was estimated for Sargodha District because of the absolutely poor supply of canal water at the tail areas and the availability of less off-farm employment opportunities as shown in Table 3.2.8. The lowest proportion (21.5 percent) was found for Gujrat District where there was relatively less inequality in land distribution (Table 3.2.5) and greater inflow of remittances (Table 3.2.9). Similarly, the highest level of poverty was estimated (69 percent) for Khadir Distributary because of poor infrastructure and high proportion of non-farmers while the lowest poverty was estimated (20 percent) for 9-R Khoja Distributary due to relatively smaller household size and dependency ratio

(Table 3.2.3). The comparison of the head count poverty indices across all selected distributaries is shown in Figure 3.3.1. These results were consistent with other studies. Ahmad (1998) reported 47 percent poverty in 1992-93 and 50 percent in 1995-96 in Punjab, by using basic needs poverty approach. Similarly, Bhatti et al. (1999) also reported 50 percent of population as below poverty line.

Table 3.3.1. Estimates of poverty head count –indices based on annual expenditure.

		PL-I = Rs. 730 per capita per month		PL-II = Rs. 530 per capita per month	
District	Distributary	Non poor	Poor	Non poor	Poor
Gujrat	9-R Khoja	0.578	0.422	0.800	0.200
	10-R Dhup Sari	0.598	0.402	0.770	0.230
	Group total	0.588	0.412	0.785	0.215
M.B. Din	13-R Saroki	0.584	0.416	0.787	0.213
	14-R Maggowal	0.489	0.511	0.711	0.289
	Phalia	0.500	0.500	0.721	0.279
	Kakowal	0.568	0.432	0.773	0.227
	Group total	0.535	0.465	0.748	0.252
Sargodha	Lalian	0.367	0.633	0.482	0.518
	Khadir	0.226	0.774	0.315	0.685
	Group total	0.296	0.704	0.398	0.602
Toba Tek Singh	Khikhi	0.310	0.690	0.450	0.550
Bahawalnagar	Hakra 4-R	0.294	0.706	0.424	0.576
All cases		0.411	0.589	0.568	0.432

Figure 3.3.1. Head count poverty across households in sample distributaries using PL-I and PL-II.



Poverty Gap and Squared Poverty Gap

Table 3.3.2 shows estimates of poverty gap based on PL-I, the overall poverty gap was estimated at 42 percent indicating that poor households needed an additional 42 percent of the present expenditures to attain minimum basket of basic needs. Comparison of districts shows that the depth of poverty was lowest for Mandi Bahauddin (28.9 percent) while slightly higher estimate for Gujrat District (29.3 percent). Depth of poverty estimated was 17, 19.4, and 19.6 percent higher in Toba Tek Singh, Sargodha and Bahawalnagar districts than Mandi Bahauddin district, respectively.

Table 3.3.2. Estimates of poverty gap and squared poverty gap-based on annual expenditure.

		PL-I = Rs. 730 per capita per month		PL-II = Rs. 530 per capita per month	
District	Distributary	Poverty gap	Squared poverty gap	Poverty Gap	Squared poverty gap
Gujrat	9-R Khoja	0.281	0.108	0.225	0.069
	10-R Dhup Sari	0.307	0.122	0.213	0.063
	Group total	0.293	0.115	0.219	0.066
M.B. Din	13-R Saroki	0.270	0.099	0.179	0.050
	14-R Maggowal	0.291	0.115	0.203	0.058
	Phalia	0.285	0.110	0.194	0.057
	Kakowal	0.307	0.129	0.246	0.089
	Group total	0.289	0.113	0.205	0.063
Sargodha	Lalian	0.457	0.248	0.347	0.159
	Khadir	0.504	0.286	0.377	0.179
	Group total	0.483	0.269	0.364	0.171
Toba Tek Singh	Khikhi	0.459	0.247	0.357	0.161
Bahawalnagar	Hakra 4-R	0.485	0.276	0.387	0.192
All cases		0.415	0.215	0.329	0.147

Poverty gap squared estimates indicated the highest depth of poverty for Khadir Distributary (28.6 percent) and the lowest (9.9 percent) for 13-R Saroki Distributary. Severity of poverty was almost same for Gujrat and Mandi Bahauddin districts with estimates of 11.5 and 11.3 percent, respectively (for reasons of similar dependence on off farm income and almost similar employment opportunities) as shown in Table 3.3.2. Estimated poverty gaps for Sargodha, Toba Tek Singh and Bahawalnagar districts were 26.9, 24.7, and 27.6 percent, respectively, showing significant variation across districts mainly because of bad quality groundwater and less off farm income in these areas as compared with the situation in Gujrat and Mandi Bahauddin districts (Table 3.2.8).

At PL-II, the highest poverty gap of 38.7 percent was estimated for Bahawalnagar District while the lowest gap of 20.5 percent was for Mandi Bahauddin District. Poverty gap was lower for distributaries in Mandi Bahauddin, where it ranged between 17.9 percent for 3-R Saroki Distributary and 24.6 percent for Kakowal Distributary. On the other hand, the use of PL-II showed that the poverty gap was the highest (38.7 percent) for Hakra 4-R Distributary, which was 20.8 percent higher than that for 13-R Saroki Distributary.

Comparison of poverty gap by using line-I and II indicated that poverty gap estimates decreased more for distributaries in Sargodha District (11.9 percent) than for other areas where the decline was estimated as 7.4 percent for Gujrat District. The decrease inpoverty gap in Sargodha District was because of the greater number of non-farmers and poor infrastructure whereas in Gujrat District the households were relatively better off due to off farm income and employment opportunities. Across distributaries, the highest decline was observed for Khadir Distributary which was 12.7 percent because of greater concentration of land ownership and increased dependence on farm employment while lowest (5.6 percent) was for 9-R Khoja Distributary due to greater non-farm income. The overall decrease in poverty gap was estimated at 8.6 percent (Table 3.3.5).

At PL-I, the lowest estimate of squared poverty gap of 11.3 percent was computed for Mandi Bahauddin District while the highest was estimated for Bahawalnagar District (27.6 percent) showing a relatively high severity of poverty in Bahawalnagar District. The severity of poverty (squared poverty gap) was found highest for Hakra 4-R Distributary owing to poor quality groundwater, less canal water availability and poor harvest of the cotton crop in the area while the lowest was estimated at 9.9 percent for 13-R Saroki Distributary due to high income rice-wheat cropping pattern and good employment opportunities in the area. Using PL-II, the highest severity of poverty was found at19.2 percent for households at Hakra 4-R Distributary while the lowest (5 percent) was estimated for 13-R Saroki Distributary. At district level, the highest squared poverty gap was estimated for Bahwalnagar District (19.2 percent) whereas the lowest (6.3 percent) was for Mandi Bahauddin District.

The difference of squared poverty gap estimated by using PL-I and PL-II showed the decline in the severity of poverty across districts using different poverty lines. The highest decline in the severity of poverty estimates was 9.8 percent observed for Sargodha District. On the other hand, the lowest decline in squared poverty gap estimates was 5.9 percent for Gujrat District. Similarly, at the distributary level, the highest decline in the severity of poverty was estimated at 10.7 percent for Khadir Distributary while the lowest of 3.9 percent, for 9-R Khoja Distributary. Overall decline in the severity of poverty was 6.8 percent for all the sample households in the study area. The change in poverty gap and squared poverty gap across distributaries, using both poverty lines, is shown in Figure 3.3.2 and Figure 3.3.3, respectively.

Figure 3.3.2. Poverty gap across households in sample distributaries using PL-I and PL-II.

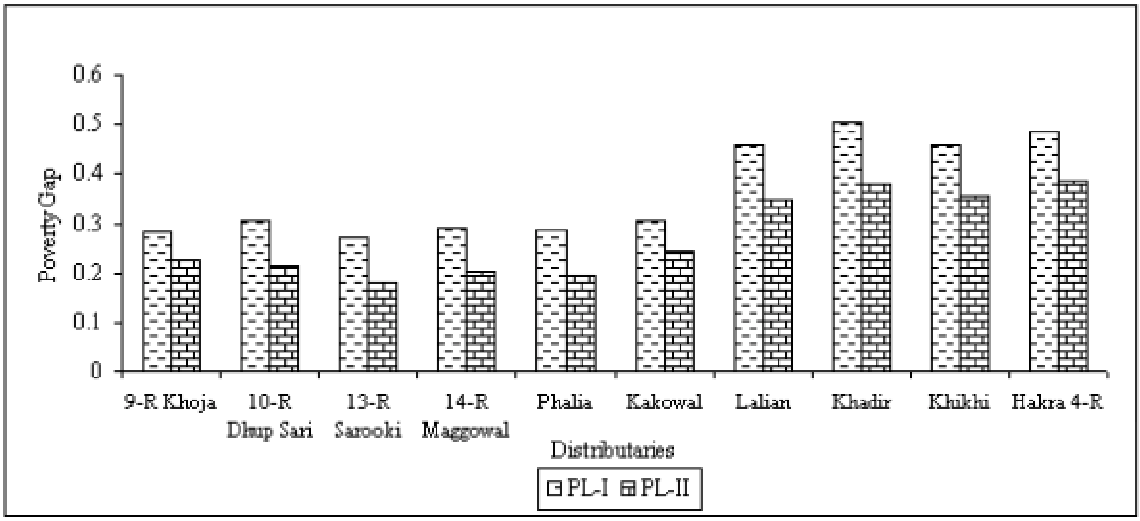
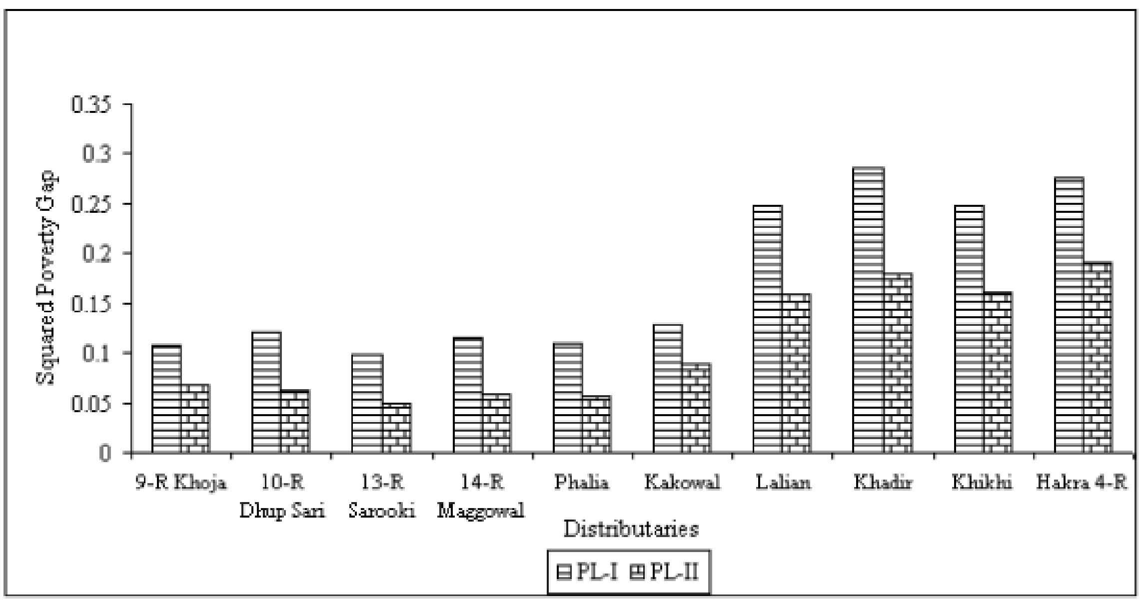


Figure 3.3.3. Squared poverty gap across households in sample distributaries using PL-I and PL-II.



Spatial Dimensions of Poverty across Irrigation Systems

It is important to analyze various dimensions of poverty across different irrigation systems and reaches in order to develop in the depth understanding of why poverty is high in command areas and reaches of some distributaries but lesser in others. As the incomes of rural farm households are directly dependent on efficiency and reliability with which surface water is supplied by the irrigation systems, poverty was expected to vary across reaches (head, middle and tail reaches) of the irrigation systems.

Table 3.3.3 indicates that by using poverty line-I, an overall comparison of poverty incidence across different reaches of the distributaries revealed that the lowest number of poor households were in the middle reach of the distributaries while the highest head count poverty estimates were for households living in the head reach of the distributaries for reasons of high dependency ratio, less non-farm income and less groundwater extraction in the area. The overall incidence of poverty at distributary level was estimated as 55, 58.9 and 62.9 percent for middle, tail and head reach areas. Higher incidence of poverty at the head reach was due to high dependency ratio when compared with the middle and tail reach areas. At the head reach, the highest poverty incidence is shown at Khikhi and Khadir Distributaries where 81 and 77 percent of the households were poor, respectively. In Khadir Distributary, expensive groundwater extraction, shortage of canal water and in Khikhi Distributary, heavy dependence on canal water and poor quality groundwater are the main reasons for higher poverty at head reaches, respectively. At the head reaches, the lowest number of poor households was 37 percent estimated for Kakowal Distributary, which may be attributed to canal water theft and the ability of big farmers to extract good quality groundwater. Moreover, incidence of poverty was higher for 5 distributaries (Phalia, Lalian, Khadir, Khikhi and Hakra 4-R) than the overall poverty incidence of 63 percent.

In the middle reach area, the highest incidence of poverty was 70.2 percent, again for Khadir Distributary, mainly due to sandy soils, lack of off-farm employment, severe shortage of canal water and inequality in land distribution while the lowest was 37 percent for 14-R Maggowal Distributary. Additionally, head count poverty estimates were higher for four distributaries than the overall estimate of 55 percent. For the tail reaches, the highest head count poverty estimate was 86 percent for Khadir Distributary while the lowest was 27 percent for 10-R Dhup Sari Distributary for the reasons of equity in landholdings, good quality groundwater and better methods of cultivation. However, the head count poverty estimate was higher for 4 distributaries (13-R Saroki, Kakowal, Khadir and Hakra 4-R) than the overall estimate of 55 percent in the middle reach areas.

By using PL-II, it was found that the overall incidence of poverty was the lowest (39.6 percent) at the middle reach while it was 45 percent for both head and tail reach areas. At the head reach, the highest poverty incidence was estimated at 68 percent for Khadir Distributary while the lowest (16.7 percent) was for 13-R Saroki Distributary. At the middle reach, the lowest incidence of poverty was estimated at 20.7 percent for 9-R Khoja Distributary while the highest was 58 percent for Khadir Distributary. Similarly, a lower head count poverty estimate was for 10-R Dhup Sari Distributary (10 percent) while a higher estimate was for tail reach areas of Khadir Distributary at 80 percent.

The comparison of estimates based on PL-I and PL-II shows that at the head reach, the highest decline in headcount poverty estimate was 26.7 percent for 14-R Maggowal Distributary due to non-perennial nature of canal water supply compensated to some extent by good quality rather expensive groundwater while the lowest decline of 8.8 percent was estimated for Hakra 4-R Distributary where farmers face the double edged problem of bad quality groundwater and shortage of surface water. This indicated that more households at 14-R Maggowal were lying close to the poverty line and would be able to shift above the poverty line if a productive push is provided to them. At the middle reach areas, the comparison of PL-I and PL-II estimates showed the probability of the highest decline in poverty as 32 percent for 3-R Saroki Distributary while the lowest was 5.3 percent for Lalian Distributary. Similarly, at the tail reach areas the estimates computed through PL-I and PL-II showed the highest decline of poverty (26.7 percent) for the command area of 14-R Maggowal Distributary while the lowest estimated (5.5 percent) was for Khadir Distributary. An overall comparison of the incidence of poverty across head, middle and tail reach areas is shown in Figure 3.3.4 while spatial distribution of head count poverty across distributaries is revealed in Figure 3.3.5 and Figure 3.3.6 by using PL-I and PL-II, respectively.

Table 3.3.3. Estimates of poverty head count across different reaches at distributaries (based on annual expenditures).

	PL-I = Rs. 730 per capita per month			PL-II = Rs. 530 per capita per month		
Distributaries	Head	Middle	Tail	Head	Middle	Tail
	Poor	Poor	Poor	Poor	Poor	Poor
9-R Khoja	0.484	0.379	0.400	0.226	0.207	0.167
10-R Dhup Sari	0.444	0.500	0.267	0.222	0.367	0.100
13-R Saroki	0.400	0.571	0.290	0.167	0.250	0.226
14-R Maggowal	0.600	0.367	0.567	0.333	0.233	0.300
Phalia	0.633	0.464	0.393	0.367	0.214	0.250
Kakowal	0.367	0.586	0.345	0.200	0.276	0.207
Lalian	0.696	0.509	0.698	0.536	0.456	0.566
Khadir	0.768	0.702	0.855	0.679	0.579	0.800
Khikhi	0.807	0.526	0.737	0.614	0.439	0.596
Hakra 4-R	0.684	0.684	0.750	0.596	0.526	0.614
Table total	0.629	0.550	0.589	0.450	0.396	0.450

Figure 3.3.4. *Head count poverty across different reaches of distributaries by using PL-I and PL-II.*

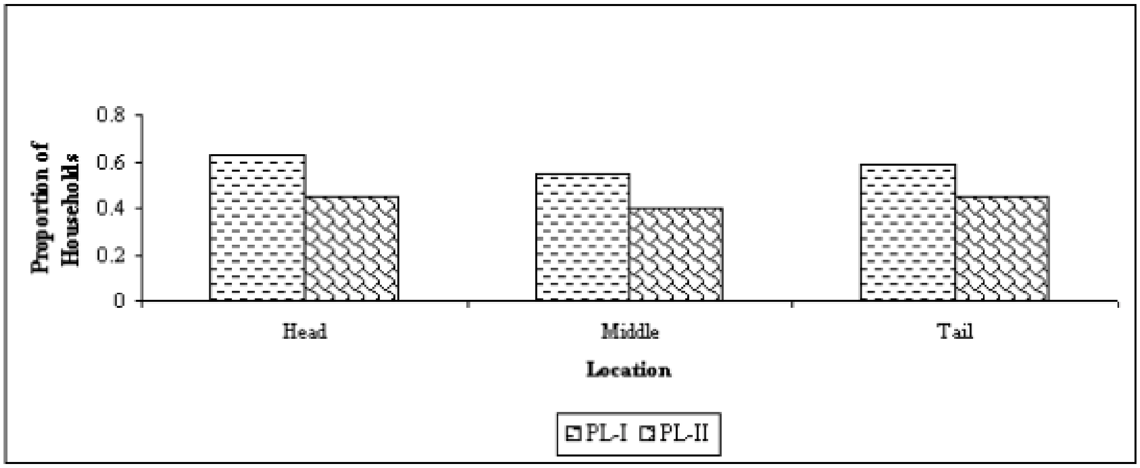


Figure 3.3.5. *Head count poverty across different reaches of selected distributaries by using PL-I.*

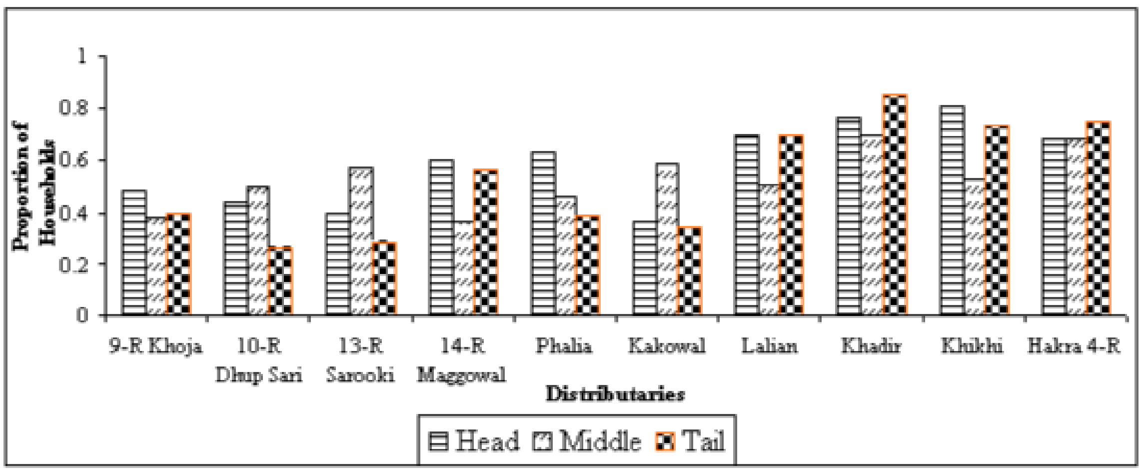


Figure 3.3.6. *Head count poverty across different reaches of selected distributaries by using PL-II.*

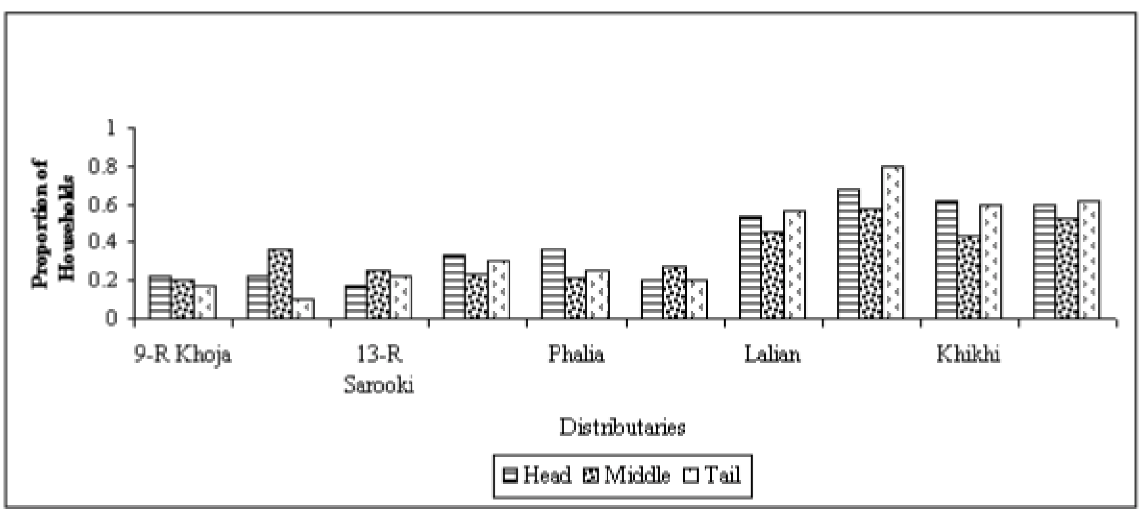


Table 3.3.4 compares poverty gap across the reaches of the distributaries by employing PL-I and shows that the depth of poverty was higher at tail reaches (44.1 percent) mainly due to the prevalence of shortage of canal water, greater proportion of non-farmers and less off-farm employment opportunities in the area (Table 3.2.8) while the lowest was prevailing in the middle reach areas (38.9 percent). However, there was a significant variation across distributaries at head, middle and tail reaches as seen from their respective overall estimates as a whole. At head reaches, the highest poverty gap was estimated at 51.2 percent for Hakra 4-R Distributary, which was due to natural calamity to the cotton crop, poor quality groundwater while the lowest was computed as 26.5 percent for 13-R Saroki Distributary where the conditions were rather better. Poor households at 4 out of 10 distributaries required even higher percentage of additional expenditure than the overall poverty gap estimates for all households at head reaches.

Table 3.3.4. Estimates of poverty gap and squared poverty gap across different reaches at distributaries (indices based on annual expenditure, PL-I).

	PL-I = Rs. 730 per capita per month							
Distributaries	Head		Middle		Tail		Total	
	Poverty gap	S. Poverty gap	Poverty gap	S. Poverty gap	Poverty gap	S. Poverty gap	Poverty gap	S. Poverty gap
9-R Khoja	0.307	0.130	0.270	0.092	0.257	0.094	0.281	0.108
10-R Dhup Sari	0.271	0.110	0.361	0.149	0.259	0.089	0.307	0.122
13-R Saroki	0.265	0.112	0.237	0.074	0.338	0.126	0.270	0.099
14-R Maggowal	0.271	0.102	0.315	0.120	0.298	0.125	0.291	0.115
Phalia	0.293	0.113	0.258	0.108	0.303	0.108	0.285	0.110
Kakowal	0.296	0.111	0.291	0.118	0.346	0.166	0.307	0.129
Lalian	0.458	0.256	0.429	0.210	0.478	0.269	0.457	0.248
Khadir	0.509	0.285	0.447	0.231	0.549	0.334	0.504	0.286
Khikhi	0.446	0.236	0.466	0.247	0.469	0.259	0.459	0.247
Hakra 4-R	0.512	0.294	0.458	0.255	0.486	0.279	0.485	0.276
Table total	0.413	0.214	0.389	0.190	0.441	0.239	0.415	0.215

At middle reaches, households at 4 out of ten distributaries needed higher expenditure than the overall average to become non-poor. Poor households at the middle reaches required an additional 39 percent of expenditure to fill the poverty gap. The highest poverty gap prevailed in Khikhi Distributary (46.6 percent) which was due to bad quality groundwater, shortage of surface water and lack of off-farm employment opportunities while the lowest of 23.7 percent was for 13-R Saroki Distributary where there were some off-farm employment opportunities. At tail reaches, the highest poverty gap was estimated as 55 percent for Khadir Distributary due to the absence of off-farm employment opportunities for the majority of non-farmers, and canal water, while the lowest was estimated as 25.7 percent for the tail reach at 9-R Khoja Distributary, which may be attributed to the rice-wheat cropping pattern and somewhat equal land distribution. It was also found that households at six distributaries (9-R Khoja, 10-R Dhup Sari, 13-R Saroki, 14-R Maggowal, Phalia and Kakowal) required less proportional increase in expenditure than the average poverty gap of 44.1 percent at the tail reach of the study areas mainly due to good quality ground water that contributes a lot towards agricultural production in these areas.

Estimates of squared poverty gap indicated that the severity of poverty was the lowest at middle reaches and the highest at the tail reach areas. At head reaches, the highest squared poverty gap estimate was computed as 29.4 percent for households at Hakra 4-R Distributary, which was 8 percent higher than the average squared poverty gap for overall head reach households. The reason was brackish groundwater and poor yield of cotton crop. On the other hand, the lowest estimate of 10.2 percent was for 14-R Maggowal Distributary where groundwater was of good quality and the rice-wheat cropping pattern contributed towards poverty reduction. The estimate was, therefore, 11.2 percent lower than the overall estimate for households at head reach areas.

At the middle reach areas, squared poverty gap was estimated to be 19 percent for all the households of the study area. The highest severity of poverty appeared at Hakra 4-R Distributary with a squared poverty gap estimated as 25.5 percent, which is around 6.5 percent higher than the overall estimate for all middle reach households. Moreover, the lowest squared poverty gap estimate was calculated at 7.4 percent for 13-R Saroki Distributary.

In the tail reach area, the severity of poverty was estimated as 23.9 percent.. The highest and the lowest of squared poverty gap were estimated as 33.4 percent and 10.8 percent for Kakowal Distributary and Phalia Distributary, respectively. Figure 3.3.7 gives a comparison of poverty gap and squared poverty gap across head, middle and tail reaches for the whole study area while Figure 3.3.8 shows the poverty gap across different reaches of the selected distributaries by using poverty line-I.

Figure 3.3.7. Poverty gap and squared poverty gap across different reaches of selected distributaries by using PL-I.

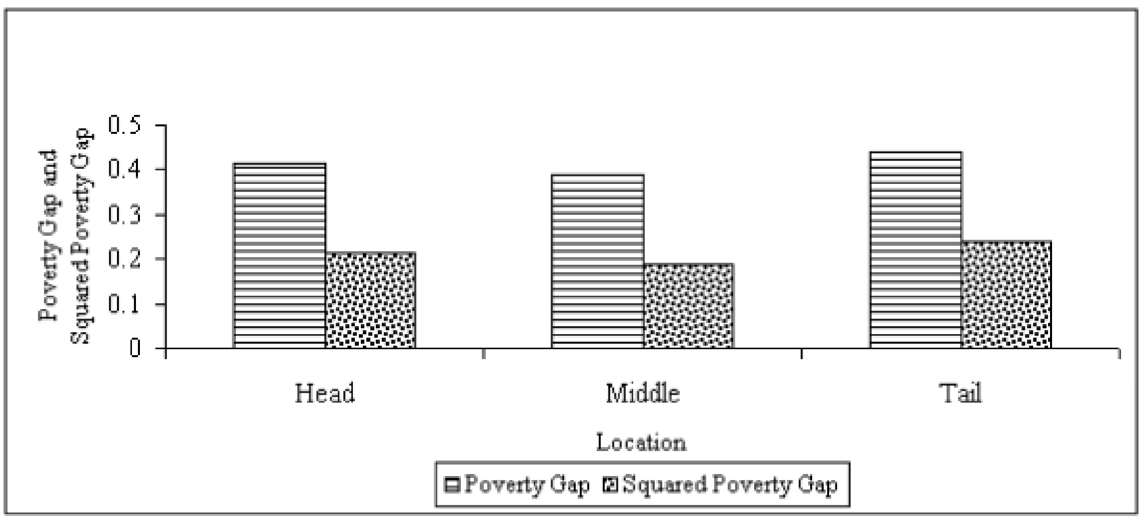
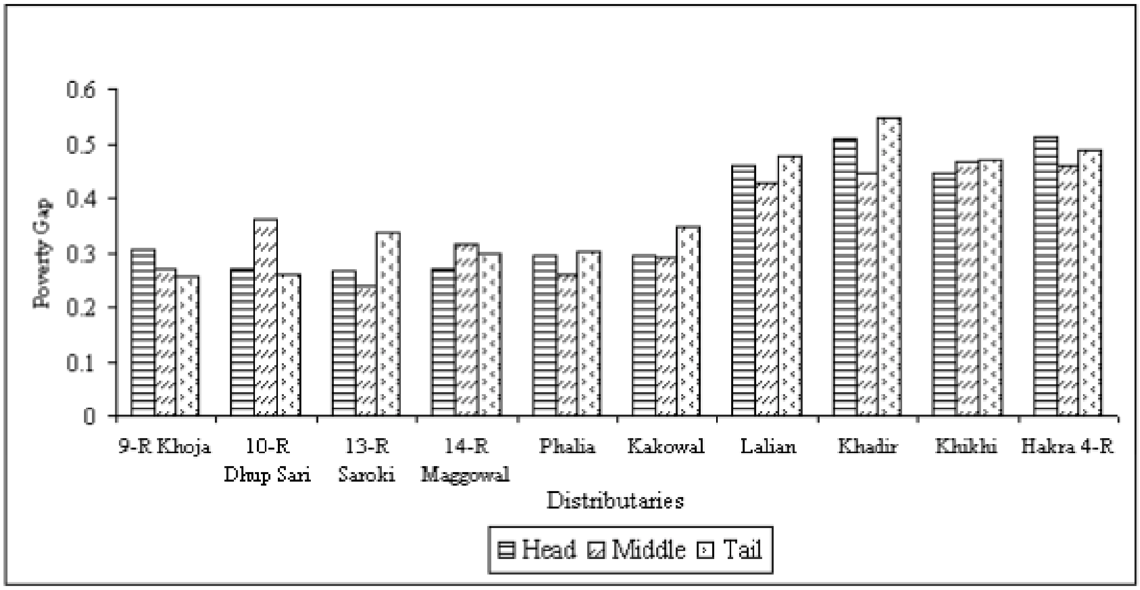


Figure 3.3.8. Spatial variation in poverty gap among households across sample distributaries using PL-I.



Comparison of poverty gap using PL-II as shown in Table 3.3.5 reveals that the depth of poverty was the highest (35.8 percent) at tail reaches and the lowest (29 percent), at the middle reach areas. At head reaches, poor households required about 34 percent of additional expenditures to fill the poverty gap. Poor households at 4 out of 10 distributaries required even higher percentage of additional expenditure than the overall poverty gap estimates for all households at head reach. The lowest depth of poverty was estimated as 17.2 percent for the households at 14-R Maggowal at the head reach, because of more equal land distribution, while the highest estimate was 39.5 percent for households at Hakra 4-R Distributary due to greater inequality in land distribution and larger proportion of small and marginal farmers (Table 3.2.5).

Poor households at the middle reach required an additional 29 percent of average expenditure to fill the poverty gap. Relatively higher estimates of poverty gap were found for poor households at 3 out of 10 distributaries than overall estimate of 29 percent in the middle reach. The highest estimate was computed for Hakra 4-R Distributary (37.5 percent) while the lowest estimate was for 13-R Saroki Distributary (13.3 percent). About 36 percent of additional expenditure was required by tail reach households to bridge the gap from the poverty line. Poor households at four distributaries (Lalian, Khadir, Khikhi and Hakra 4-R) out of ten in the tail reach required even a higher proportion of expenditures than average poverty gap estimates for the tail reach to ensure the basic needs availability to household members.

The severity of poverty was estimated lowest at the middle reach (11.8 percent) and the highest at the tail reach (17.3 percent) areas. The highest squared poverty gap estimate (19.1 percent) was for the head reach of Hakra 4-R Distributary while the lowest 4.9 percent was for the head reach of 14-R Maggowal Distributary. In the middle reach area, the peak severity of poverty was found for Hakra 4-R Distributary (18.5 percent) while the lowest estimate was 2.7 percent for the middle reach of 13-R Saroki Distributary. Similarly, at the tail reach areas the lowest and the highest squared poverty gap estimates were 3 percent and 22.2 percent for 13-R

Saroki Distributary and Hakra 4-R Distributary, respectively. In the former, the severity of poverty was lower due to greater dependence on non-farm income and off-farm employment (Table 3.2.8). Figure 3.3.9 shows a comparison of poverty gap and squared poverty gap across head, middle and tail reaches for the study area while Figure 5.10 shows the poverty gap across different reaches of the selected distributaries by using poverty line-II.

Table 3.3.5. Estimates of poverty gap and squared poverty gap across different reaches at distributaries (indices based on annual expenditure, PL-II).

	PL-II = Rs. 530 per capita per month							
Distributaries	Head		Middle		Tail		Total	
	Poverty gap	S. Poverty gap	Poverty gap	S. Poverty gap	Poverty gap	S. Poverty gap	Poverty gap	S. Poverty gap
9-R Khoja	0.294	0.110	0.150	0.029	0.218	0.057	0.225	0.069
10-R Dhup Sari	0.228	0.078	0.213	0.057	0.183	0.058	0.213	0.063
13-R Saroki	0.275	0.110	0.133	0.027	0.158	0.030	0.179	0.050
14-R Maggowal	0.172	0.049	0.188	0.043	0.251	0.080	0.203	0.058
Phalia	0.184	0.056	0.260	0.086	0.154	0.035	0.194	0.057
Kakowal	0.190	0.050	0.240	0.092	0.309	0.122	0.246	0.089
Lalian	0.387	0.185	0.261	0.100	0.381	0.184	0.347	0.159
Khadir	0.384	0.173	0.320	0.135	0.413	0.219	0.377	0.179
Khikhi	0.353	0.160	0.340	0.149	0.373	0.171	0.357	0.161
Hakra 4-R	0.395	0.191	0.375	0.185	0.408	0.222	0.394	0.200
Table Total	0.339	0.151	0.290	0.118	0.358	0.173	0.331	0.148

Figure 3.3.9. Poverty gap and squared poverty gap among households across different reaches of selected distributaries based on PL-II.

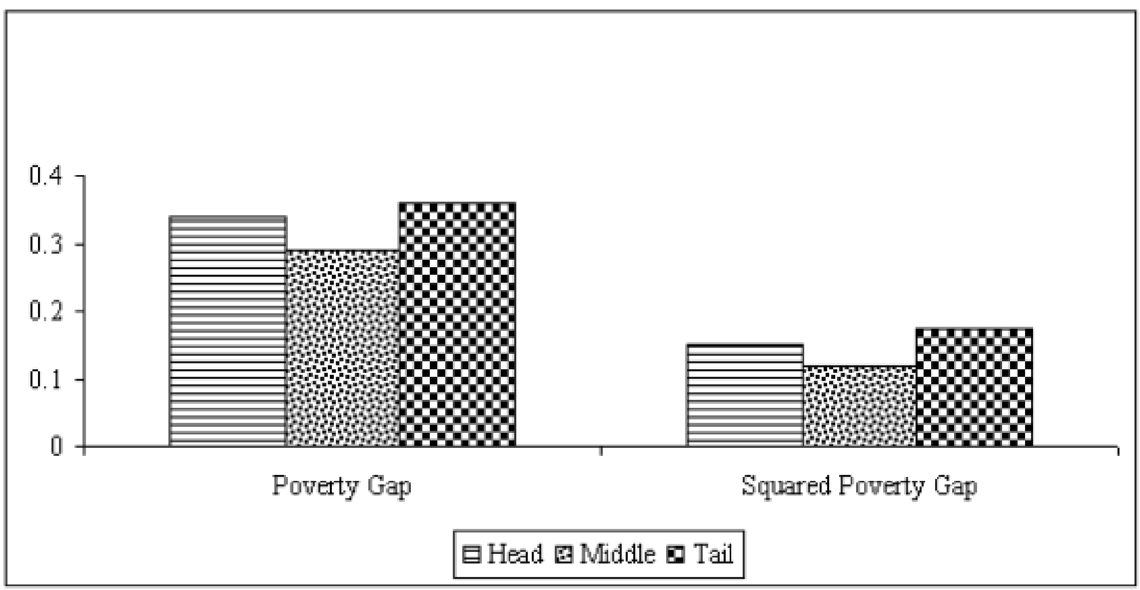
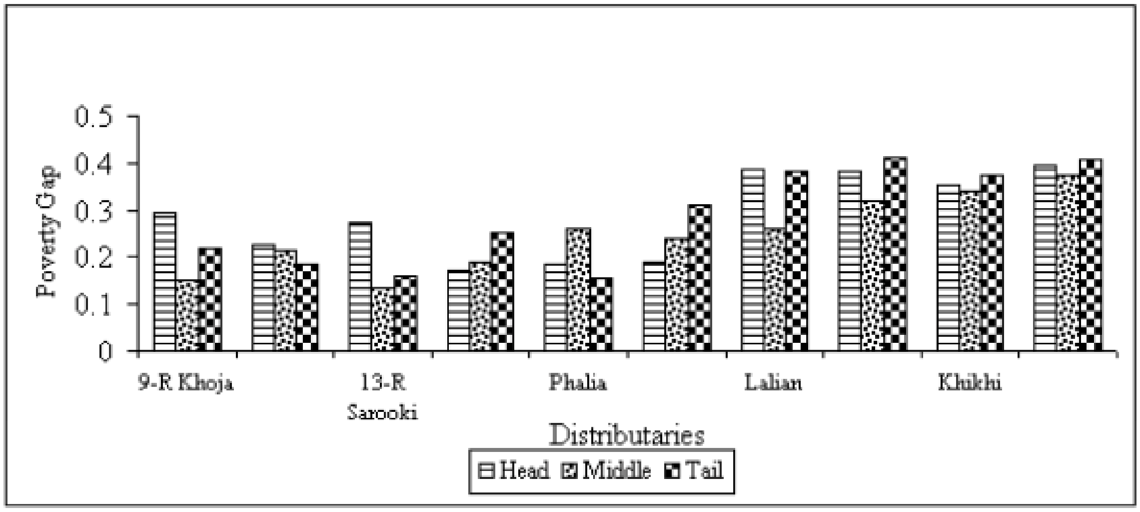


Figure 3.3.10. Spatial variation in poverty gap among households across sample distributaries using PL-II.



Poverty among Farm and Non-Farm Households

Discussion on poverty would remain deficient without a comparison between farm and non-farm households. The rural economy is primarily dependent on farm households that aim at raising crops and livestock while non-farm households provide various services to them. In this way, non-farm households are dependent on the farm households for earning their fortune. It was expected that poverty incidence would be higher among non-farm households when compared with farm households.

Table 3.3.6 shows that by using PL-I, the incidence of poverty among farm households was found to be the highest (60.8 percent) at the head reach areas while it was the lowest for the middle reach areas. For non-farm households, the highest headcount poverty index was estimated for tail reach areas (74.5 percent) while it was the lowest for middle reach areas (66.7 percent). Comparing the farm and non-farm households, it was found that at all three reaches, incidence of poverty was higher among non-farm households when compared with farm households due to greater dependency ratio and seasonal unemployment.

Among farm households at the tail reach, the depth of poverty (poverty gap) was higher (45.2 percent) while it was lower at the middle reach areas (38.3 percent). The highest poverty gap among non-farm households was found at the tail reaches (42 percent) while the lowest estimates were for the non-farm households in the middle reach areas (40.3 percent).

The severity of poverty (squared poverty gap) was estimated the highest (24.9 percent) for the tail reach farm households while it was the lowest for middle reach farmers (18.8 percent). On the other hand, the highest squared poverty gap estimate was for tail reaches (21.9 percent) while the lowest squared poverty gap (19.2 percent) was estimated for non-farm households at middle reach areas. The severity of poverty of non-farmers is again contingent upon the economic condition of farmers. According to PL-II, the highest and the lowest incidence of poverty among farm households were estimated as 41.9 percent at the head and 35 percent at the middle reach areas, respectively. For non-farm households, the highest head count poverty (55.7 percent) was found at tail reaches while lowest estimate (52.4 percent) was at middle reach areas.

The highest poverty gap for farm households (36.6 percent) was estimated at tail reach areas while the lowest (29.9 percent) was for farm households in the middle reach areas. The non-farm households also followed the same pattern with the highest estimate of 33.2 percent at the tail reaches and the lowest estimate of 27.2 percent at the middle reaches. For farm households, the severity of poverty shows the highest value of 17.8 percent at the tail reach whereas it was lower at 12.7 percent at middle reaches. Similarly, for non-farm households, the highest squared poverty estimate (14.9 percent) was for tail reaches while the lowest was for middle reaches, as shown in Table 3.3.6. The distribution of poverty gap among the farm and non-farm households for PL-II follows almost the same trends as for PL-I.

Comparisons of head count using PL-I and PL-II, shows similar trends for farm households. However, head count estimates show a decline of poverty by 18.9 percent, 15.8 percent and 12.2 percent for farm households at head, middle and tail reach areas, respectively, indicating that more farm households at the head and middle reaches were lying near the poverty line than the households at the tail reach area. Moreover, higher poverty gap and squared poverty gap estimates were found for the households at the tail reach areas when compared with the head and middle reaches, which showed higher depth and severity of poverty concentration at the tail reach areas where the proportion of the chronic poor tends to be greater.

As far as the non-farm households were concerned, a higher percentage (19.8 percent) was found sensitive to the poverty line change at tail reaches as compared with the households at head (14.5 percent) and middle reaches (14.3 percent). However, depth and severity of poverty indices were also highest for non-farm households at the tail reaches than non-farm households at head and middle reaches as shown in Figure 3.3.11. It reflects the concentration of severe poverty at the tail reaches.

Table 3.3.6. Estimates of poverty gap and squared poverty gap for farm households and non-farm households across different reaches at distributaries (indices based on annual expenditure, PL-II).

		Head		Middle		Tail	
		Non-farmer	Farmer	Non-farmer	Farmer	Non-farmer	Farmer
PL-I	Head Count Index	0.689	0.608	0.667	0.508	0.745	0.532
	Poverty Gap	0.417	0.412	0.403	0.383	0.420	0.452
	Squared Poverty Gap	0.211	0.216	0.192	0.188	0.219	0.249
PL-II	Head Count Index	0.544	0.419	0.524	0.350	0.557	0.410
	Poverty Gap	0.304	0.354	0.272	0.299	0.332	0.366
	Squared Poverty Gap	0.127	0.161	0.102	0.127	0.149	0.178

Figure 3.3.11. Head count poverty, poverty gap and squared poverty gap of sample farm households across different reaches by using PL-I and PL-II.

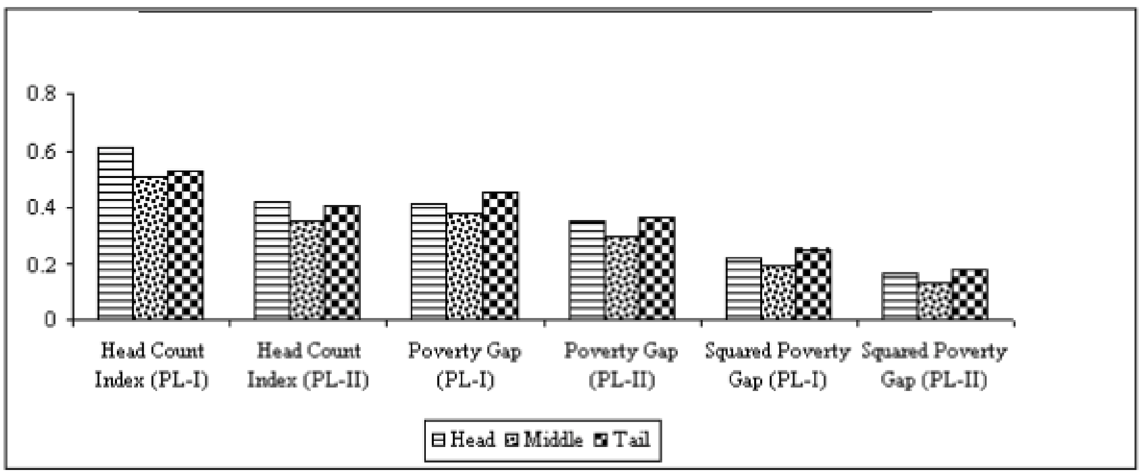


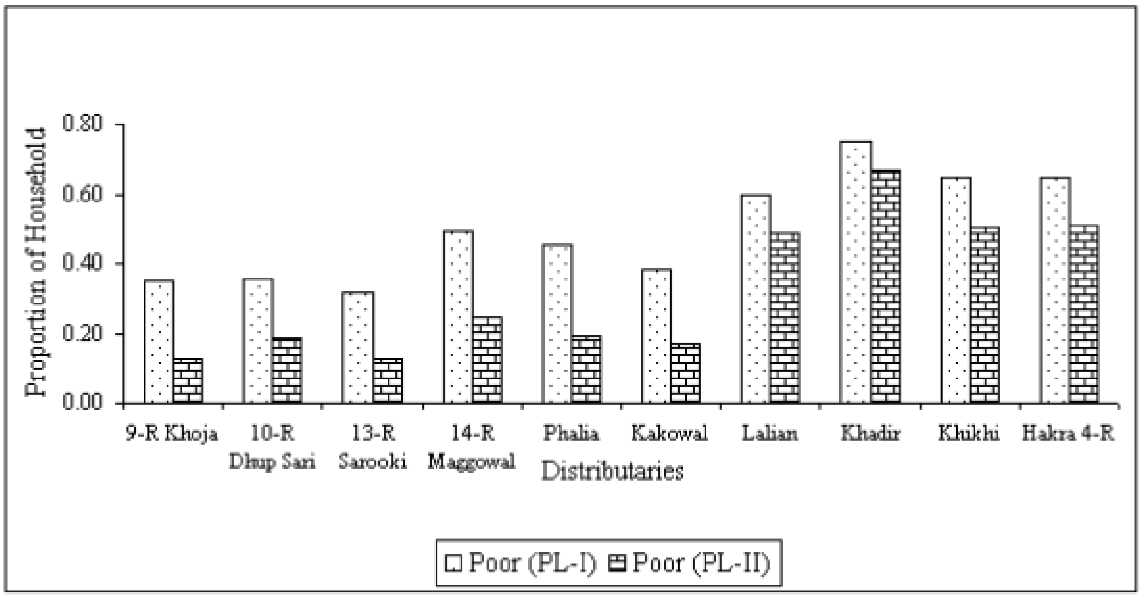
Table 3.3.7 shows that by using PL-I, poverty among farm households was estimated to be around 55 percent. At four out of ten distributaries, poverty head count was higher than the overall estimate for all households (55 percent). The highest poverty incidence was estimated for Khadir Distributary (75 percent) while the lowest was estimated as 31.7 percent for 13-R Saroki Distributary.

Using PL-II, overall poverty incidence among farm households was estimated around 39.3 percent. The highest estimate of poverty head count was again found for Khadir Distributary as 66.7 percent while the lowest was for 13-R Saroki Distributary (12.7 percent) and 9-R Khoja Distributary (12.7 percent).The comparison of the poverty head count among farm households across selected distributaries is also shown in Figure 3.3.12.

Table 3.3.7. Estimates of head count poverty for farmers and non-farmers across sample distributaries (indices based on annual expenditure; PL-I and PL-II).

	PL-I = Rs. 730 per capita per month		PL-II = Rs. 530 per capita per month	
Distributaries	Non-Poor	Poor	Non-Poor	Poor
9-R Khoja	0.651	0.349	0.873	0.127
10-R Dhup Sari	0.646	0.354	0.815	0.185
13-R Saroki	0.683	0.317	0.873	0.127
14-R Maggowal	0.508	0.492	0.754	0.246
Phalia	0.548	0.452	0.810	0.190
Kakowal	0.615	0.385	0.831	0.169
Lalian	0.405	0.595	0.511	0.489
Khadir	0.250	0.750	0.333	0.667
Khikhi	0.356	0.644	0.496	0.504
Hakra 4-R	0.351	0.649	0.493	0.507
All	0.450	0.550	0.607	0.393

Figure 3.3.12. Head count poverty among farm households across sample distributaries by using PL-I and PL-II.



Characteristics of Poor and Non-Poor Sample Households

Discussion on poverty remains incomplete, unless characteristics of poor and non-poor households are analyzed using other relevant monetary and non-monetary indicators. This analysis will help to more clearly understand the causes and symptoms of poverty. We focus on identifying social, agricultural and economic characteristics of the poor and non-poor households.

Social characteristics

Social characteristics of the population comprises the average household size, number of employed persons, dependency ratio and educational level of household head. Table 3.3.8 shows that the average household size of poor households was significantly higher (8.85) than of non-poor households (6.49) for PL-1. Higher family size of the poor households resulted in more dependents (4.55 family members) when compared with that of non-poor households (having average of 2.91 dependent members). Due to larger family size and higher number of dependents, poor households had to incur higher expenditure to fulfill their basic needs. On an average, more members of the poor households had to work in order to earn income to meet the minimum required expenditure. The estimates showed that, on an average, 2.2 members of poor households were working as compared to 1.9 members of the non-poor households. Two different dependency ratios, DR_1 and $DR_{2,}$ were estimated. According to DR_1, the number of household members below 15 years and above 60 years was divided by family size. The DR_1 showed that the poor households were burdened by higher dependency ratio of 0.5 when compared with 0.41 for non-poor households. According to DR_2 (the number of household members below 15 years and above 60 years divided by the number of household members between age 16-60 years), the estimates for poor households were higher (1.19) when compared with that for non-poor households (0.91). For poor households, the average number of completed schooling years of the household head was 3.37 years. This was 5.48 years for non-poor households. A further decomposition shows that 54.65 percent of the poor household heads were illiterate when compared with 38.38 percent of the non-poor households. More interestingly, about 15 percent of non-poor household heads completed more than 10 years of schooling when compared with 4.9 percent of poor households. Figure 3.3.13 shows the comparison of average household size, average number of dependents and average number of schooling years completed by the heads of the poor and non-poor households. Similar results were found through the use of PL-II.

Table 3.3.8. Characteristics of poor and non-poor households in the study area.

	PL-I		PL-II	
	Non poor	Poor	Non-poor	Poor
Average household size (number)	6.46	8.85	7.02	8.98
Dependents (Average)	2.91	4.55	3.33	4.59
Average number of working members	1.90	2.20	1.99	2.19
Dependency ratio 1 (dependents/family size)	0.41	0.5	0.43	0.49
Dependency ratio 2 (dependents/members between 16-60 years)	0.91	1.19	0.99	1.19
Education level of household head (years)	5.48	3.37	5.12	3.08
Educational status of head of household (percentage)				
No Education (%)	38.38	54.65	40.73	57.50
Up to 5 years (%)	10.51	15.63	11.53	16.15
5-10 years (%)	36.16	24.79	35.18	21.92
More than 10 years (%)	14.95	4.93	12.55	4.42

Figure 3.3.13. Average household size, number of dependents and number of schooling years completed by heads of households between poor and non-poor households.

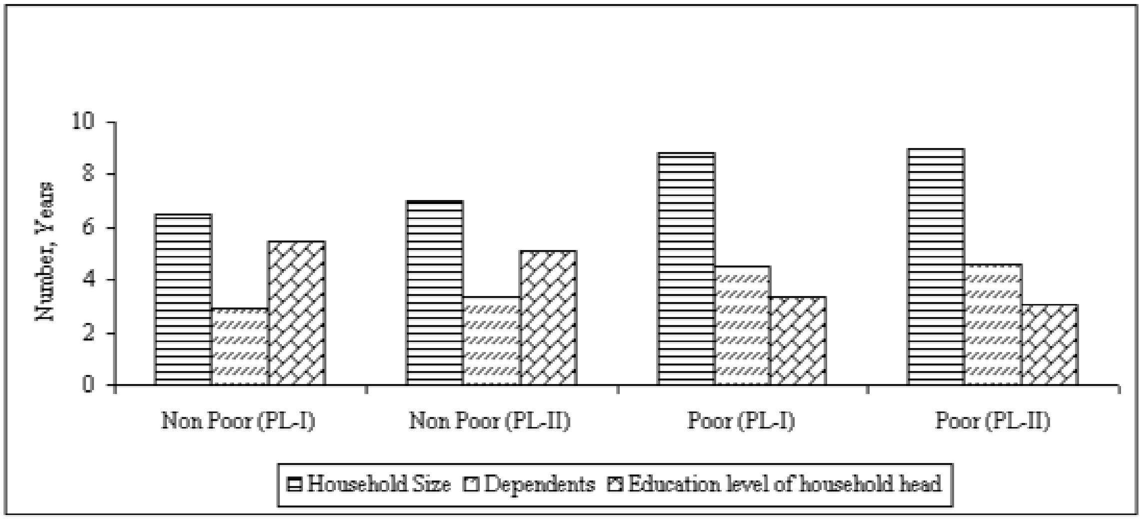


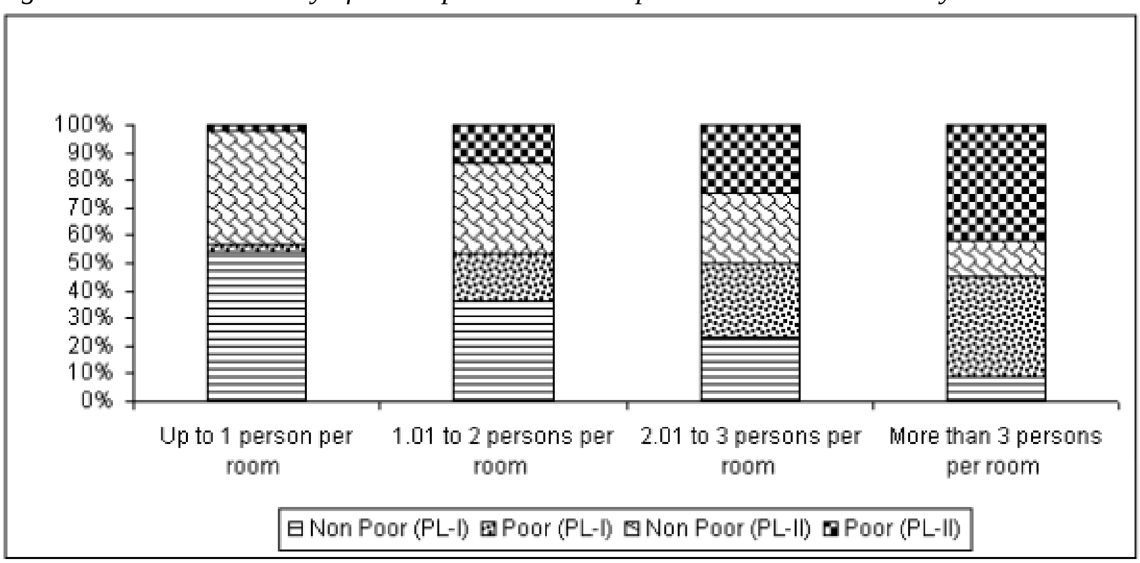
Table 3.3.9 shows the quality of housing and other facilities available to the poor and non-poor sample households in the study area. No significant variation was found in the proportion of poor and non-poor households using tap water and hand pump. However, there was a difference in use of the motor pump for the extraction of drinking water, between non-poor households (16.16 percent) and poor households (9.15 percent). This difference was due to the fact that the majority of poor households was unable to afford electricity charges and they were not using pumps to use groundwater for their household needs. Only 2.41 percent of the households in the study area had gas facility for cooking in. Around 67 percent of the poor households did not have any toilet facility within household boundary when compared with 44.85 percent of the non-poor households.

In poor households, more than three persons were sharing one room while for non-poor households the corresponding estimate was around 2 persons. Arif (2000) also reported that in rural areas, on an average 3.4 persons occupied one room. Overall, 19.19 percent of non-poor households were enjoying one room per person when compared with only 1.13 percent of the poor households. On the other extreme, 48.73 percent of poor households were forced to share one room by more than 3 persons as shown in Figure 3.3.14.

Table 3.3.9. Social amenities and quality of housing across poor and non-poor households in the study area.

	PL-I		PL-II		Total
	Non- poor	Poor	Non- poor	Poor	
Drinking water source (%)					
Tap water (%)	11.52	11.55	10.95	12.31	11.54
Hand pump (%)	70.51	73.66	72.26	72.50	72.37
Motor pump (%)	16.16	9.15	14.74	8.46	12.03
Other (%)	1.82	5.63	2.04	6.73	4.07
Total (%)	100	100	100	100	100
Electricity connection (%)					
Yes	92.32	76.34	91.53	71.54	82.90
No	7.68	23.66	8.47	28.46	17.10
Gas facility (%)					
Yes	3.64	1.55	3.07	1.54	2.41
No	96.36	98.45	96.93	98.46	97.59
Toilet facilities (%)					
Outside (%)	44.85	67.04	48.47	70.38	57.93
Flush (%)	47.68	29.15	44.96	25.96	36.76
Non-Flush (%)	7.47	3.80	6.57	3.65	5.31
Room space					
Persons per room (Average)	2.07	3.64	2.31	3.89	2.99
Up to 1 person per room (%)	19.19	1.13	14.45	0.77	8.55
1.01 to 2 persons per room (%)	43.03	19.58	39.27	15.96	29.21
2.01 to 3 persons per room (%)	26.26	30.56	29.20	28.27	28.80
More than 3 persons per room (%)	11.52	48.73	17.08	55.00	33.44
Total (%)	100.00	100.00	100.00	100.00	100.00

Figure 3.3.14. Availability of room space across sample households in the study area.



Agricultural Characteristics

Table 3.3.10 provides information on access to vital resources such as land and water by poor and non-poor households. Non-poor farm households were operating an average farm size of 5.68 ha while corresponding estimate for poor households was 3.86 ha. Further decomposition showed that 57.86 percent of the non-poor households were operating more than 3 ha of agricultural land when compared with 43.06 percent of the poor households. Only 8.98 percent of the non-poor households were operating less than 1 ha of agricultural land when compared with 12.45 percent of the poor households. Cropping intensity was higher (152 percent) for non-poor farm households and lower (145) for poor households. A higher proportion (5.71 percent) of poor farm households were using only canal water for irrigation when compared with 3.74 percent of non-poor farm households. It was mainly due to smaller landholdings of poor farm households as well as their inability to meet the cost of expensive groundwater irrigation.

Table 3.3.10. Distribution of land and irrigation water resources between poor and non-poor households in the study area.

	PL-I		PL-II	
	Non-Poor	Poor	Non Poor	Poor
Land distribution in the sample areas	Non- poor	Poor	Non- poor	Poor
Average farm size (ha)	5.68	3.86	5.24	3.82
Less than 1 ha (%)	8.98	12.45	9.98	12.29
1.001 to 2 ha (%)	13.97	21.22	15.71	21.43
2.001 to 3 ha (%)	19.20	23.27	20.15	23.43
Above 3 ha (%)	57.86	43.06	54.16	42.86
Cropping intensity (%)	152	145	153	140
Source of irrigation (%)				
Canal irrigation (%)	3.74	5.71	3.51	6.86
Private tubewell (%)	12.22	11.84	12.75	10.86
Canal & private tubewell (%)	83.29	82.04	82.99	82.00
Others (%)	0.75	0.41	0.74	0.29

Figure 3.3.15. Cropping intensity at poor and non-poor farm households in the study area.

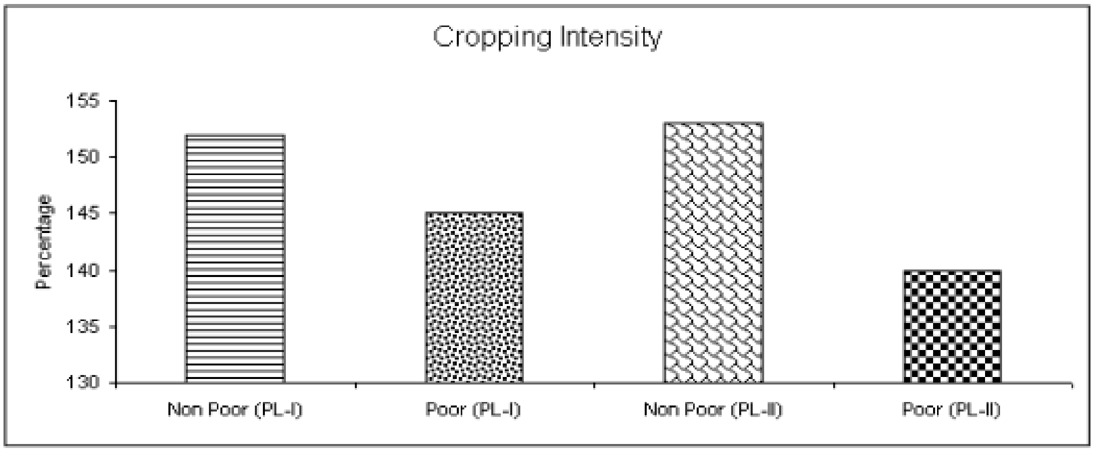


Table 3.3.11 shows that the average cultivated area under sugarcane crop was 0.38 ha for both poor and non-poor households. The non-poor household's productivity of sugarcane (10131 kg/ha) was significantly lower than that of poor households (13163 kg/ha). Non-poor households cultivated more area with wheat, rice, and cotton crops. Also, their productivity (kg/ha) was higher except for cotton crop. However, per hectare GVP for major crops (sugarcane, wheat, rice and cotton) was higher for non-poor households (Rs. 20966 per ha) when compared with that of poor households (Rs. 18679 per ha). Due to diseconomies of scale, it cost higher to the poor households to buy smaller amounts of inputs with high overheads, without the quality assurance of the inputs bought (seeds, fertilizer, pesticide, insecticides, etc). This leads to the higher cost of production for major crops raised by the poor households (Rs. 13145 per ha) when compared with that of non-poor households (Rs. 12428 per ha) showing inefficiencies on the part of poor households. This indicated that non-poor households were able to generate higher level of gross margins for major crops when compared with poor households. All crops taken together, gross value of production was estimated as Rs. 24485 per ha for non-poor households and Rs. 19802 per ha for poor households. A lower cost of production for all crops was found for poor households (Rs. 13591 per hectare) than for non-poor households (Rs. 15107 per hectare). This was due to the greater use of family labor on farms owned by the poor households. However, gross margin for all crops clearly indicated higher profitability for non-poor households (Rs. 9378 per ha) when compared with that of poor households (Rs. 6211 per ha).

Table 3.3.11. Agricultural productivity and profitability of poor and non-poor households in the study area.

	PL-I		PL-II	
	Non-poor	Poor	Non-poor	Poor
Sugarcane cultivated area (ha)	0.38	0.38	0.38	0.38
Sugarcane productivity (kg/ha)	10131	13163	9784	14913
Wheat cultivated area (ha)	3.11	2.00	2.89	1.90
Wheat productivity (kg/ha)	2644	2387	2578	2386
Rice cultivated area (ha)	0.98	0.40	0.92	0.26

Rice productivity (kg/ha)	1125	664	1118	492
Cotton cultivated area (ha)	1.04	0.75	0.98	0.73
Cotton productivity (kg/ha)	236	279	232	303
Productivity (Rs./ha)				
Gross value of production for major crops	20966	18679	20408	18627
Total cost of production for major crops	12428	13145	12338	13570
Gross value of production for all crops	24485	19802	24026	18638
Total cost of production for all crops	15107	13591	15226	12801
Gross margin for all crops	9378	6211	8800	5837

Economic Characteristics

Table 3.3.12 indicates that 71.3 percent of the heads of the non-poor sample households were engaged primarily in agriculture. Significantly a higher proportion (10.42 percent) of poor household heads was working as agricultural workers/laborers. Comparison of the poor and non-poor households in Table 3.3.12 shows that only 2.68 percent of poor household heads were engaged in services sector when compared with 2.02 percent for non-poor households. Interestingly, 6.87 percent of non-poor household heads did not work at all while the corresponding estimate for poor households was 3.38 percent indicating additional earning stress for meeting the household's basic needs expenditure.

Table 3.3.12. Different sources of employment reported by the sample household heads in the study area.

	PL-I		PL-II	
	Non-poor	Poor	Non-poor	Poor
Employment of household head				
Agriculture (%)	71.31	64.08	69.49	63.85
Agriculture worker / labor (%)	3.23	10.42	3.65	12.50
Non-agricultural business/entrepreneurship (%)	6.87	7.75	8.03	6.54
Services (%)	2.02	2.68	2.04	2.88
Other (%)	9.70	11.69	10.66	11.15
No Job (%)	6.87	3.38	6.13	3.08

Table 3.3.13 shows that the annual crop income (net crop income (all crops) + land rent received - land rent paid + share of income from shared out land - share of income for shared in land) of non-poor households was significantly high (Rs. 45176) than poor households (Rs.12272) in the study area. Average non-crop income (income from artisan + repair work + other enterprises + interest from household savings + pensions + remittances from relatives inside the country + remittances from outside the country + gifts/transfer payments + animal products + poultry products + fish + lottery + other non crop items + handicrafts + salaries + others) of non-poor households was estimated as Rs. 62853 when compared with Rs. 36733 of poor households. Average income from sale of animals (income from selling animals - cost of buying animals) of non-poor households was Rs. 4891 when compared with Rs. 3944 for poor households. Non-poor households were earning an annual income (crop income + non crop income + income from

selling of animals + income from agricultural assets) of Rs. 115080, which is significantly higher when compared with the annual income of Rs. 54028 for poor households. It was estimated that 68 percent of the poor household's annual income was from non-crop income sources when compared with 54.62 percent of that of non-poor households. Similarly, the share of crop income in annual income was 39.26 percent for non-poor households when compared with 22.71 percent of that for poor households. Interestingly, income from the sale of animals constituted a relatively greater share of 7.3 percent in annual income for poor households when compared with 4.25 percent for the non-poor households. Poor households were receiving 7.17 percent of their annual income as remittances from relatives within the country when compared with 5.28 percent for non-poor households. However, non-poor households were receiving 15.72 percent of their annual income as remittances from relatives outside the country when compared with 7.17 percent for the poor households. Per capita annual income of non-poor households was three times the per capita income of poor households. Figure 3.3.16 shows the proportion of crop income, non-crop income, and income from the sale of animals in the annual income of selected households in the study area.

Table 3.3.13. Sources of income for poor and non-poor households in study area.

	PL-I		PL-II	
Income	Non-poor	Poor	Non-poor	Poor
Annual crop income (Ave.)	45176	12272	38197	9442
	(39.26)	(22.71)	(37.41)	(19.34)
Annual non-crop income (Ave.)	62853	36733	57760	33899
	(54.62)	(67.99)	(56.57)	(69.44)
Income from sale of animals (Ave.)	4891	3944	4057	4697
	(4.25)	(7.30)	(3.97)	(9.62)
Annual income (Ave.)	115080	54028	102102	48816
	(100)	(100)	(100)	(100)
In country remittances (% of annual income)	5.28	6.14	5.13	7.01
Out country remittances (% of annual income)	15.72	7.17	15.36	3.78
Per capita annual income (Rs.)	18652	6035	15607	5436

Note. Figures in parentheses are percentages

Figure 3.3.16. Sources of income for poor and non-poor farm households using PL-I.

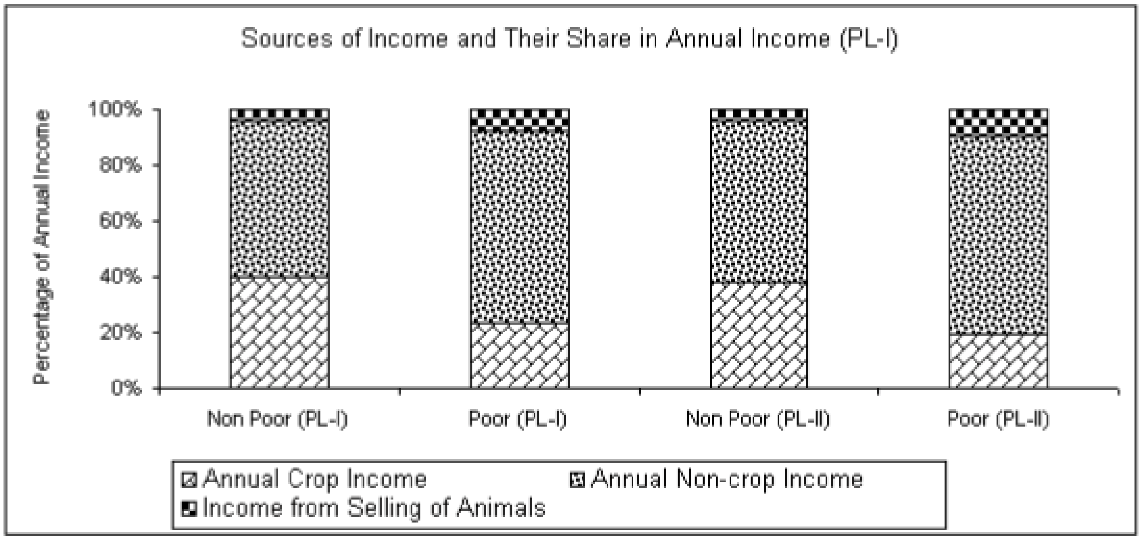


Table 3.3.14 shows that non-poor households incurred a higher expenditure on food items (Rs. 26467) when compared with that of Rs. 20229 of poor households. As expected, poor households spent a higher proportion of their income on food items than non-poor households. These households spent 48 percent of their total expenditure on food items when compared with 31 percent in the case of non-poor households. Grimad (1996) also reported that rural households spent about 50 percent of their monthly income on food items. It was estimated that non-poor households incurred an annual expenditure of Rs. 100057 when compared with the significantly lower amount of Rs. 44553 in case of poor households. Per capita annual expenses for non-poor households were almost three times of that of poor households. Similarly, per capita expenditure incurred on food items by non-poor households were more than double what was incurred by poor households.

Borrowing was higher for non-poor households as when compared with poor households. Average annual borrowing of non-poor households was Rs. 47519 when compared with Rs. 18521 for the poor households. Major source of borrowing was non-institutional (from relatives, non-relatives, traders, dealers and professional money lenders) for both non-poor and poor households. However, 81.22 percent of the total borrowing of the poor households was from non-institutional sources, and 18.73 percent from institutional sources (from banks and cooperatives). On the other hand, 59.34 percent of the total borrowing by non-poor households was from non-institutional sources and 40.66 percent, from institutional sources. Overall, non-institutional sources of credit are important, and poor depend on them more than the non-poor.

Table 3.3.14. Average annual expenditures and sources of borrowing in the study area.

	PL-I		PL-II	
	Non - poor	Poor	Non- poor	Poor
Average annual food expenditures (Rs.)	26467	20229	26164	18349
Ratio of food to total expenditures	0.31	0.48	0.34	0.51
Annual expenditures	100057	44553	89841	37730
Per capita annual expenditure (Rs.)	16962	5129	14331	4271
Per capita food expenditure (Rs.)	4571	2385	4164	2123
Credit				
Institutional credit (Rs.)	19320	3478	16251	1733
Non-institutional credit (Rs.)	28199	15043	27574	11059
Total credit (Rs.)	47519	18521	43825	12792
Institutional credit (%)	40.66	18.78	37.08	13.55
Non-institutional credit (%)	59.34	81.22	62.92	86.45
Total credit (%)	100.00	100.00	100.00	100.00

Figure 3.3.17. Annual total expenditures and annual food expenditures of selected households in the study area by using PL-I and PL-II.

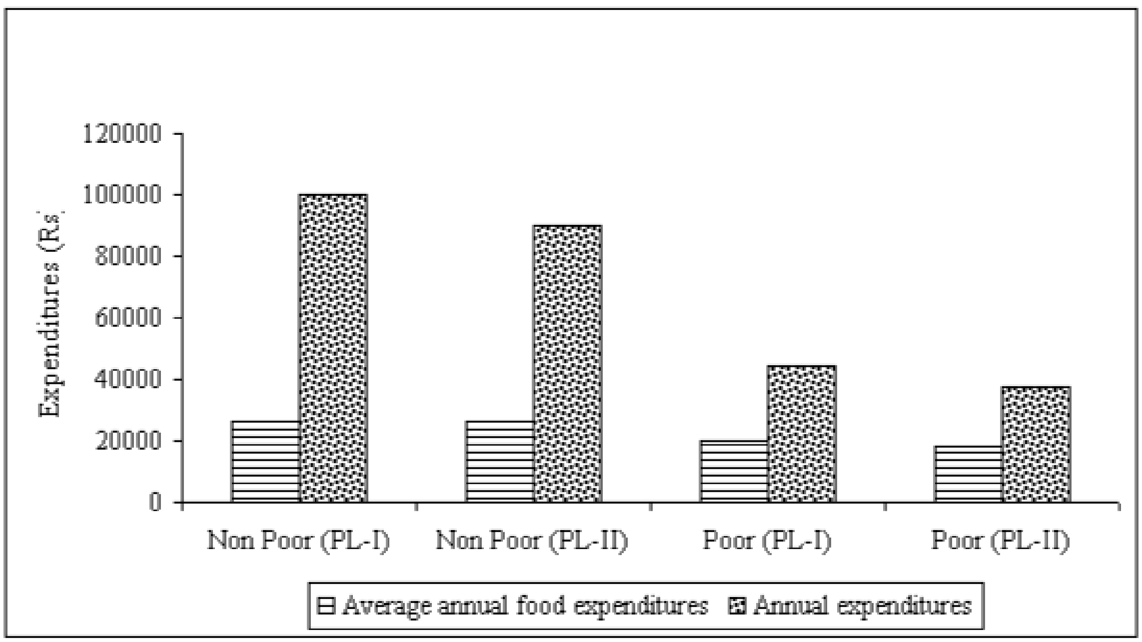


Figure 3.3.18. Per capita annual expenditures and per capita annual food expenditure by selected households in the study area by using PL-I and PL-II.

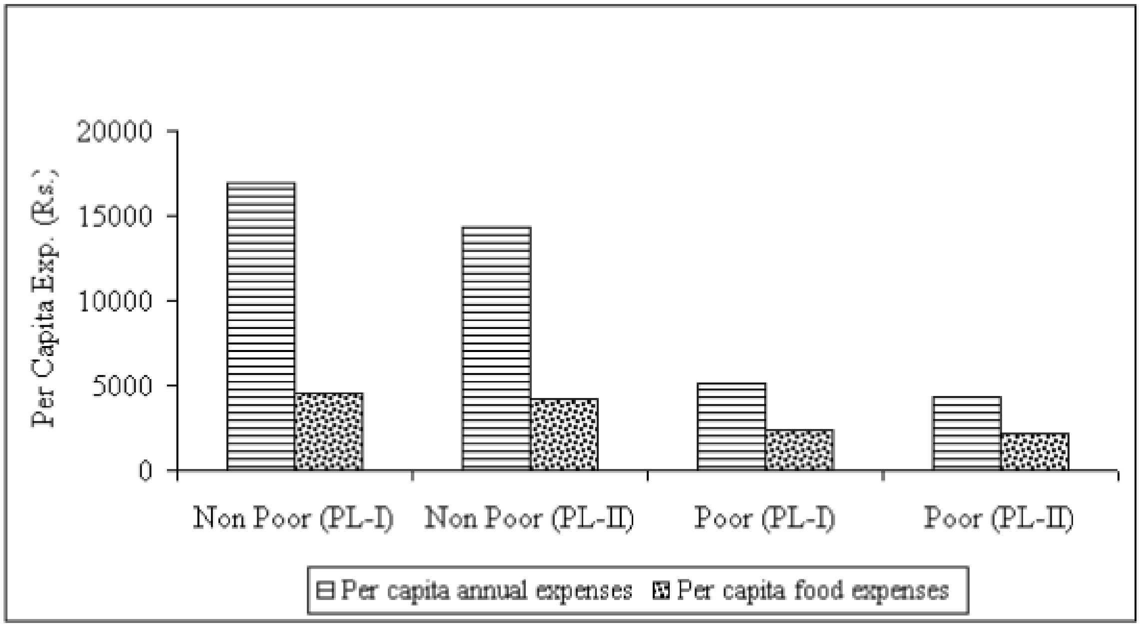


Figure 3.3.19. Proportionate share of annual food expenditure in annual total expenditure of selected households in the study area by using PL-I and PL-II.

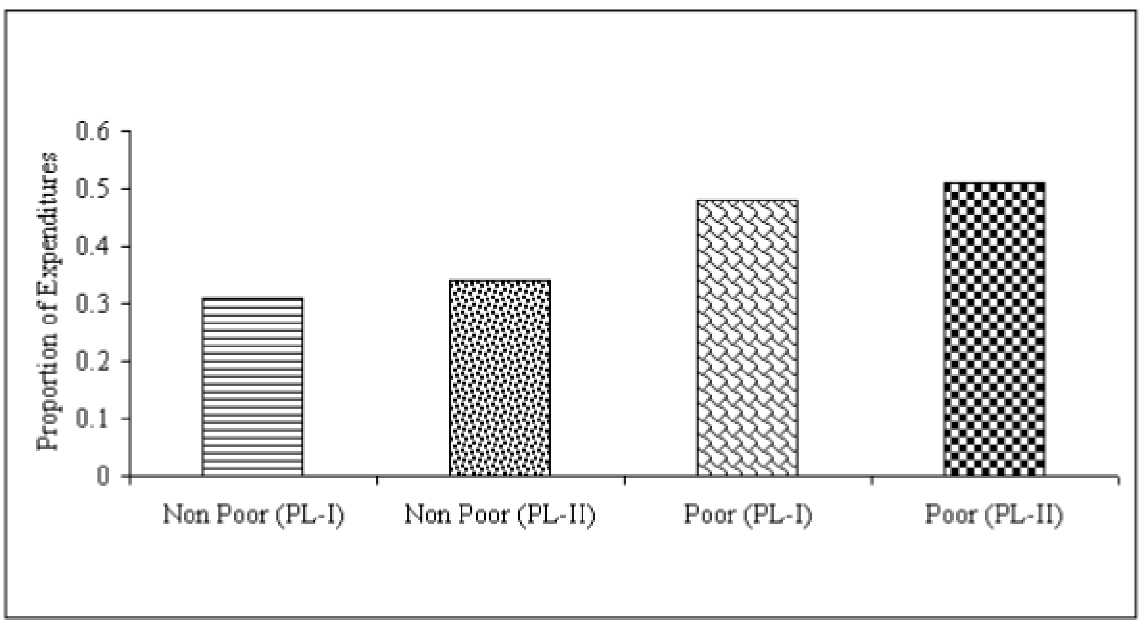
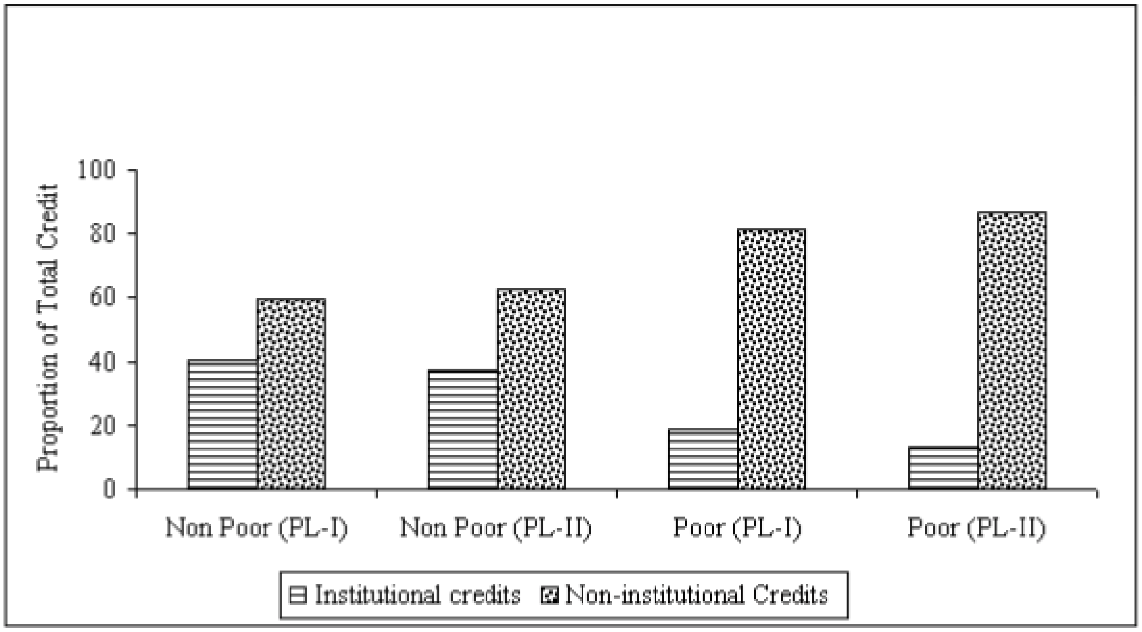


Figure 3.3.20. Proportionate share of institutional and non-institutional credit in total credit borrowing of selected households in the study area by using PL-I and PL-II.



Income Distribution across Sample Households

Gini-Coefficients and Lorenz Curves

In order to assess income distribution pattern and inequity in income distribution Gini Coefficients were estimated from the survey data. Gini coefficient is the most popular measure of inequality. Gini coefficient estimates the degree of inequality in distribution of incomes/expenditures across sample households.The value of Gini coefficient ranges from 0-1, where 0 shows complete equality while the value of 1 shows complete inequality. It is based on Lorenz curve that shows the relationship between cumulative percentages of population with cumulative percentages of incomes/expenditures.

Table 3.3.15 shows the Gini-coefficients estimated for income, expenditure and landholding across selected distributaries in the study area. An income Gini-coefficient of 0.58 was estimated for all the selected households. It was found that for 4 out of 10 selected distributaries, the value of income Gini-coefficient was higher than the overall estimate for the study area (0.58), indicating skewed income distribution across distributaries. The highest income inequality was observed for Hakra 4-R Distributary with a Gini-coefficient of 0.69 while the lowest inequality was for 13-R Saroki Distributary and 14-R Maggowal Distributary with similar Gini-coefficients of 0.51. It is attributed to greater inequality in land ownership and economic opportunities in Hakra 4-R Distributary, but more equity in resource endowment in 13-R Saroki and 14-R Maggowal distributaries. However, expenditure Gini-coefficient was fairly less than the income Gini-coefficient with a value of 0.39 for all the selected households in the study area indicating relatively less inequality in terms of expenditures than those for income. The highest expenditure Gini-coefficient was estimated for Khadir Distributary (0.43) and the lowest of 0.28 for Kakowal Distributary. Similarly, the estimate of land Gini-coefficient was around 0.49. The highest inequality in land distribution was estimated for Khadir Distributary while the lowest was for 10-R Dhup Sari Distributary with Gini-coefficients of 0.56 and 0.31, respectively. The former had a high Gini-coefficient due to the presence of large landowner as against a greater proportion of more equal small farmers in the latter case. Lorenz curves are also plotted for showing income, expenditures and land inequity across distributaries and for all the selected households in the study area. These are shown in Figure 3.3.21 to Figure 3.3.29.

Table 3.3.15. Gini-coefficient for income, expenditure and land across selected distributaries in the study area.

	Gini-Coefficients		
Distributaries	Income	Expenditure	Land
9-R Khoja Distributary	0.59	0.36	0.46
10-R Dhup Sari Distributary	0.55	0.33	0.31
13-R Saroki Distributary	0.51	0.29	0.38
14-R Maggowal Distributary	0.51	0.33	0.34
Phalia Distributary	0.63	0.32	0.52
Kakowal Distributary	0.58	0.28	0.38
Khikhi Distributary	0.53	0.37	0.51
Lalian Distributary	0.55	0.41	0.44
Khadir Distributary	0.60	0.43	0.56
Hakra 4-R Distributary	0.69	0.39	0.49
All	0.58	0.38	0.49

Figure 3.3.21. Lorenz curves for five selected distributaries in the study area with respect to income.

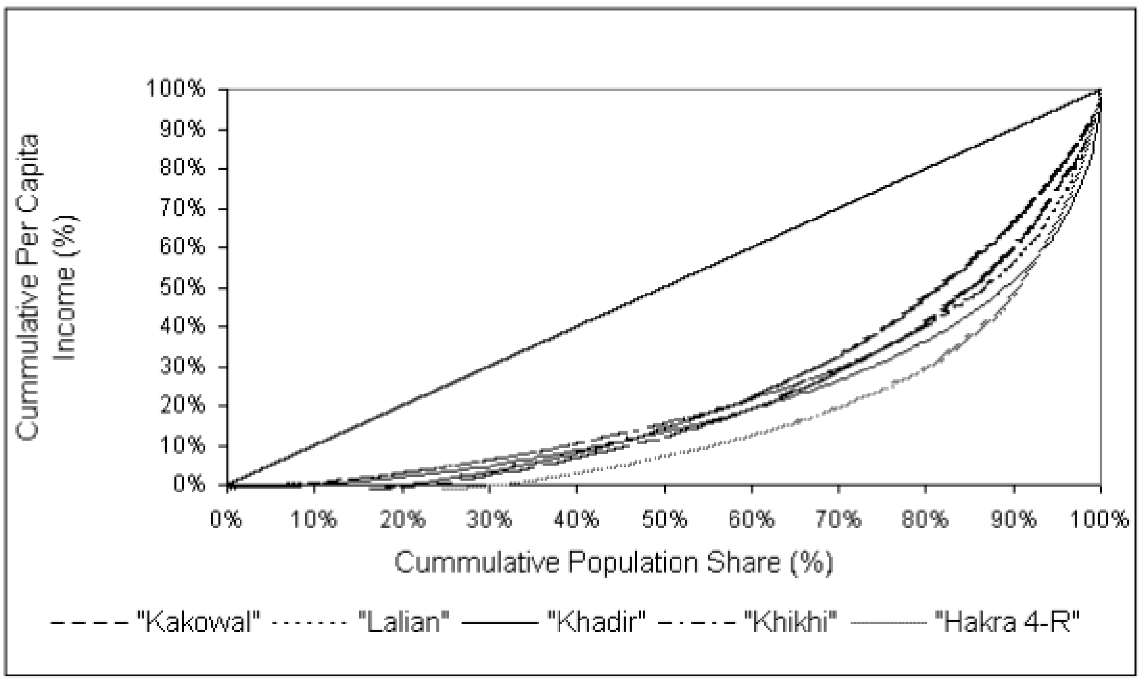


Figure 3.3.22. Lorenz curves for five selected distributaries in the study area with respect to income.

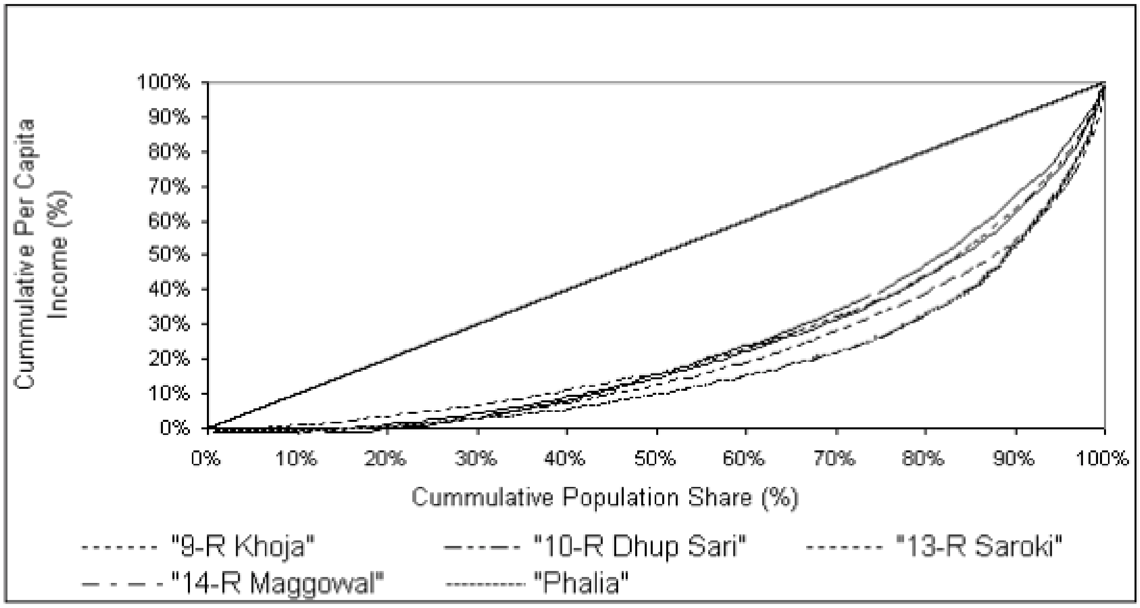


Figure 3.3.23. Lorenz curve for all the selected households in the study area with respect to income.

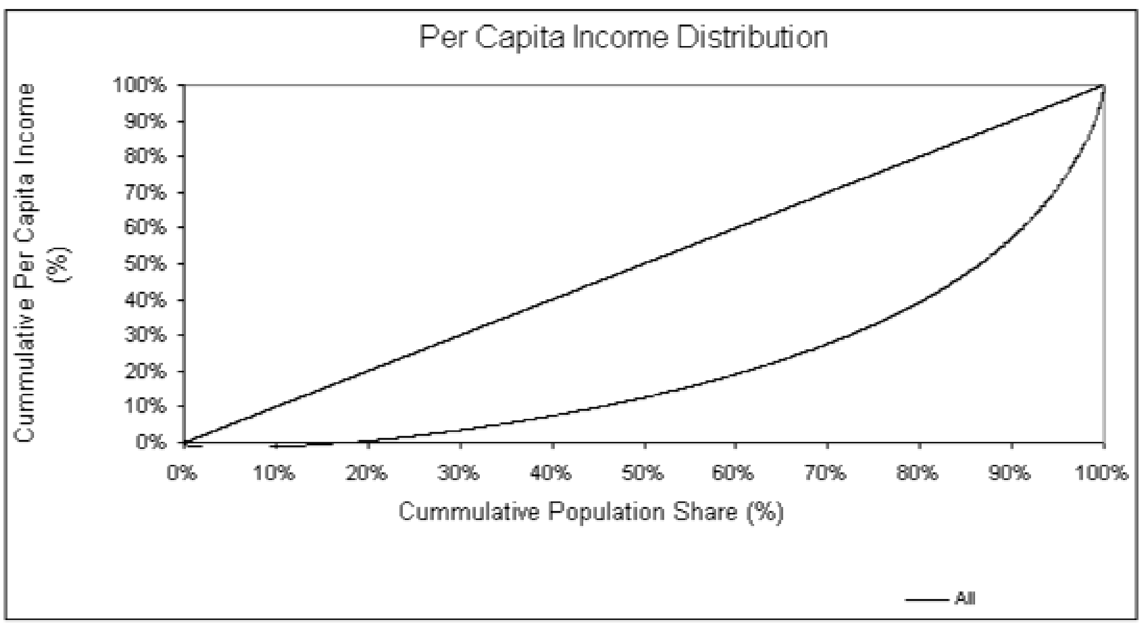


Figure 3.3.24. Lorenz curves for five selected distributaries in the study area with respect to expenditure.

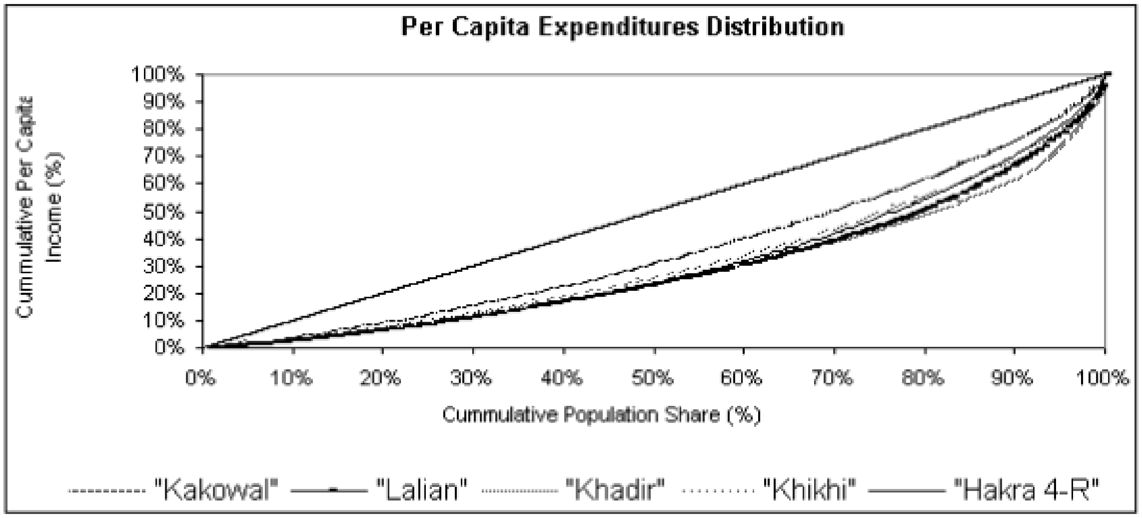


Figure 3.3.25. Lorenz curves for five selected distributaries in the study area with respect to expenditure.

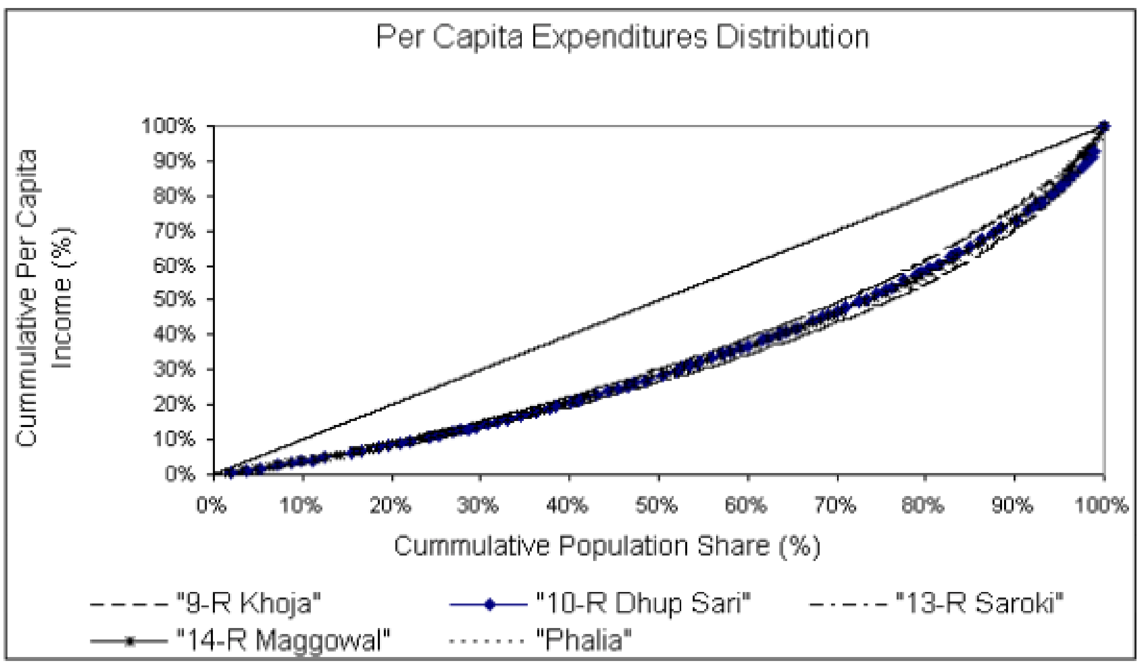


Figure 3.3.26. Lorenz curve for all selected households in the study area with respect to income.

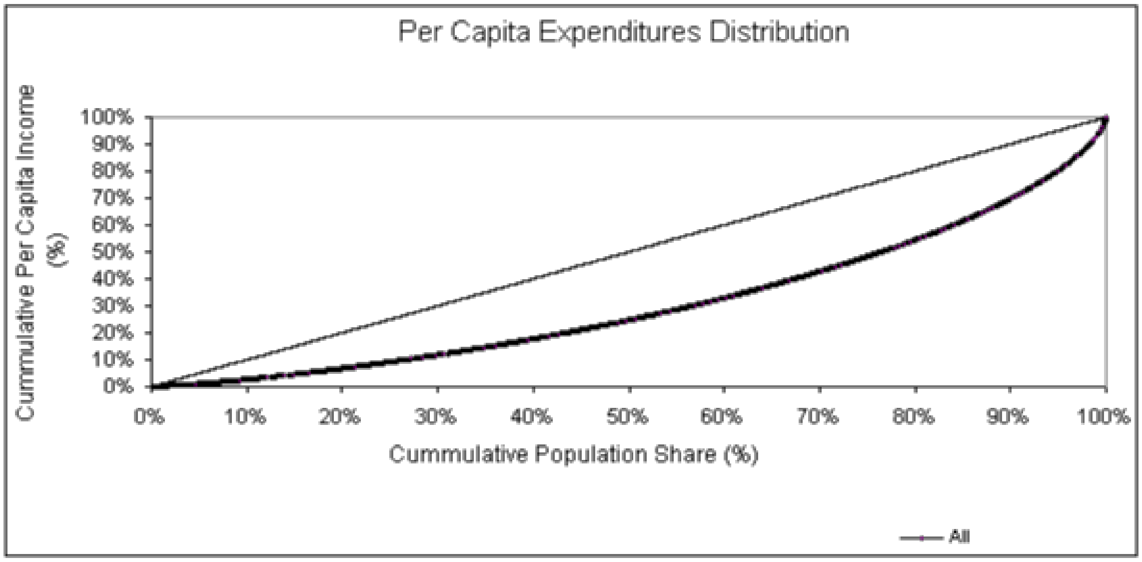


Figure 3.3.27. Lorenz curves across five selected distributaries in the study area with respect to land.

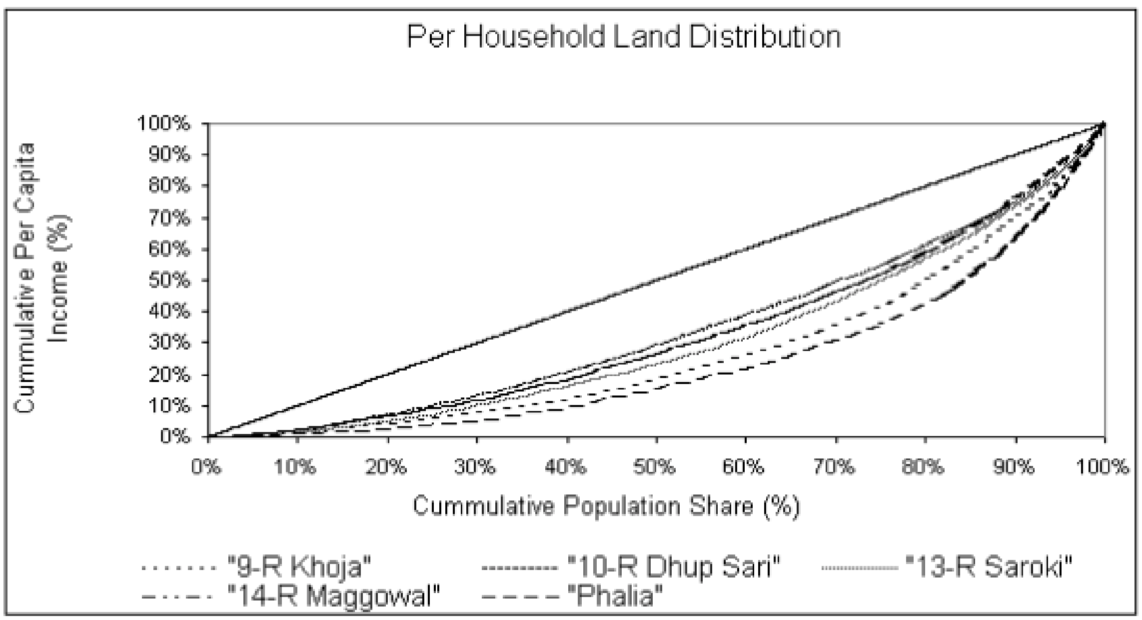


Figure 3.3.28. Lorenz curves across five selected distributaries in the study area with respect to land.

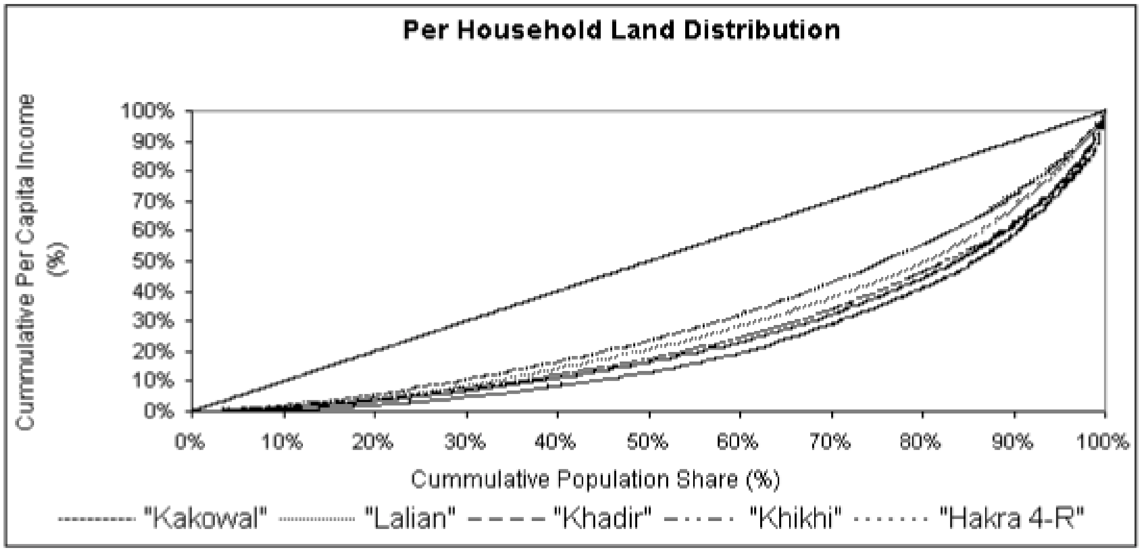
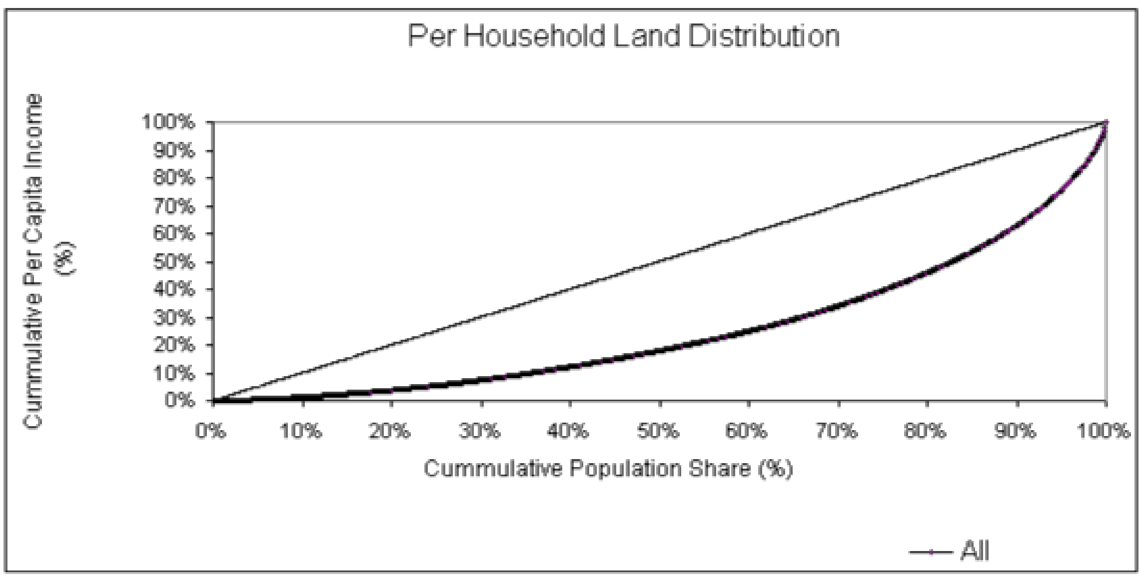


Figure 3.3.29. Lorenz curve for all selected households in the study area with respect to land.



Summary and Conclusions

- While using PL-I (Rs. 730 per capita per month), it was found that 59 percent of sample households were below poverty line. These households required 42 percent additional income for ensuring the basic needs basket to their members whereas the intensity of poverty was estimated to be about 22 percent. Analyses with PL-II (Rs. 530 per capita per month) showed that head count index was 43 percent with poverty gap and squared poverty gap estimates of 33 percent and 15 percent, respectively. These figures indicate that 43 percent of the households are in chronic poverty.

- Incidence of poverty was significantly low in Gujrat and Mandi Bahauddin districts, which have good quality groundwater when compared with Toba Tek Singh, Sargodha, and Bahawalnagar districts where groundwater quality is poorer.

- The head count poverty estimate was the highest for Khadir Distributary, and the lowest estimate was for 10-R Dhup Sari Distributary.

- Contrary to common perception, incidence of poverty was the highest at the head reaches while it was the lowest in the middle reach areas. However, poverty gap estimates indicated that depth of poverty was higher at the tail reaches as compared to head and middle reach areas. Similarly, severity of poverty was the highest at the tail reach areas and the lowest in the middle reach areas.

- Incidence, depth and severity of poverty were significantly higher among non-farm households when compared with that for farm households.

- For farm households, incidence of poverty was higher at the head reach area but depth and severity of poverty was higher at the tail reach areas. Additionally, incidence of chronic poverty was similar at the head and tail reach areas, though its depth and severity was higher among households at tail reaches.

- Poor households have larger family size with high dependency ratio households.

- Quality of housing for poor households was low compared with that for non-poor households.

- Poor households operated less farm area with significantly low profitability per hectare when compared with non-poor households.

- Higher proportions of poor household heads were primarily agricultural workers/laborers.

- Poor households achieved poor performance in agriculture (in terms of GVP and Gross Margins per hectare).

- Poor households had significantly low per capita income and expenditure, but with higher proportional spending on food items and lower access to institutional credit when compared with non-poor households.

- Annual crop income of the poor households was around one-fourth of the annual crop income of the non-poor households.

- Non-crop income of the poor households is bigger when compared with that of non-poor households.

- Remittances from abroad constitute a significantly higher proportion of the incomes of non-poor households when compared with those of the poor households.

- Per capita annual income of poor households was around one-third of the per capita income of the non-poor households.

- Incidence of poverty was the highest in Bahawalnagar District and was the lowest in Gujrat District.

- Incidence of poverty was the highest at Khadir Distributary areas and the lowest for10-R Dhup Sari Distributary.

- A higher proportion of the poor population was found sensitive to change in poverty line in Mandi Bahauddin District when compared with that of other districts.

- A higher percentage of poor population in 9-R Khoja and 14-R Maggowal distributaries showed sensitivity to change in poverty line.

- The highest poverty gap was estimated for the households in Bahawalnagar District while the lowest was for households in Mandi Bahauddin District.

- The highest poverty gap was estimated for households in the command area of Khadir Distributary while the lowest was worked out for 13-R Saroki Distributary area.

- Severity of poverty was the highest in Bahawalnagar District while it was the lowest in Mandi Bahauddin District.

- The peak for the severity of poverty was estimated for Khadir Distributary while the minimum was calculated for 13-R Saroki Distributary.

- Annual crop income of the poor households was around one-fourth of the annual crop income of the non-poor households.

- Non-crop income constitutes a bigger pie of the poor households when compared with the non-poor households.

- Remittances from abroad constitute a significantly higher proportion of the incomes of non-poor households when compared with those of the poor households.

- Per capita annual income of poor households was around one-third of the per capita income of the non-poor households.

4. DETERMINANTS OF POVERTY IN IRRIGATED AGRICULTURE

This section is divided into two sub-sections. The first sub-section quantifies determinants of household expenditures, and statistically test the significance of various determinants. Sub-section two quantifies determinants of poverty. The quantitative analyses will help understand key factors influencing household level expenditures and poverty. Analyses are carried out at various levels: district, distributary command, and canal reach level.

Determinants of Expenditure in Sample Areas

The specification of the model for annual expenditures is given below. Annual expenditures were regressed on a number of independent variables.

$$AE = \beta_0 + \beta_1 * NLH + \beta_2 * EduH + \beta_3 * FmlSize + \beta_4 * CrpInc + \beta_5 * NonCrpInc + \beta_6 * ValDur + \beta_7 * CrdIns + \beta_8 * CrdNinst + \beta_9 * PCI + e$$

AE	= Annual expenditures of the selected households (dependent variable)
NLH	= Net landholdings in hectares
EduH	= Education of the household head in years
FmlSize	= Family size in number
CrpInc	= Annual crop income of the households in rupees.
NonCrpInc	= Annual non-crop income of the households in rupees.
ValDur	= Total value of durable items in rupees
CrdIns	= Institutional credit in rupees
CrdNinst	= Non institutional credit in rupees
PCI	= Per capita income in rupees
β_0	= Constant term
$\beta_{1...}\beta_9$	= Coefficients to be estimated
e	= Error term

The variables included in the model are explained below:

Net Landholding

It was expected that higher net landholding would result in higher expenditures because this vital resource is directly linked with higher income and wealth in the rural economy. The coefficient of net landholding was expected to have a positive sign because more landholding simply means more income, which would consequently lead to higher level of expenditures for those households.

Education of Household's Head

As the head of household is the decision maker, the more he/she is educated, the better decision will be the outcome regarding income and expenditures. It was expected that higher education of the decision maker would result in higher expenditure that would result in ensuring the availability of basic needs basket. The coefficient of education for head of households was expected to have a positive sign.

Family Size

It was expected that higher family size would result in higher expenditures, with coefficient expected to carry a positive sign.

Annual Crop Income

Since the crop income is an -important part of household total income, it was expected that a higher crop income would result in higher expenditures. The coefficient of annual crop income was expected to have a positive sign.

Non-Crop Income

With the passage of time, rural economy has gone through certain structural changes. Non-crop income is increasingly becoming an important source of household income in rural areas. Increase in population has given rise to smaller landholdings due to subdivision, higher unemployment in agriculture sector and dependency on non-crop means of income. Therefore, it was expected that coefficient for non-crop income would have a positive sign reflecting that with an increase in non-crop income, households would spend more.

Total Value of Durable Items

Households with ownership of high value durable items like TV sets, refrigerators, air coolers and fans, etc. would increase the expenditures in terms of utility bills and maintenance. A positive sign of coefficient for total value of durable items was expected.

Institutional Credit

Access to institutional credit is assumed easy for non-poor households when compared with poor households mainly due to the possession of collaterals. Thus, it is expected that the higher institutional credit may lead to higher annual expenditures. Therefore, a positive sign of coefficient was expected for institutional credit.

Non-Institutional Credit

Access to non-institutional credit may be relatively easier than institutional credit. It was expected that households borrowed more of non-institutional credit than institutional credit. It was also expected that higher the amount borrowed, more would be the increase in annual expenditures. It was expected that the sign of the coefficient would be positive for non-institutional credit.

Per Capita Income

A household's per capita income indicates its ability to meet basic need requirements. It is expected that higher per capita income would result in higher annual expenditures incurred by the household members. The magnitude of the increase in expenditures due to increase in per capita income would depend on marginal propensity to consume. Higher the marginal propensity to consume, higher would be the total addition in expenditures incurred by the household.

Regression Results for Determinants of Expenditure in Sample Areas

The regression results are presented in Table 3.4.1. Equation had a R^2 value of 0.439 indicating that around 44 percent of the variation in annual expenditures was explained by the independent variables. The coefficients for the parameters were significant at 99 percent confidence level. Coefficient of net landholding was positive as expected; showing that with an increase in one hectare of household's area under crop would result in an increase of Rs. 1399 in household annual expenditures. Coefficient for the education of household head was positive and meant that one more completed year of education would cause increase in income, and ultimately, additional expenditures of Rs. 1312 for that household. The coefficient of family size was positive as expected showing that an increase of one member in the household size would result in an increment of annual expenditure of Rs. 2384. The positive signs were found for the coefficients of crop income and non-crop income though magnitude was higher for non-crop income than crop income. Magnitude of coefficients indicate that one rupee increase in crop income would result in Rs. 0.08 increase in annual expenditures when compared with increase of Rs. 0.14 for each rupee increase in non-crop income. As expected, an increase in money borrowed resulted in an increase in annual expenditures, shown by positive signs of coefficients for institutional and non-institutional credit. However, it was found that one rupee increase in institutional credit borrowed would result in Rs. 0.19 increase in annual expenditures. On the other hand, one rupee increase in non-institutional credit would result in 0.04 rupee increase in the annual expenditures of the households. Sign of coefficient for per capita income was positive, with one rupee increase in per capita income resulting in an increment of Rs. 0.51 in annual household expenditures. It was an important finding showing that half of the per capita income would go for household expenditures.

Table 3.4.1. Regression results for determinants of expenditure in the sample areas.

Variables	Coefficients	Std. Error	t-value	Sig.
(Constant)	14515.38	3302.028	4.396	0.00**
Net landholding (Ha)	1399.46	274.203	5.104	0.00**
Education of HHH (Years)	1312.84	274.983	4.774	0.00**

Family size (number)	2384.94	381.263	6.255	0.00**
Crop income (Rs.)	0.08	0.026	2.949	0.003**
Non-crop income (Rs.)	0.14	0.025	5.695	0.00**
Total value of durable items (Rs.)	0.06	0.007	8.909	0.00**
Institutional credit (Rs.)	0.19	0.027	7.082	0.00**
Non-institutional credit (Rs.)	0.04	0.02	2.175	0.03**
Per capita annual income (Rs.)	0.51	0.111	4.583	0.00**
F-statistics = 104.11	Sig. = 0.00**			
N = 1204	R2 = 0.439	df = 9		

** Significant at 99 percent confidence level.

Determinants of Expenditure across Different Reaches of Irrigation System (Head, Middle and Tail)

Owing to prevalent uncertainty and inequity in the distribution of canal water, location of the household at different reaches (head, middle and tail) is expected to influence access to canal irrigation water for irrigation purposes. It was expected that farmers at the head reach of the distributary were able to ensure relatively adequate and timely availability of good quality irrigation water due to their spatial advantage (being located at the head reach of the distributary). It was expected that, though, the sign for all the spatial (head, middle, and tail) dummies would be positive, the magnitude of the coefficients would be high for head and middle reaches than for the tail reach. The higher magnitude of spatial dummies is directly related to higher productivity and profitability of farming at the head and middle reaches than at the tail reach, enabling them to spend more due to higher incomes. Moreover, since it was found in the previous sections that productivity and profitability of farmers at the middle location was higher than at head and tail reach areas, a higher magnitude was expected for the middle reach area.

The above regression was further expanded to evaluate the disaggregated impact of household's location (head, middle and tail reaches) on annual expenditures.

The regression equation estimated was as follows:

$$AE = \beta_0 + \beta_1 * NLH + \beta_2 * EduH + \beta_3 * FmlSize + \beta_4 * CrpInc + \beta_5 * NonCrpInc + \beta_6 * ValDur + \beta_7 * CrdIns + \beta_8 * CrdNinst + \beta_9 * PCI + \beta_{10} * D_H + \beta_{11} * D_M + e$$

AE	= Annual expenditures of the selected households (dependent variable)
NLH	= Net landholdings in hectares
EduH	= Education of the household head in years
FmlSize	= Family size in number
CrpInc	= Annual crop income of the households in rupees.
NonCrpInc	= Annual non-crop income of the households in rupees
ValDur	= Total value of durable items in rupees
CrdIns	= Institutional credit in rupees
CrdNinst	= Non institutional credit in rupees
PCI	= Per capita income in rupees

D_H	= Dummy for head reach (If household is located at head reach, then it is equal to 1, otherwise =0)
D_M	= Dummy for middle reach (If household is located at middle reach, then it is equal to 1, otherwise =0)
β_0	= Constant term
$\beta_{1...}\beta_{11}$	= Coefficients to be estimated
e	= Error term

Regression Results for Determinants of Expenditure for Head, Middle and Tail

The results are shown in Table 3.4.2. It was found that 44 percent of the variation was explained by the independent variable as represented by an R-square value of 0.44. Signs of all the parameters were according to *a priori* expectations, though dummies for the head and middle reach areas were not significant. Rest of the coefficients were significant at 99 percent confidence level except coefficient for non-institutional credit, which was significant at 95 percent confidence level. It was estimated that one-hectare increase in net landholding would increase annual expenditures by Rs. 1405. One more completed year of education by household head would result in a Rs. 1319 increase in total annual expenditures incurred by a household. One member increase in family size will increase expenditures by Rs. 2396 per annum. One rupee increase in crop income would result in a Rs. 0.07 increase in annual expenditure while one rupee earned as non-crop income would increase the annual expenditures by Rs. 0.14. Similarly, one rupee borrowed from institutional sources would increase annual expenditures by Rs. 0.19 per year. Additionally, one rupee borrowed from non-institutional sources would result in a Rs. 0.04 increase in annual household expenditures. One rupee increase in per capita income would result in a Rs. 0.51 increase in annual expenditures of a household. Location of a household have positive effect on annual expenditures, though it was found insignificant. If a household was located at head reach areas, its annual expenditures would be higher, by Rs. 414 when compared with a household located at the tail reach areas. Similarly, if a household was located at the middle reach areas, its expenditure will be higher by Rs. 3114 as compared with a household located at the tail reach areas. The estimated results of the model were quite consistent with the previous findings of the report that households at the middle reaches were relatively better off when compared with the households at the head and tail reaches. It was mainly because of better irrigation water supply at middle reach, which led to better productivity.

Table 3.4.2. Regression results according to head, middle, and tail reach area.

Variables	Coefficients	Std. error	t-value	Sig.
(Constant)	13254.06	3679.612	3.602	0.00**
Net landholding (Ha)	1405.51	274.754	5.116	0.00**
Education of HHH (Years)	1319.04	275.699	4.784	0.00**
Family size (number)	2396.95	383.129	6.256	0.00**
Crop income (Rs.)	0.07	0.026	2.883	0.004**
Non-crop income (Rs.)	0.14	0.025	5.602	0.00**

Total value of durable items (Rs.)	0.06	0.007	8.937	0.00**
Institutional credit (Rs.)	0.19	0.027	7.101	0.00**
Non-institutional credit (Rs.)	0.04	0.02	2.117	0.034*
Per capita annual income (Rs.)	0.51	0.111	4.62	0.00**
Dummy for head reach	414.71	2980.499	0.139	0.889
Dummy for middle each	3114.58	2970.668	1.048	0.295
F-statistics = 85.248	Sig. = 0.00**			
N = 1204	R2 = 0.44	df = 11		

* Significant at 95 percent confidence level
** Significant at 99 percent confidence level

Determinants of Expenditure across Households in Different Districts

As discussed in the previous sections, it was found that the selected distributaries were located in different regions with different socio-economic and hydrological characteristics. The structure of annual income differed across these districts, and consequently, propensity to consume also varied. Positive signs were expected for coefficients; however, magnitude was expected to be tilted more towards the districts located in upper reaches of the basin (Gujrat and Mandi Bahauddin districts) due to higher average incomes of the households than districts in the middle reach (Sargodha and Toba Tek Singh districts) and the district at the tail reach of the system (Bahawalnagar district).

The following regression equation was estimated to separate the impact of household's location in different districts of the study area.

The regression equation estimated was as follows:

$$AE = \beta_0 + \beta_1 * NLH + \beta_2 * EduH + \beta_3 * FmlSize + \beta_4 * CrpInc + \beta_5 * NonCrpInc + \beta_6 * ValDur + \beta_7 * CrdIns + \beta_8 * CrdNinst + \beta_9 * PCI + \beta_{10} * D_G + \beta_{11} * D_{MN} + \beta_{12} * D_{TT} + \beta_{13} * D_S + e$$

AE	= Annual expenditures of the selected households (dependent variable)
NLH	= Net landholdings in hectares
EduH	= Education of the household head in years
FmlSize	= Family size in number
CrpInc	= Annual crop income of the households in rupees
NonCrpInc	= Annual non-crop income of the households in rupees
ValDur	= Total value of durable items in rupees
CrdIns	= Institutional credit in rupees
CrdNinst	= Non institutional credit in rupees
PCI	= Per capita income in rupees
D_G	= Dummy for Gujrat district (If household is located Gujrat district then it is equal to 1, otherwise =0)
D_{MN}	= Dummy for Mandi Bahauddin district, (If household is located in Mandi Bahauddin district then it is equal to 1, otherwise =0)
D_{TT}	= Dummy for Toba Tek Singh district (If household is located in Toba Tek Singh district, then it is equal to 1, otherwise =0)
D_S	= Dummy for Sargodha district (If household is located in Sargodha district, then it is equal to 1, otherwise =0)

β_0 = Constant term
$\beta_{1...}\beta_{13}$ = Coefficients to be estimated
e = Error term

Regression Results for Determinants of Expenditure across Households in Different Districts

The results of the regression equation are shown in Table 3.4.3, indicating that 45 percent of the variation in annual household expenditures was explained by independent variables. The signs of all the coefficients were according to *a priori* expectation though the significance varied. The coefficient of net landholding was positive and found significant at 99 percent confidence level. One-hectare increase in net landholding of the household would lead to an increase of Rs. 1703 in household annual expenditures. Coefficient of education of the household head was positive and significant at 99 percent confidence level. The regression equation shows that one more completed year of education of the household's head would increase annual expenditures by Rs. 1419. Family size was found positively correlated with annual expenditures at 99 percent confidence level. Increase of one member in the family size resulted in an increment of Rs. 2653 in household annual expenditures. The sign for coefficient of crop income was positive and significant at 95 percent confidence level. It showed that one rupee increase in crop income would result in an increase of Rs. 0.06 in annual expenditures. Similarly, coefficient of non-crop income was positive and significant at 99 percent confidence level indicating that one rupee increase in non-crop income would result in a Rs. 0.15 increase in annual expenditures of a household. Coefficient of per capita income was positive and significant at 99 percent confidence level, with one rupee increase in per capita income resulting in an increase of Rs. 0.55 per annum in expenditures incurred by a household. The coefficients estimated for district dummies were positive and significant. Average annual expenditures differed significantly across districts. Household annual expenditures were higher by Rs. 20298 for Gujrat, Rs. 19169 for Mandi Bahauddin, by Rs. 9462 for Toba Tek Sing, and by Rs. 8293 for Sargodha when compared with household expenditures in Bahawalnagar district. The results of the model were consistent with the previous findings of the report that all the districts had less concentration of poverty when compared with Bahawalnagar District. Gujrat and Mandi Bahauddin districts were better off because of good quality groundwater and better farm employment opportunities.

Table 3.4.3. Regression results across districts.

Variables	Coefficients	Std. Error	t-value	Sig.
(Constant)	639.80	4660.281	0.137	0.891
Net landholding (Ha)	1703.72	278.923	6.108	0.00**
Education of HHH (Years)	1419.19	276.029	5.141	0.00**
Family size (number)	2653.33	389.197	6.817	0.00**
Crop income (Rs.)	0.06	0.026	2.518	0.012*
Non-crop income (Rs.)	0.15	0.025	5.864	0.00**
Total value of durable items (Rs.)	0.04	0.009	5.112	0.00**

Institutional credit (Rs.)	0.19	0.026	7.054	0.00**
Non-institutional credit (Rs.)	0.03	0.02	1.68	0.093
Per capita annual income (Rs.)	0.55	0.11	4.947	0.00**
Dummy for Gujrat district	20298.27	4835.605	4.198	0.00**
Dummy for Mandi Bahauddin district	19169.05	4318.138	4.439	0.00**
Dummy for Toba Tek Singh district	9462.32	4552.268	2.079	0.038*
Dummy for Sargodha district	8293.37	3952.38	2.098	0.036*
F-statistics = 75.16	Sig. = 0.00**			
N = 1204	R^2 = 0.451	df = 13		

* Significant at 95 percent confidence level
** Significant at 99 percent confidence level

Determinants of Expenditure across Households in Different Distributaries

The following regression equation was estimated to separate the impact of household's location across distributaries in the study area. The regression equation estimated is given as follows:

$$AE = \beta_0 + \beta_1 * NLH + \beta_2 * EduH + \beta_3 * FmlSize + \beta_4 * CrpInc + \beta_5 * NonCrpInc + \beta_6 * ValDur + \beta_7 * CrdIns + \beta_8 * CrdNinst + \beta_9 * PCI + \beta_{10} * D_{KJ} + \beta_{11} * D_{DS} + \beta_{12} * D_{SR} + \beta_{13} * D_{MG+} + \beta_{14} * D_{PH+} + \beta_{15} * D_{KW+} + \beta_{16} * D_{LN+} + \beta_{17} * D_{KD+} + \beta_{18} * D_{KI+} e$$

AE	= Annual expenditures of the selected households (dependent variable)
NLH	= Net landholdings in hectares
EduH	= Education of the household head in years
FmlSize	= Family size in numbers
CrpInc	= Annual crop income of the households in rupees
NonCrpInc	= Annual non-crop income of the households in rupees
ValDur	= Total value of durable items in rupees
CrdIns	= Institutional credit in rupees
CrdNinst	= Non-institutional credit in rupees
PCI	= Per capita income in rupees
D_{KJ}	= Dummy for 9-R Khoja distributary (If household is located 9-R Khoja distributary then it is equal to 1, otherwise 0)
D_{DS}	= Dummy for 10-R Dhup sari distributary (If household is located in 10-R Dhup sari distributary then it is equal to 1, otherwise 0)
D_{SR}	= Dummy for 13-R Saroki distributary (If household is located in 13-R Saroki distributary, then it is equal to 1, otherwise 0)
D_{MG}	= Dummy for 14-R Maggowal distributary (If household is located in 14-R Maggowal distributary, then it is equal to 1, otherwise 0)
D_{PH}	= Dummy for Phalia distributary (If household is located in Phalia distributary, then it is equal to 1, otherwise 0)
D_{KW}	= Dummy for Kakowal distributary (If household is located in Kakowal distributary, then it is equal to 1, otherwise 0)
D_{LN}	= Dummy for Lalian distributary (If household is located on Lalian distributary, then it is equal to 1, otherwise 0)
D_{KI}	= Dummy for Khadir distributary (If household is located on Khadir distributary,then it is equal to 1, otherwise 0)
β_0	= Constant term

$\beta_{1...}\beta_{18}$ = Coefficients to be estimated
e = Error term

Regression Results for Determinants of Expenditure among Households across Different Distributaries

The results are presented in Table 3.4.4. Estimated equation has an R^2 value of 0.454, indicating that 45.4 percent variation in annual expenditures was explained by the independent variables. Signs of all the coefficients were according to the *a priori* expectations though magnitude and significance was different. Sign of the coefficient of net landholding was positive and found significant at 99 percent confidence level. One hectare increase in net landholding would result in an increase of Rs. 1746 in annual household expenditures. Coefficient for education of the head of a household was found positive and significant at 99 percent confidence level. One completed year of additional education of a household head would result in an increment of Rs. 1376 in annual expenditures. Family size was found positively correlated with annual expenditures and its coefficient was found significant at 99 percent confidence level. An increase of one member in the household size would lead to an increment of Rs. 2652 in annual expenditures incurred by a household. Coefficients of crop income and non-crop income had positive signs but were significant at 95 and 99 percent confidence levels, respectively. An addition of Rs 1 from crop income and non-crop income would result in an increase of Rs. 0.06 and Rs. 0.14 in annual expenditures of a household, respectively. An increment of one rupee in per capita income of the household would result in a Rs. 0.55 increase in annual expenditures of a household and the coefficient was found significant at 99 percent confidence level. Moreover, significant variation in annual expenditures of the households was estimated across different selected distributaries, signs of coefficients were positive. Coefficients of all the distributaries were found significant at 99 percent confidence level except for Khikhi and Khadir distributaries. The coefficient for Khikhi distributary was significant at 95 percent confidence level while that for Khadir was insignificant. Household annual expenditures were for all distributaries when compared with Hakra-4R, with expenditures greater by Rs 22343 for 9-R Khoja distributary and Rs. 3472 for Khadir distributary. The results of the model were consistent with findings regarding poverty across the distributaries. The specific results regarding Khadir distributary were due to comparatively skewed land distribution, while greater concentration of poverty at 4-R Hakra distributary was because of poor quality of groundwater and less canal water supplies, which was one of the important factors that aggravate poverty.

Table 3.4.4. Regression results across distributaries.

Variables	Coefficients	Std. Error	t-value	Sig.
(Constant)	667.92	4659.935	0.143	0.886
Net landholding (Ha)	1746.79	279.681	6.246	0.00**
Education of HHH (Years)	1376.48	279.757	4.92	0.00**
Family size (number)	2652.35	389.134	6.816	0.00**
Crop income (Rs.)	0.06	0.026	2.372	0.018*

Non-crop income (Rs.)	0.14	0.025	5.819	0.00**
Total value of durable items (Rs.)	0.04	0.009	5.111	0.00**
Institutional credit (Rs.)	0.19	0.027	6.961	0.00**
Non-institutional credit (Rs.)	0.04	0.02	1.724	0.085
Per capita annual income (Rs.)	0.55	0.11	5.024	0.00**
Dummy for 9-R Khoja Distributary	22343.25	5750.517	3.885	0.00**
Dummy for 10-R Dhupsari Distributary	18194.73	5761.475	3.158	0.002**
Dummy for 13-R Saroki Distributary	16646.47	5762.17	2.889	0.004**
Dummy for 14-R Maggowal Distributary	20572.02	5788.581	3.554	0.00**
Dummy for Phalia Distributary	23041.32	5754.065	4.004	0.00**
Dummy for Kakowal Distributary	16508.97	5821.161	2.836	0.005**
Dummy for Khikhi Distributary	9555.43	4549.735	2.1	0.036*
Dummy for Lalian Distributary	13234.73	4571.625	2.895	0.004**
Dummy for Khadir Distributary	3471.95	4558.236	0.762	0.446
F-statistics = 54.72	Sig. = 0.00**			
N = 1204	R2 = 0.454	df = 18		

* Significant at 95 percent confidence level
** Significant at 99 percent confidence level

Determinants of Poverty among Households across Reaches of Distributaries

Logit modeling technique was used to test the null hypothesis that there were no significant differences in the incidence of poverty across head, middle and tail reach areas. Dependent variable, poverty, is binary variable with values 1 or 0. Coefficients of independent variables indicate the probability of being poor or not poor with respect to independent variables.

The model specification is as follows:

Dependent variable = Poverty (if poor, then 1, otherwise 0)

$$Poverty = \beta_0 + \beta_1 * FS + \beta_2 * DR + \beta_3 * Edu\_HH + \beta_4 * NLH + \beta_5 * GVP\_Ha + \beta_6 * D_M + \beta_7 * D_T + e$$

FS	= Family size in number
DR	= Dependency ratio
Edu_HH	= Number of formal schooling years completed by household head.
NLH	= Net landholding (hectares)
GVP_Ha	= predicted values gross value of production per hectare (in thousand rupees)
D_M	= Dummy for the middle location (if household is located at middle reach =1, otherwise =0)
D_T	= Dummy for the tail location (if household is located at tail reach =1, otherwise =0)
β_0	= Constant term

$\beta_{1...}\beta_7$ = Coefficients to be estimated
e = Error term

From the estimated coefficients of the model, marginal effect of each independent variable was calculated. The marginal probability is defined by the partial derivative of the probability that dependent variable assumes a value of 1 with respect to that independent variable. The marginal probability is defined by

$$\partial P / \partial B = f\ (BX)\ B$$

B is the slope of the coefficient. X is the independent variable while *f* is the density function of the cumulative probability distribution function [F(BX)], which ranges from 0 to 1). The marginal effect could be interpreted as the change in the probability of household being poor with a one-unit increase in the explanatory variable. The marginal probability values were estimated at the mean values of the explanatory variables.

Regression Results for Determinants of Poverty among Households across Different Reaches of Distributaries

The results of the Logit regression are presented in Table 3.4.5. Signs of the explanatory variables were in conformity with the *a priori* expectations. All the coefficients except dummies for the middle and tail were found significant at 99 percent level of confidence. Results indicate that one member increase in the family would increase the probability of being poor by 0.026. One unit increase in dependency ratio would increase the probability of being poor by 0.246. One more completed year of household head's education would decrease the probability of household being poor by 0.017. Similarly, one hectare increase in net landholding would reduce the probability of being poor by 0.035. An increase of rupees one thousand in gross value of production per hectare would diminish the probability of being poor by 0.009. Probability of being poor would increase by 0.012 and 0.96, in the household were located at middle and tail reach areas, respectively, instead of the head reach. The results shown in Table 3.4.5 rejected the hypothesis that there was no significant difference in the incidences in poverty across head and middle reach areas when compared with the tail reach areas since the dummy for the tail reach was significant at 90 percent confidence level. Dummy for middle reach areas also indicated higher incidence of poverty though non-significant when compared with the head reach areas.

Table 3.4.5. Regression results according to location of households at distributaries.

Variable	Coefficients	Std. Error	Sig.	Marginal Probability
Constant	0.756	0.233	0.001**	0.143
Family size (Number)	0.125	0.023	0.00**	0.026
Dependency ratio (ratio)	1.178	0.287	0.00**	0.246
Education of the household head (years)	-0.069	0.016	0.00**	-0.017
Dummy for middle reach	0.05	0.174	0.775	0.012

Dummy for tail reach	0.31	0.179	0.083	0.096
Net landholding (ha)	-0.148	0.021	0.00**	-0.035
Gross value of production per hectare (thousands)	-0.055	0.005	0.00**	-0.009
-2 Log likelihood = 1193.546				
Cox & Snell R square = 0.271				
Nagelkerke R square = 0.371				
Chi-square = 380.269	Df = 7	Sig. = 0.00**		

** Significant at 99 percent confidence level

Determinants of Poverty among Households across Different Farm Sizes

Since the land is inequitably distributed in the study areas, there may be differences in incidence of poverty across various land size groups. The following Logit regression was estimated to test the hypothesis that under prevailing conditions, there exists no significant difference in the incidence of poverty for households with small, medium or large landholdings.

Dependent variable = Poverty (if poor, then 1, otherwise 0)

$$Poverty = \beta_0 + \beta_1 * FS + \beta_2 * DR + \beta_3 * Edu\_HH + \beta_4 * GVP\_Ha + \beta_5 * D_S + \beta_6 * D_M + \beta_7 * D_L + e$$

FS	= Family size in number
DR	= Dependency ratio
Edu_HH	= Number of formal schooling years completed by household head
GVP_Ha	= Predicted values gross value of production per hectare (in thousand rupees)
D_S	= Dummy for the small farmers (if farm size is 2.01-5 hectares, then1, otherwise 0)
D_M	= Dummy for the medium farmers (if farm size is 5.01-10 hectares, then 1, otherwise0)
D_L	= Dummy for the large farmers (if farm size is 10.01 and above hectares, then 1, otherwise 0)
β_0	= Constant term
$\beta_{1...}\beta_7$	= Coefficients to be estimated
e	= Error term

In order to capture the relationship between poverty and farm size, categorical dummies of farm size were introduced. Under prevailing conditions, larger the farm size, more proportionate the share of surface irrigation water available. It means that larger farm size would enable the farm households to acquire more irrigation water by installing the tubewells along with the surface water. Consequently, the larger farm household may have greater gross margins than small farmer and would be less prone to poverty than the small farmer.

Regression Results for Determinants of Poverty among Households across Farm Sizes

The results of the model are shown in Table 3.4.6. Signs of the coefficient were in conformity with the *a priori* expectations and were logical. All the coefficients were found significant at 99 percent confidence level. Higher family size would increase the probability of a household to become poor. Estimates show that the increase of one member in the family size would increase the probability of the household to be poor by 0.038. Lower dependency ratio would decrease the probability of being poor and vice versa. Education of the household head showed inverse relationship with incidence of poverty. One more completed year of formal education would reduce the probability of household to be poor by 0.016. Gross value of production per hectare also showed negative relationship with poverty. It was estimated that an increase of a thousand rupees in GVP would reduce the probability of a household to become poor by 0.016. The dummies for farm size show that probability of household to become poor decreases with the rise in farm size. It was estimated that probability of becoming poor decreases by 0.129, 0.328, and 0.638 for small, medium and large farmers compared to marginal farmers (having farm size of up to 2 hectares), respectively. Thus, when compared with farm households having landholdings less than 2 hectares, probability of higher incidence of poverty for larger farm households was significantly less which rejects the null hypothesis that incidence of poverty was not significantly different for marginal, small, medium and large households. Hence, we accept the alternate hypothesis that under existing conditions, marginal and smaller farmers receive fewer benefits from irrigation than large farmers and are more prone to fall in the poverty trap.

Table 3.4.6. Regression results according to farm size.

Variable	Coefficients	Std. Error	Sig.	Marginal Probability
Constant	1.108	0.270	0.000**	0.272
Family size (Number)	0.154	0.026	0.000**	0.038
Dependency ratio (ratio)	0.992	0.324	0.002**	0.243
Education of the household head (years)	-0.064	0.017	0.000**	-0.016
Gross value of production per hectare (thousands)	-0.066	0.007	0.000**	-0.016
Dummy for small farmer (2.01-5 ha)	-0.525	0.197	0.008**	-0.129
Dummy for medium farmer (5.01-10 ha)	-1.338	0.248	0.000**	-0.328
Dummy for large farmer (above 10 ha)	-2.600	0.347	0.000**	-0.638
-2 Log likelihood = 935.575				
Cox & Snell R square = 0.274				
Nagelkerke R square = 0.367				
Chi-square = 284.7285	Df = 7	Sig. = 0.00**	N=891	

** Significant at 99 percent confidence level

Determinants of Poverty across Households and Groundwater Quality

Groundwater is an important source of irrigation, along with surface water. However, groundwater quality varies across distributaries, with various impacts on productivity and profitability of crop production. Therefore, quality of groundwater was considered as an important factor that might seriously affect agricultural productivity, and ultimately, farm income of households. The groundwater quality of Hakra 4-R, Khikhi and Lalian distributaries was found poor and farmers were mainly dependent on surface water supplies for agricultural purposes. The following regression equation estimated the relationship between groundwater quality and incidence of poverty across different groundwater quality areas.

The model specification is as follows:

Dependent variable = Poverty (if poor, then 1, otherwise 0)

$$Poverty = \beta_0 + \beta_1 * FS + \beta_2 * DR + \beta_3 * Edu\_HH + \beta_4 * NLH_{+} + \beta_5 * GVP\_Ha + \beta_6 * D_{GW} + e$$

FS	= Family size in number
DR	= Dependency ratio
Edu_HH	= Number of formal schooling years completed by household head
NLH	= Net landholding (hectares)
GVP_Ha	= Predicted values gross value of production per hectare (in thousand rupees)
D_{GW}	= Dummy for the groundwater quality (if the farm household is located in the canal command of Hakra 4-R, Khikhi and Lalian distributaries, then1, otherwise 0)
β_0	= Constant term
$\beta_{1...}\beta_6$	= Coefficients to be estimated
e	= Error term

Regression Results for Determinants of Poverty across Households and Groundwater Quality

Results of the estimated equation are presented in Table 3.4.7. All the variables show signs for the *a priori* expectations and were significant at 99 percent confidence level except the dummy for the poor quality of groundwater, which was found significant at 90 percent confidence level. The dummy for the poor quality of groundwater had positive correlation with poverty. It was estimated that if farm household is located in an area of poor quality groundwater (as is the case of farm households in Hakra 4-R, Khikhi and Lalian distributaries), its probability of being poor increased by 0.057 when compared with farm households located in areas of good quality groundwater.

Table 3.4.7. Regression results according to quality of groundwater.

Variable	Coefficients	Std. Error	Sig.	Marginal Probability
Constant	0.857	0.205	0.000**	0.189
Family size (number)	0.115	0.023	0.000**	0.025
Dependency ratio (ratio)	1.197	0.287	0.000**	0.264
Education of the household head (years)	-0.070	0.016	0.000**	-0.016
Net landholding (ha)	-0.145	0.021	0.000**	-0.032
Gross value of production per hectare (thousands)	-0.056	0.005	0.000**	-0.012
Dummy for poor quality groundwater	0.257	0.150	0.086	0.057
-2 Log likelihood = 1194.012				
Cox & Snell R square = 0.270				
Nagelkerke R square = 0.371				
Chi-square = 379.8032	Df = 6	Sig. = 0.00**	N=1205	

** Significant at 99 percent confidence level

Determinants of Poverty among Households across Districts

The following equation was estimated using district dummies.

Poverty = $\beta_0 + \beta_1 * FS + \beta_2 * DR + \beta_3 * Edu\_HH + \beta_4 * NLH {}_{+} + \beta_5 * GVP\_Ha + \beta_6 * D_G + \beta_7 * D_M + \beta_8 * D_S + \beta_9 * D_T + e$

Dependent variable = Poverty (if poor then 1, otherwise 0)

FS	= Family size in number
DR	= Dependency ratio
Edu_HH	= Number of formal schooling years completed by household head
NLH	= Net landholding (hectares)
GVP_Ha	= predicted values gross value of production per hectare (in thousand rupees)
D_G	= Dummy for the Gujrat district (if household is located in Gujrat district, then 1, otherwise 0)
D_M	= Dummy for the Mandi Bahauddin district (if household is located in Mandi Bahauddin district, then 1, otherwise 0)
D_S	= Dummy for the Sargodha district (if household is located in Sargodha district, then 1, otherwise 0)
D_T	= Dummy for the Toba Tek Singh district (if household is located in Toba Tek Singh district, then 1, otherwise 0)
β_0	= Constant term
$\beta_{1...}\beta_9$	= Coefficients to be estimated
e	= Error term

Regression Results for Determinants of Poverty among Households across Districts

The results of the Logit regression are presented in Table 3.4.8. Signs of the explanatory variables were in conformity with the *a priori* expectations. All the coefficients except dummies for Mandi Bahauddin, Toba Tek Singh and Sargodha districts were found significant at 99 percent confidence level. However, dummies for Mandi Bahauddin and Toba Tek Singh were significant at 95 percent confidence level. Coefficient of dummy for Sargodha district was found insignificant. Results indicate that one member increase in family would increase the probability of household being poor by 0.026. One unit change in dependency ratio would increase the probability of being poor by 0.283. One more completed year of household head's education would decrease the probability of household being poor by 0.014. Similarly, an increase in land area would result in less probability of the household to be poor. One hectare increase in net landholding would reduce the probability of being poor by 0.034. An increase of one thousand rupee in gross value of production per hectare would diminish the probability of being poor by 0.012. It was also found that the probability of being poor decreases by 0.175, 0.115, 0.121, and 0.04, if households were located in Gujrat, Mandi Bahauddin, Toba Tek Singh and Sargodha districts, respectively, instead of Bahawalnagar district. It clearly indicates that the probability of household to be poor was lower if it were located in Gujrat district as compared with a household in Bahawalnagar district.

Table 3.4.8. Regression results according to districts.

Variable	Coefficients	Std. Error	Sig.	Marginal Probability
Constant	1.318	0.29	0.00**	0.290
Family size (number)	0.116	0.023	0.00**	0.026
Dependency ratio (ratio)	1.286	0.294	0.00**	0.283
Education of the household head (years)	-0.066	0.016	0.00**	-0.014
Dummy for Gujrat District	-0.796	0.271	0.003**	-0.175
Dummy for Mandi Bahauddin District	-0.523	0.241	0.03*	-0.115
Dummy for Toba Tek Singh District	-0.548	0.274	0.046*	-0.121
Dummy for Sargodha District	-0.179	0.243	0.46	-0.040
Net landholding (ha)	-0.156	0.021	0.00**	-0.034
Gross value of production per hectare (thousands)	-0.055	0.005	0.00**	-0.012
-2 Log likelihood = 1184.536				
Cox & Snell R square = 0.276				
Nagelkerke R square = 0.379				
Chi-square = 389.278	Df = 9	Sig. = 0.00**		

* Significant at 95 percent confidence level
** Significant at 99 percent confidence level

Summary and Conclusions

- An increase in family size increased the probability of a household to be poor.
- An increase in dependency ratio enhances the chances of a household to be poor.
- An increase in the landholding size reduces the probability of a household to be poor.
- An increase in productivity per hectare reduces the probability of being poor.
- Households at tail reach areas are more prone to the risk of being poor when compared with households at the head reach of the irrigation system.
- Tail reach area can be characterized as a low productivity area, usually receiving less irrigation water per hectare and tagged with high incidence of poverty.
- Households with well-educated heads are less prone to the risk of being poor.
- More investment on education is needed to improve the livelihoods of the rural population.
- Large farmers were found to be the main beneficiaries of the irrigation water than marginal and small farmers and their probability to be poor was significantly less than that of the households with small landholdings.
- A new round of land reconsolidation is required to address the issue of rural poverty in Pakistan.
- Efforts to improve the productivity of the agriculture sector should be more effective and efficient.
- Population planning requires immediate attention in order to curb further population increase.
- More employment creation activities for the rural population in non-agricultural sector are required to increase the number of earners as well as the income of the households.
- Incidence of poverty is higher in those irrigated areas where groundwater quality is poor due to higher concentration of salts.

5. IRRIGATION SYSTEM PERFORMANCE: IMPLICATIONS FOR THE POOR

Historically, Pakistan's irrigation system was developed to support a cropping intensity of around 70 percent with emphasis on extensive rather than intensive cultivation of land. With a population boom (spread over decades since independence), the need for improving productivity has increased and put stress on available resources for efficient allocation and utilization. In this scenario, not only the land and water productivity at farm level but also at watercourse and distributary command level in the irrigation system has to be increased. Comparison of irrigation system performance would enhance the understanding of constraints faced by the farmers and the system managers that need to be addressed for achieving higher efficiency and productivity in irrigated agriculture.

This chapter is divided into two parts. In the first part, performance of various irrigation systems (Distributaries) is compared using a set of indicators developed based on broad criteria of productivity, equity, and water supply, systems sustainability and system management. In the second part, regression analysis is carried out to test various hypotheses.

Irrigation Performance

Various performance indicators have been developed and used for the assessment of efficiency of irrigation systems in the project areas under the study. Abernethy (1989) defined performance as, "… measured levels of achievement in terms of one, or several, parameters, which are chosen as indicators of the system's goals." These indicators help in comparing the commonalities resulting in comparative categorization of irrigation systems. Murray-Rust and Snellen (1993) described performance indicators as they " do more than measure the value of a particular item such as yield or canal discharge. They have to include a measure of quality as well as of quantity, and be accompanied by appropriate standards or permissible tolerances. If the value of indicators falls outside a particular range of values then performance is presumed to be unsatisfactory". As performance is influenced by a number of factors, several of the performance indicators were used to assess the absolute and relative performance of irrigation systems based on the productivity of the irrigation system, amount of water supply, environmental impacts, O&M of the irrigation infrastructure, and institutional dimensions to improve irrigation management in the system.

This section of the chapter analyzes performance of the irrigation system in the study area (comprising ten distributaries originating from 4 different canal systems and serving agricultural lands in 5 districts namely Gujrat, Mandi Bahauddin, Sargodha, Toba Tek Singh and Bahawalnagar) in the Punjab province as shown in Table 3.5.1. Out of the ten selected distributaries, six originate from Upper Jhelum Canal (UJC) and supply irrigation water to the agricultural lands of Gujrat and Mandi Bahauddin districts.

Table 3.5.1. Distribution of sample distributaries according to canals and districts in the study area.

Distributaries	System	District
9-R Khoja	Upper Jhelum Canal	Gujrat
10-R Dhup Sari	Upper Jhelum Canal	Gujrat
13-R Saroki	Upper Jhelum Canal	M.B.Din
14-R Maggowal	Upper Jhelum Canal	M.B.Din
Phalia	Upper Jhelum Canal	M.B.Din
Kakowal	Upper Jhelum Canal	M.B.Din
Lalian	Lower Jhelum Canal	Sargodha
Khadir	Lower Jhelum Canal	Sargodha
Khikhi	Lower Chenab Canal	T.T.Singh
Hakra 4-R	Eastern Saddiqia Canal	Bahawalnagar

Two of the remaining four distributaries originate from Lower Jhelum Canal (LJC) and serve the area of Sargodha district. The last two distributaries originate from Lower Chenab Canal (LCC) and Eastern Saddiqia Canal and serve the agricultural landholdings, which are in the districts of Toba Tek Singh and Bahawalnagar, respectively.

Performance Indicators

The performance indicators were classified on the basis of three broad criteria and six sub-criteria for comprehensive analyses as shown in Table 3.5.2. Indicators representing the productivity, equity and water supply were further sub-categorized into productivity and water supply related indicators. Moreover, formal irrigation agency and community related indicators are represented in institutional and management related categories for their comparison across irrigation systems in the study area.

Table 3.5.2. Criteria of irrigation systems comparison.

Broad criteria	Sub-criteria
1. Productivity, equity, and water supply	I. Productivity
	II. Water supply
2. Sustainability	I. Economic
	II. Environmental
	III. Infrastructure
3. Institutional/Management	I. Formal irrigation agency and community

Productivity, Equity, and Water Supply

A number of productivity, equity, and water supply related indicators were estimated to provide a comprehensive comparative analysis of selected distributaries in the study area.

a. Productivity Indicators

Several of the productivity indicators were computed across distributaries for comparison and the estimates are shown in Table 7.3 and discussed below.

i. Irrigation Intensity

Irrigation intensity is defined as the ratio of net irrigated area[4] to the designed command area. It explains how much of the designed command area is irrigated by water supplied through distributary or by groundwater during Rabi and Kharif seasons. The highest irrigation intensity is estimated for 13-R Saroki Distributary as 182 percent and the lowest (124 percent) estimate is for Khadir Distributary. In general, distributaries with lower irrigation intensity were facing either scarcity of surface water supplies such as Khadir Distributary, or poor groundwater quality problem such as Lalian, Khikhi and Hakra 4-R Distributaries or a combination of both. Table 3.5.3 shows various productivity indicators across distributaries in the study area

Table 3.5.3. Various productivity indicators across distributaries in the study area.

Productivity indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R
Irrigation intensity (%)	137	158	182	162	166	145	135	124	136	151
Cropping intensity (%)	152	162	183	164	170	153	138	124	137	152
Total production in command area (million Rs.)	85.94	98.62	88.96	598.49	697.53	163.76	1060.65	802.52	998.64	407.21
Out put per unit of irrigation water cost (Rs. Ratio)	5.74	5.08	5.59	5.98	5.91	4.52	7.28	5.31	6.37	10.56
Output per unit of diverted irrigation water (Rs./ m^3)	-	-	-	-	-	-	2.55	1.22	-	-
Out put per unit of consumed water (Rs./ m^3)	3.31	4.68	5.51	5.46	6.16	3.95	3.04	3.06	4.34	2.44
Output per unit of labor per ha (Rs./labor day)	422	405	542	429	557	337	582	442	710	547
Head tail equity ratio in output (Rs. ratio)	0.69	0.66	0.76	1.57	0.70	1.51	2.28	1.18	2.16	1.58
Upper Head 25 % GVP / Lower Tail 25 % GVP ratio	6.24	2.33	2.98	5.16	3.10	6.20	11.01	9.37	10.03	6.75

ii) Cropping Intensity

Cropping intensity is defined as the ratio of gross cultivated area to designed command area. The highest cropping intensity was estimated to be 183 percent at 13-R Saroki Distributary while the lowest was calculated as 124 percent for Khadir Distributary. Cropping intensity is directly dependent on cropping patterns prevailing in the area as well as the supply and cost of irrigation water and quality of groundwater. In Khadir Distributary, surface water supplies are scarce but

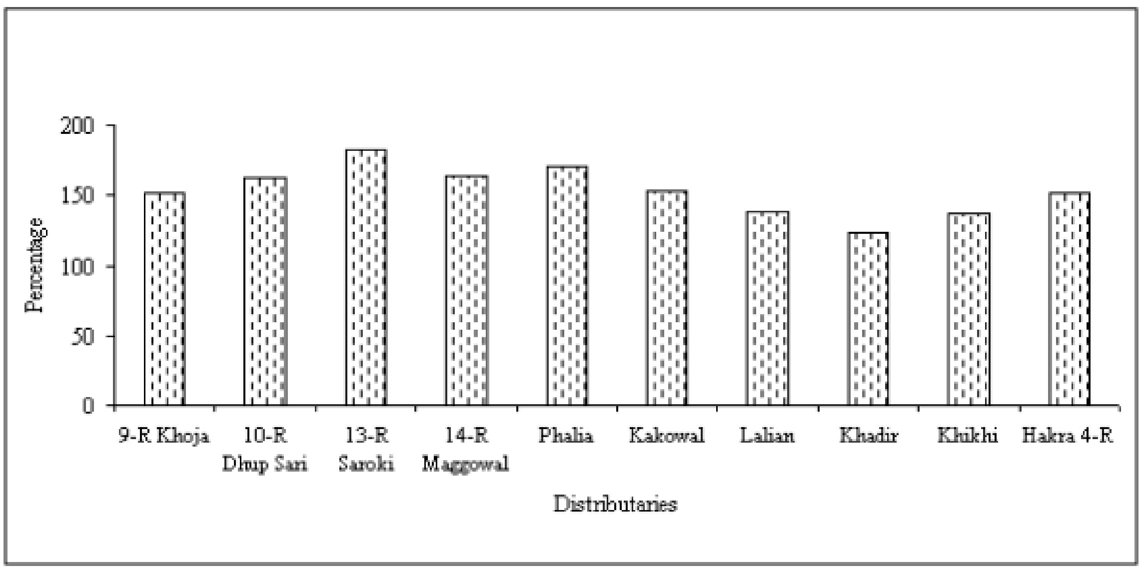
[4] Net irrigated area is area irrigated by canal and groundwater supplies in rabi + area irrigated by canal and groundwater in kharif

ground water is abundant and of good quality. The variation in cropping intensity is mainly due to the nature of cropping patterns i.e. sugarcane-wheat in Khadir Distributary and rice-wheat in 13-R Saroki Distributary command area.

iii) Total Production in Command Area

Total production in the command area is estimated as the value of output produced in the sample command areas in terms of gross value product (GVP). It varied significantly across the distributaries because of variation in command area, cropping pattern, cropping intensity, and market prices of different crops. The highest GVP was estimated for Lalian Distributary (Rs. 1060.65 million) where the citrus orchards brought higher returns. Also the command area of the distributary was relatively higher while the lowest (Rs. 85.94 million) was reported for 9-R Khoja distributary. Overall basis, the main reason of variation in GVP across distributaries was the total command area of the selected distributaries as reflected in case of 9-R Khoja, 10-R Dhup Sari, 13-R Saroki, and Kakowal distributaries where the command area was significantly smaller than in other selected distributaries. The variation in the value of total production is shown in Figure 3.5.2.

Figure 3.5.1. Cropping intensity across selected distributaries in the study area.



iv) Output per Unit of Irrigation Cost

Output[5] per unit of irrigation cost is defined as the ratio of GVP per hectare to the total cost of irrigation[6] per hectare. It indicates, for each rupee spent on irrigation, how much of the output was produced in the command area of each sample distributary. The estimates show that in the case of Hakra 4-R Distributary, with other things constant, one rupee spent on the irrigation cost

[5] Output is the total gross value of product (GVP) produced in the command area of each distributary.
[6] Total cost of irrigation is the cost of both canal water (abiana) and groundwater.

yielded output worth Rs.10.56, which was the highest estimate across distributaries while the lowest estimate was for Kakowal distributary which was about Rs. 4.52. The estimates varied significantly across distributaries and depended upon cropping pattern, cropping intensity, cost of tubewell water per hour and proportionate share of tubewell water in the total water applied along with the market price of the produce. For instance, groundwater quality of Hakra 4-R Distributary was poor and one may not expect a higher proportion of tubewell water in total water applied resulting in less irrigation cost. Moreover, as in the command area of Khadir Distributary, the surface water supplies were scarce and farmers were mainly dependent on groundwater which was inevitably associated with higher irrigation cost. High cost of tubewell water extraction in Kakowal Distributary (due to non availability of surface water supplies at the tail reach) led to a low estimate of GVP per unit of irrigation cost as against the high ratio for Hakra 4-R Distributary where there was greater dependence on low cost canal water. Figure 3.5.3 shows variation in output in terms of gross value of produce per unit of irrigation water cost across selected distributaries in the study area.

v) Output per Unit of Diverted Irrigation Water

Figure 3.5.4 shows output per unit of diverted irrigation water, which is defined as the ratio of gross value of produce to the total diverted irrigation water that includes both groundwater and canal water quantities diverted for irrigation. Moreover, estimates of surface water were computed by taking into consideration the losses at distributary, watercourse and field level that were to the tune of around 40 percent (PPWSDP, 1998). This indicator was calculated only for Lalian and Khadir distributaries due to non-availability of required data for the other distributaries. It was found that each cubic meter of irrigation water applied in the command area of Lalian Distributary resulted in an output worth Rs. 2.55 as compared with that of Rs.1.22 for the Khadir Distributary. It was found that canal water was relatively scarce at Khadir Distributary that resulted in higher utilization of groundwater and lower productivity per unit of land. Moreover, in the command area of Khadir Distributary, the excessive utilization of groundwater was practiced while prevailing cost of groundwater per hour in the Distributary was low when compared with thar of Lalian Distributary that resulted in the application of higher volume of water. As the canal water availability was low, farmers were more dependent on the extraction of groundwater. Therefore, the number of tubewells in the command area of Khadir Distributary was much more than in Lalian Distributary, and sharing of tubewells was also quite common. This resulted in relatively low cost per hour of groundwater irrigation at Khadir Distributary.

Figure 3.5.2. Total production (GVP) across selected distributaries in the study area.

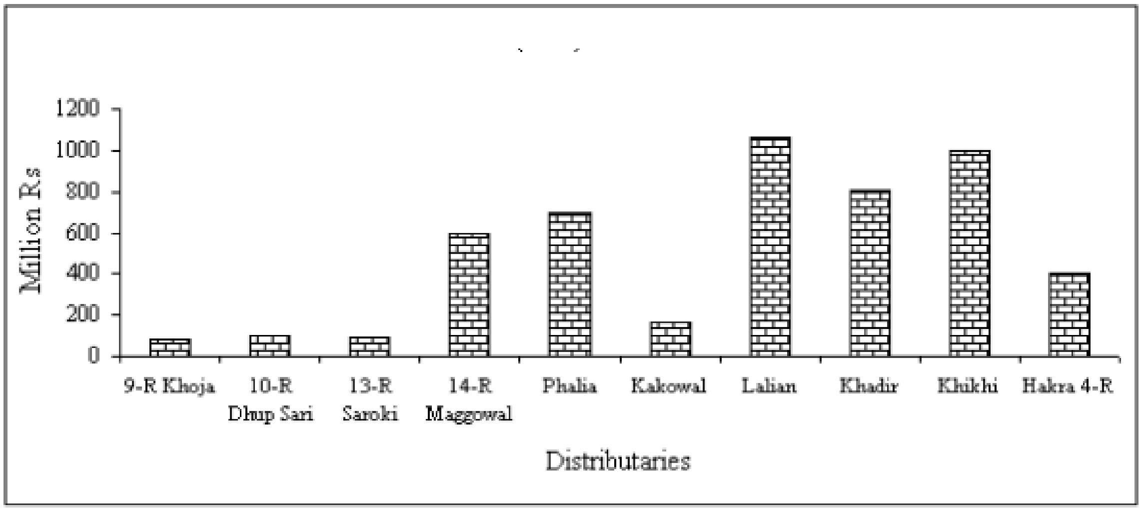
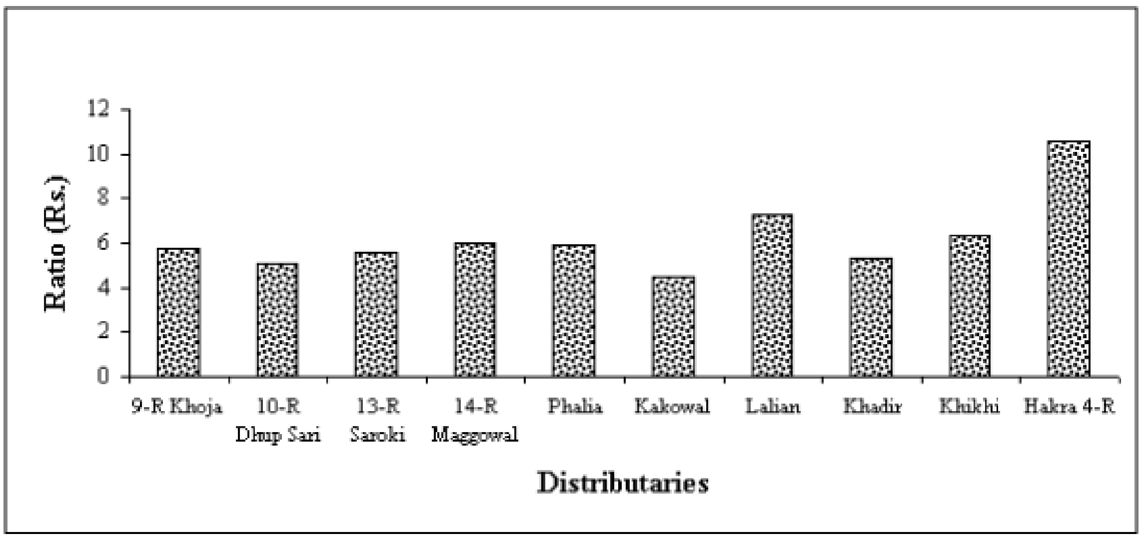
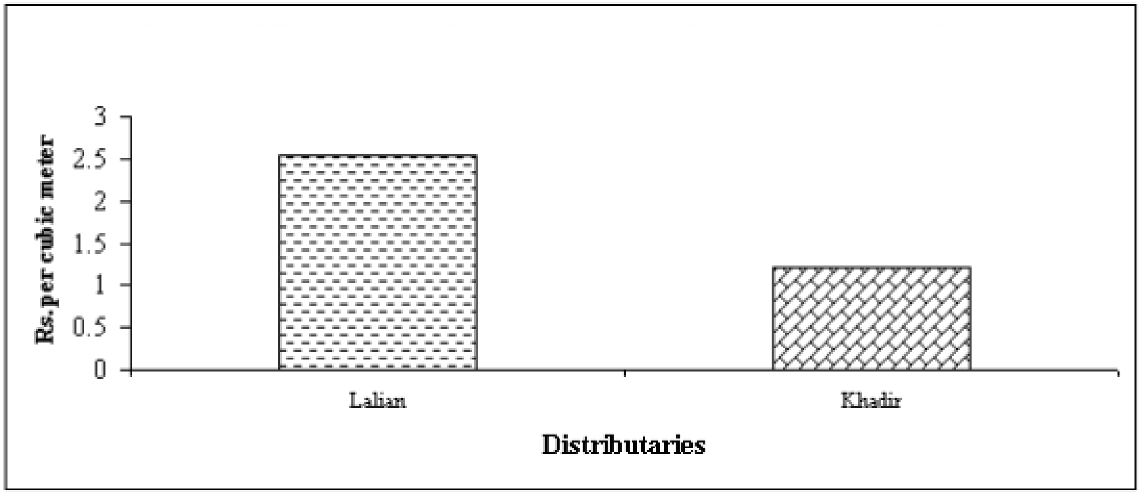


Figure 3.5.3. Output (GVP) per unit of irrigation water cost across distributaries in the study area.



In addition to this, citrus orchards were plentiful in the command area of Lalian Distributary covering around 8306 hectares of land when compared with 767 hectares on Khadir Distributary. It was also found that citrus orchards were highly profitable when compared with other cash crops in terms of volume of water applied.

Figure 3.5.4. Output (GVP) per unit of diverted irrigation water at Lalian and Khadir distributaries.



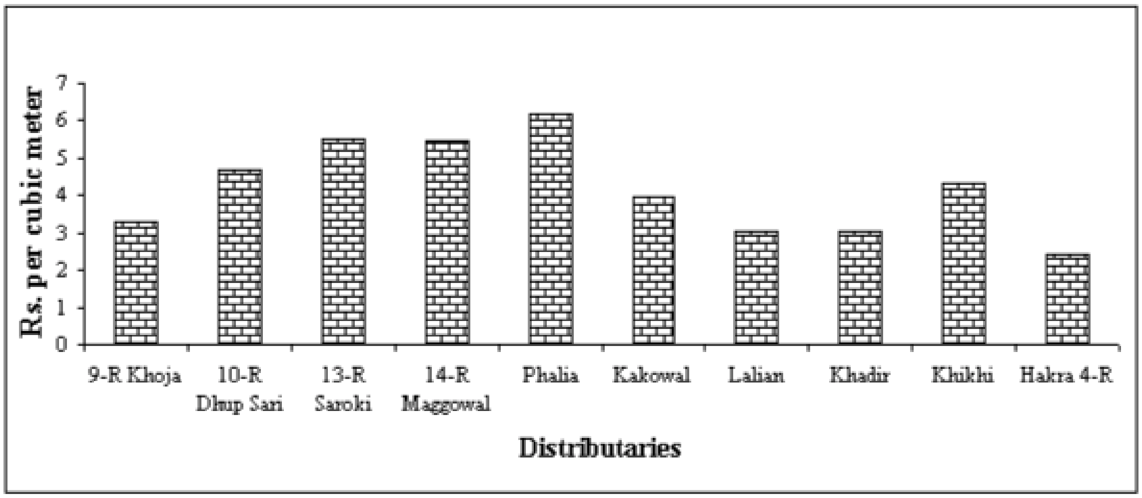
vi) Output per Unit of Consumed Water

Output per unit of consumed water is defined as the ratio of GVP to the volume of water consumed by all crops grown in the command area of a particular sample distributary. The volume of water consumed by all crops or the annual crop water requirement varied across distributaries on the basis of cropping pattern, cropping intensity and difference in agro-ecology of the areas. It describes the utilization of each unit of water by crops and the worth of output produced. The highest estimate was calculated as Rs. 6.16 per cubic meter of irrigation water for Phalia Distributary while the lowest was 2.44 for Hakra 4-R Distributary. The gross value of produce per hectare at Phalia Distributary and Hakra 4-R Distributary was estimated as Rs. 25919 and Rs. 22710 indicating not much variation. The main difference arose from the fact that calculated annual crop water requirements for Hakra 4-R Distributary were 9314 cubic meters when compared with 4210 cubic meters at Phalia Distributary. This variation in annual crop water requirement was mainly due to weather conditions, being more severe in Bahawalnagar District when compared with Mandi Bahauddin District. The variation of output per unit of consumed water is plotted in Figure 3.5.5.

vii) Output per Unit of Labor per Hectare

Output per unit of labor per hectare is defined as the ratio of GVP per hectare to the total number of labor days per hectare. It describes productivity of labor in terms of gross value of produce across distributaries. It was estimated that the highest output of Rs. 710 per unit labor day was produced in the Khikhi Distributary area and the lowest of Rs. 337 per unit labor day in the Kakowal Distributary area. The difference is due to gross value of product, number of laborers employed on farm, and the cost of labor in the area. It was estimated that the gross value product per hectare at Khikhi Distributary was Rs. 30153, while at Kakowal Distributary it was Rs. 17671 per hectare. Moreover, average labor days per hectare for Khikhi Distributary were 42 days when compared with the 52 labor days per hectare employed at Kakowal Distributary. Productivity of labor per hectare showed significant variation across distributaries due to variation in both gross value of produce per hectare and labor days used in production of crops on per hectare basis. Output per unit of labor across selected distributaries is depicted in figure 3.5.6.

Figure 3.5.5. Output (GVP) per unit of consumed water across selected distributaries in the study area.



viii) Head Tail Equity Ratio in Output

Head-Tail equity ratio in output is the ratio of average GVP per unit area produced at the system head to the average GVP per unit area at the tail of the system. It assesses and compares performance of an irrigation system on the basis of agricultural productivity per hectare between head reach farmers and tail reach farmers of the same distributary. The highest estimate was worked out as 2.28 for Lalian Distributary while the lowest of 0.66 was calculated for 10-R Dhup Sari Distributary. The difference was due to a number of factors including low cropping intensity, less access and availability of canal water at the proper time, and poor groundwater quality that severely hampered the productivity of tail reach farmers. Cropping pattern was different at the tail reach as compared to the head reach areas, as seen in the case of 10-R Dhup Sari Distributary where gross value of product per hectare was higher in the tail reach areas when compared with that of the head reach areas. It was found that cropping intensity at the tail reach was 188 percent when compared with the head reach area (153 percent). Moreover, the tail reach farmers were cultivating more area under crops such as rice and wheat than the farmers at the head reach areas. Figure 3.5.7 shows the head-tail equity ratio in output (GVP per hectare) across distributaries in the study area.

ix) Upper Head 25 percent GVP and Lower Tail 25 percent GVP ratio

For this indicator, average GVP of top 25 percent of head reach farmers is compared with the average GVP of the lowest 25 percent of the tail reach farmers of the same distributary. The highest value was estimated as 11.01 for Lalian Distributary indicating that the best 25 percent farmers of the head reach were producing 11 times more produce than the bottom 25 percent farmers at the tail reach area. It clearly indicated that how poor access to different factors of production could affect overall productivity and production. At the tail reach of the Lalian Distributary, canal water was scarce and of poor quality.

Figure 3.5.6. Output (GVP) per unit of labor per hectare across selected distributaries.

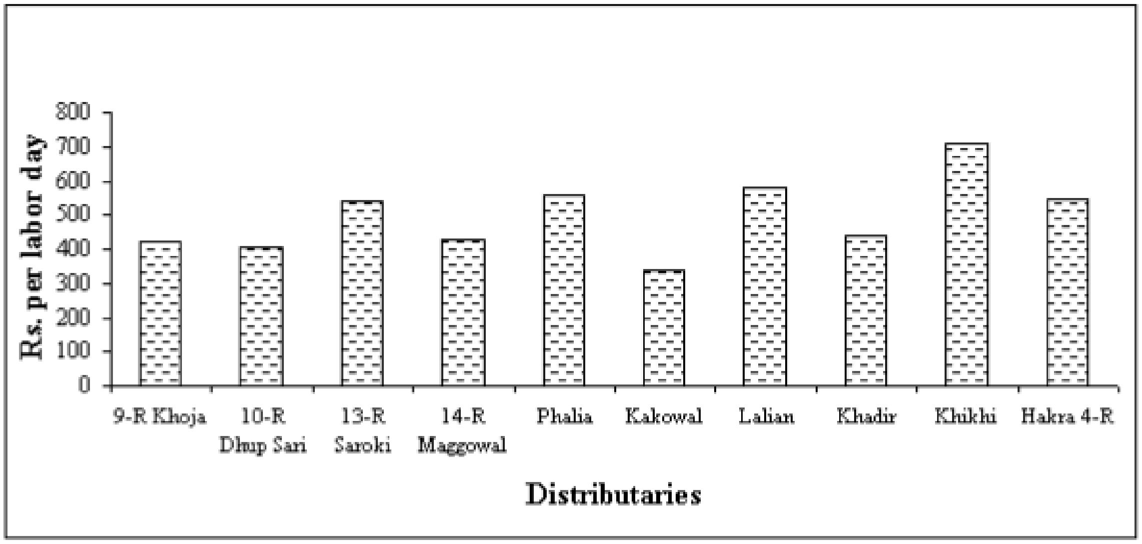
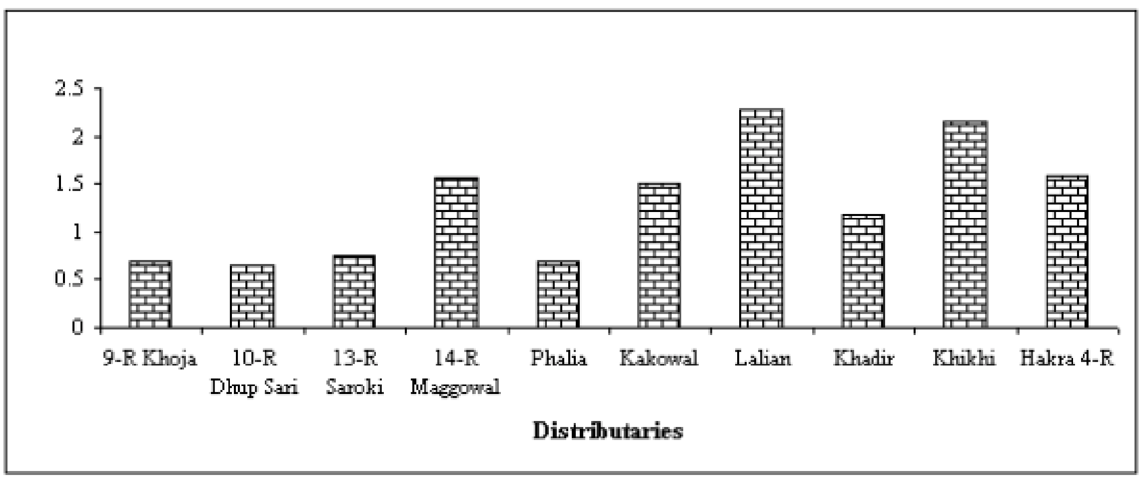
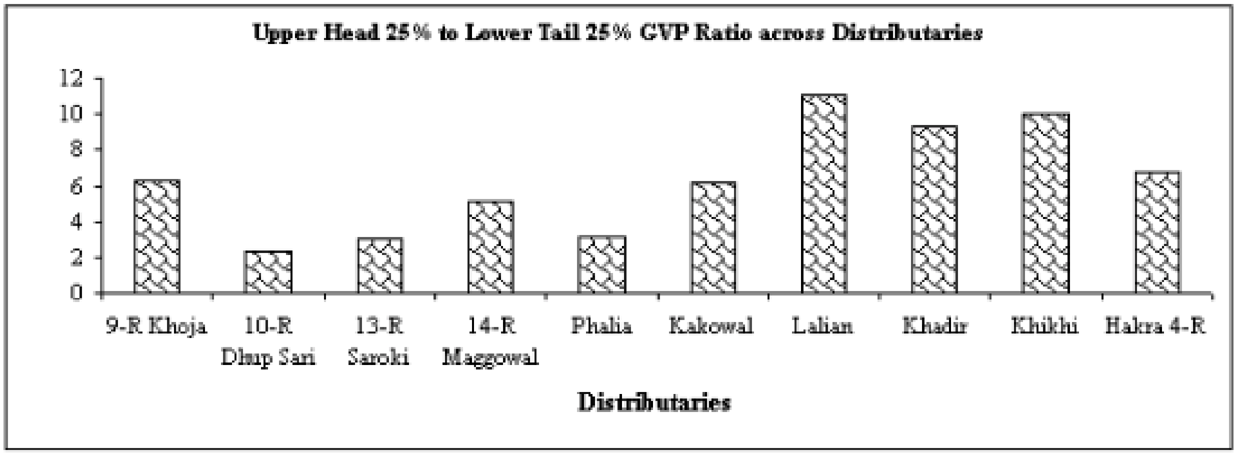


Figure 3.5.7. Head-tail equity ratio in output (GVP per hectare) across selected distributaries in the study area.



Quality of groundwater was further aggravating the situation by leaving the farmers with a limited option to grow orchards, sugarcane, etc. as well as by limiting the area that otherwise could be cultivated. On the other hand, the estimate of 2.33 at Dhup Sari Distributary indicated a much better situation where canal water was available in relatively greater quantities along with good quality groundwater resulting in more area and productivity of cash crops at the tail reach. The comparison of upper head 25 percent GVP and lower tail 25 percent GVP ratio across selected distributaries is shown in Figure 3.5.8.

Figure 3.5.8 Upper head 25% GVP and lower tail 25% GVP ratio in selected distributaries in the study area.



b) Water Supply Indicators

Various indicators of water supply were calculated in order to compare the performance of selected distributaries in the study area. The results of various performance indicators are presented in Table 3.5.4 and discussed below.

Table 3.5.4. Various indicators of water supply across distributaries in the study area.

Water supply indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R
Relative water supply with respect to number of irrigation including rainfall	0.45	0.59	0.72	0.73	0.65	0.70	0.74	0.69	0.84	0.65
Relative water supply with respect to water diverted including rainfall	-	-	-	-	-	-	1.49	2.95	-	-
Relative irrigation supply with respect to number of irrigation excluding rainfall	0.53	0.68	0.88	0.82	0.74	0.81	0.76	0.71	0.85	0.65
Relative irrigation supply with respect to water diverted excluding rainfall	-	-	-	-	-	-	1.19	2.51	-	-
Water delivery capacity with respect to design discharge	0.37	0.33	0.51	0.5	0.62	0.52	0.35	0.28	0.48	0.53
Water delivery capacity with respect to avg. discharge	0.25	0.23	0.21	0.15	0.18	0.34	0.37	0.18	0.31	0.41
Water delivery performance	0.90	0.95	0.85	0.61	0.61	0.79	0.90	0.78	0.77	0.95
Overall system efficiency	0.53	0.45	0.34	0.28	0.40	0.71	0.43	0.30	0.38	0.47
Head-tail equity with	-	1.80	-	-	-	1.23	2.00	2.50	-	1.09

i) Relative Water Supply with Respect to Number of Irrigations (Including Rainfall)

Relative water supply is defined as the ratio of the total number of irrigations applied to all crops to the total number of recommended irrigations. The total number of recommended irrigations was calculated for each crop in recommended agronomic practices issued by the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. It describes the gap between availability/supply and required amount of irrigation water to farmers. This depends upon the cropping intensity, cropping pattern, canal water availability, quality of groundwater, and cost associated with it. The highest ratio was estimated for the Khikhi Distributary as 0.84 showing a gap of 16 percent between required and available amount of water in terms of irrigation and the lowest estimate of 0.45 was for the 9-R Khoja Distributary with a 55 percent gap.

ii) Relative Water Supply with Respect to Water Diverted (Including Rainfall)

Relative water supply with respect to water diverted is defined as the ratio of total water supply (canal water + groundwater draft + rainfall) to the yearly crop water requirement. This indicator was measured for Lalian and Khadir distributaries only, due to unavailability of required data. The estimate for Khadir Distributary was 2.95 when compared with 1.49 for Lalian Distributary. The value of the indicator depends upon the annual crop water requirement, diverted canal water, total groundwater draft in the area, and annual volume of rainfall in the distributary command area. Although canal water is relatively scarce in Khadir Distributary area, due to the good quality of groundwater, and more command area, the total water supply exceeds that in Lalian Distributary. But that did not mean more productivity per hectare at Khadir Distributary, since though the groundwater was good its quality was still poorer than the canal water. Moreover, having more command area simply meant more rainfall but crops required water at critical time periods that could not be reflected in this indicator.

Yearly measured crop water requirement at Lalian Distributary (8349 cubic meters per hectare) was higher than at Khadir Distributary (5647 cubic meters per hectare) because of higher cropping intensity at Lalian Distributary and relatively different cropping pattern. Groundwater draft at the Lalian Distributary was 256.32 million cubic meters when compared with 578.18 million cubic meters at the Khadir Distributary due to better quality groundwater in the later. The relative water supply with respect to water diverted (including rainfall) is shown in Figure 3.5.10.

Figure 3.5.9. Relative water supply with respect to number of irrigations (including rainfall) across distributaries in the study area.

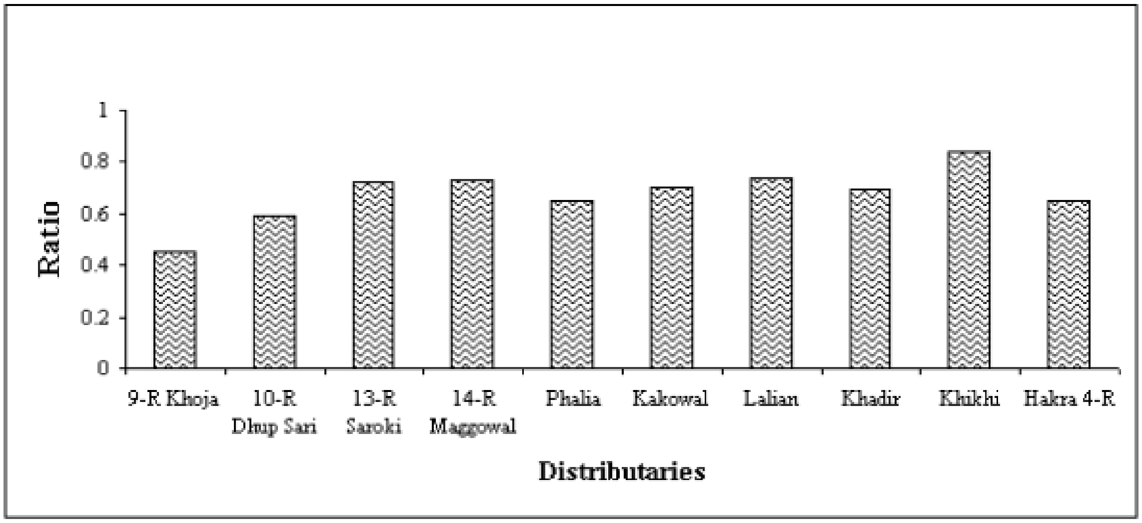
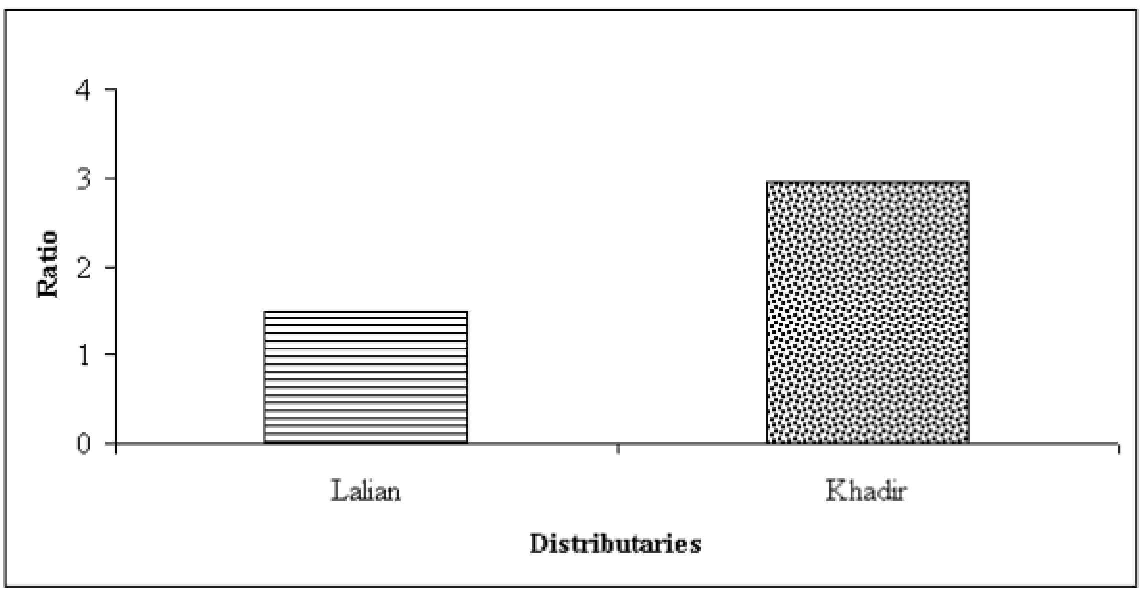


Figure 3.5.10. Relative water supply with respect to water diverted including rainfall at Lalian and Khadir distributaries in the study area.



iii) Relative Irrigation Supply with Respect to Number of Irrigations (Excluding Rainfall)

This indicator is defined as the ratio of the total number of irrigations applied for all crops grown in the area to the total number of irrigations recommended after taking out the rainfall effect as shown in Figure 3.5.11. The highest value was estimated as 0.88 for 13-R (Saroki Distributary) indicating a gap of 12 percent between required and supplied number of irrigations when compared with 0.53 at 9-R Khoja Distributary showing a gap of 47 percent. The variation in relative irrigation supply was due to dissimilarity in cropping intensity, cropping pattern, canal water availability, quality of groundwater, and the cost associated with it.

iv) Relative Irrigation Supply with Respect to Water diverted (Excluding Rainfall)

Relative irrigation supply with respect to water diverted is defined as the ratio of total irrigation supply (canal water + groundwater draft) to the yearly crop water requirement. This indicator was estimated for Lalian and Khadir distributaries only due to non-availability of required data for other distributaries. The estimated value was higher for Khadir Distributary (2.51) when compared with that for Lalian Distributary (1.19). It shows that the total volume of water applied was in excess of annual crop water requirement. It was due to a higher share of relatively poor quality groundwater in total water applied. Comparison of relative irrigation supply with respect to water diverted (excluding rainfall) is shown in Figure 7.5.12.

v) Water Delivery Capacity with Respect to Design Discharge

Water delivery capacity with respect to design discharge is defined as the ratio of canal capacity to deliver water at the system head and to the peak consumptive demand[7]. It indicates how much volume of the peak consumptive demand was met by designed surface water supplies. The highest estimate was calculated as 0.62 for Phalia Distributary while the lowest was calculated as 0.28 for Khadir Distributary. It clearly indicated that at Phalia Distributary, 62 percent of the peak consumptive demand was met by designed surface water supplies while 38 percent of the needed irrigation water was added by groundwater and rainfall. Similarly, since the surface water supplies to Khadir Distributary were very low, about 72 percent of the required water was augmented by groundwater and rainfall water supplies. Moreover, as the cropping pattern and cropping intensity varied across distributaries so was the peak consumptive demand. The estimated peak consumptive demand for Khadir Distributary was 1595 mm when compared with 1549 mm estimated for Phalia Distributary. Significant variation was found across distributaries with 5 out of 10 distributaries supplying less than 50 percent of the annual peak consumptive demand through surface water supplies. Figure 3.5.13 shows water delivery capacity with respect to design discharge across distributaries in the study area.

[7] Peak consumptive demand means the water requirement of the crop that requires the highest volume of water during a year. For example, if sugarcane is grown in the area, then as it requires the highest volume of water, peak consumptive demand of the area would essentially be equal to peak consumptive demand of sugarcane in the study area or distributary.

Figure 3.5.11.Relative irrigation supply with respect to number of irrigations excluding rainfall across distributaries in the study area.

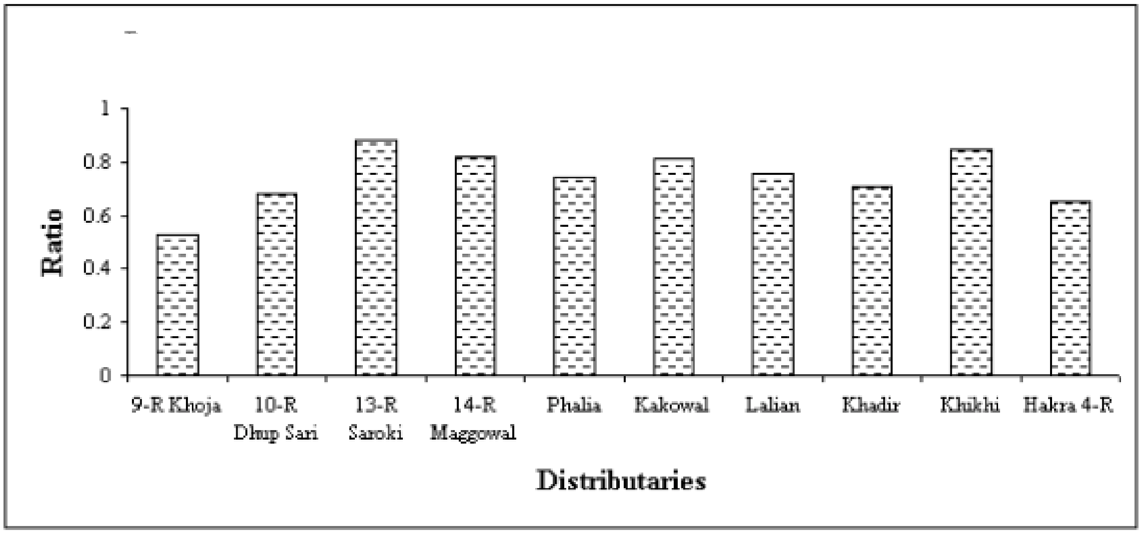


Figure 3.5.12.Relative water supply with respect to water diverted excluding rainfall at Lalian and Khadir distributaries in the study area.

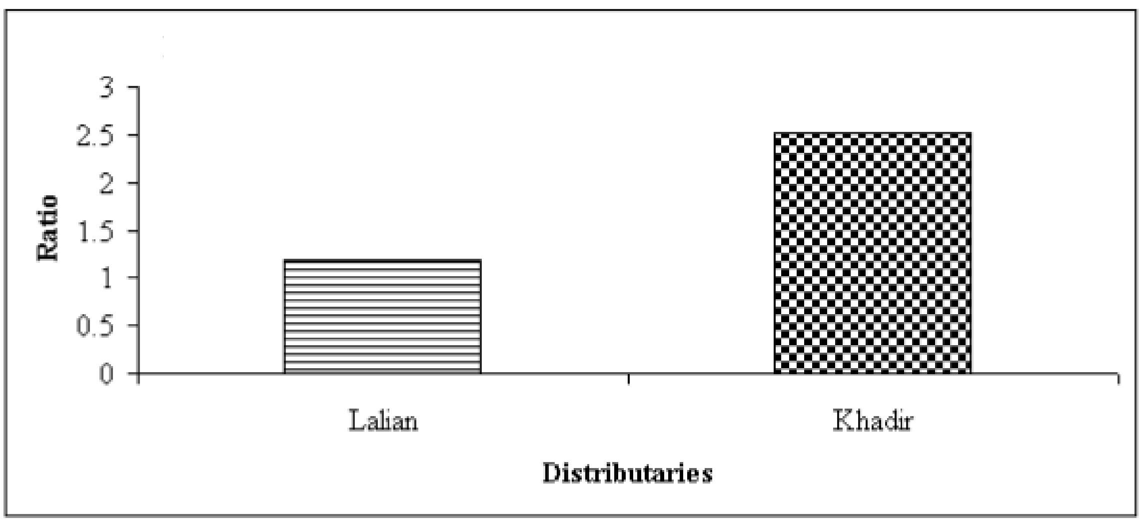
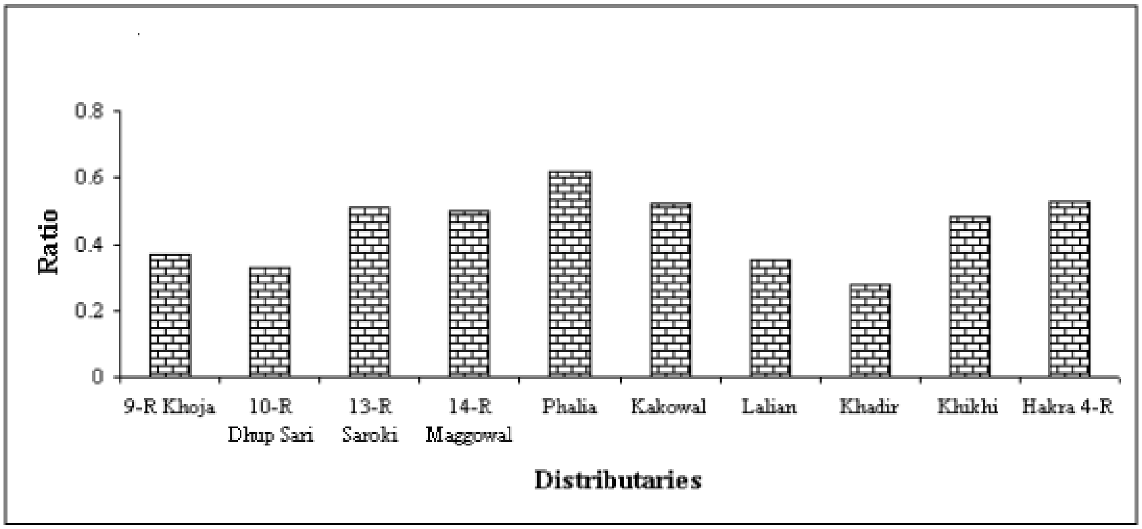


Figure 3.5.13. Water delivery capacity with respect to design discharge in the study area.



vi) Water Delivery Capacity with Respect to Average Discharge

Water delivery capacity with respect to design discharge is defined as the ratio of canal capacity to deliver water at the system head (considering 40 percent losses and annual closure days) to the peak consumptive demand. It explains the gap between the volumes of surface water actually supplied when compared with what was demanded as an annual peak consumptive demand. The highest estimate was for Hakra 4-R Distributary (0.41) when compared with the lowest estimated value for 14-R Maggowal (0.15). It clearly shows that the actual diversions of canal water were low as compared to the designed discharge. Consequently, only 41 percent of the annual peak consumptive demand was met by surface water supplies at Hakra 4-R Distributary while, on the other hand, the Upper Jehlum Canal supplied only 15 percent for 14-R Maggowal Distributary. The gap was bridged by groundwater supplies as well as by rainfall. Interestingly, it was found that no distributary was able to supply even half of the annual peak consumptive demand. Keeping in view of variable capacity of different irrigation systems to deliver water at the system head, the general cropping pattern of the area played a significant role in the assessment of water delivery capacity. Crops like sugarcane and rice required high delta of water and more area under these crops increases the annual consumptive peak demand of the area leading to lower water delivery estimate. The variation in water delivery capacity with respect to average discharge across selected distributaries in the study area is shown in Figure 3.5.14.

vii) Water Delivery Performance

Water delivery performance is defined as the ratio of actual volume to the target volume of water delivered. Hakra 4-R Distributary delivery performance ratio was the highest with an estimate of 0.95 showing that 95 percent of the target was achieved while an estimate of 0.61 for 14-R Maggowal Distributary showed that only 61 percent of the target volume of surface water was actually delivered. It was found that Hakra 4-R Distributary and 10-R Dhup Sari Distributary were running most of the times according to their design discharges while Phalia and 14-R Maggowal distributaries continued to flow around 39 percent below their design discharges. The water delivery performance primarily depends upon the capacity and the overall physical condition of the irrigation system as well as the availability of good quality groundwater. For instance, water delivery performance of Lalian Distributary was better than Khadir Distributary due to improved physical condition of the Lalian Distributary, and also due to ample availability of good quality groundwater in the command area of Khadir Distributary. The comparison of water delivery performance across selected distributaries in the study area is shown in Figure 3.5.15.

Figure 3.5.14. Water delivery capacity with respect to average discharge across selected distributaries in the study area.

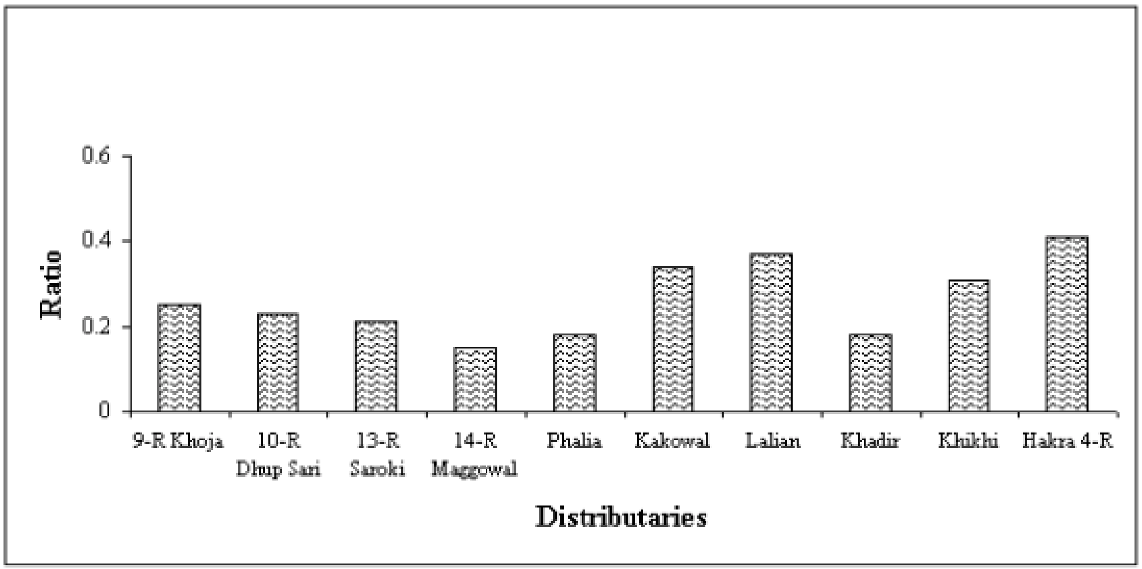
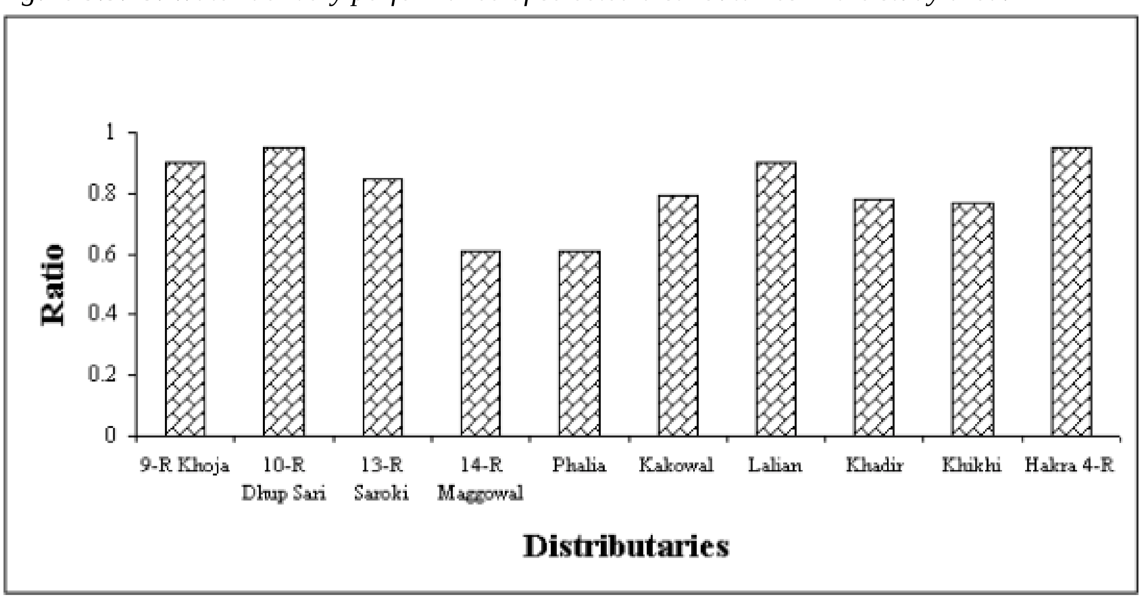


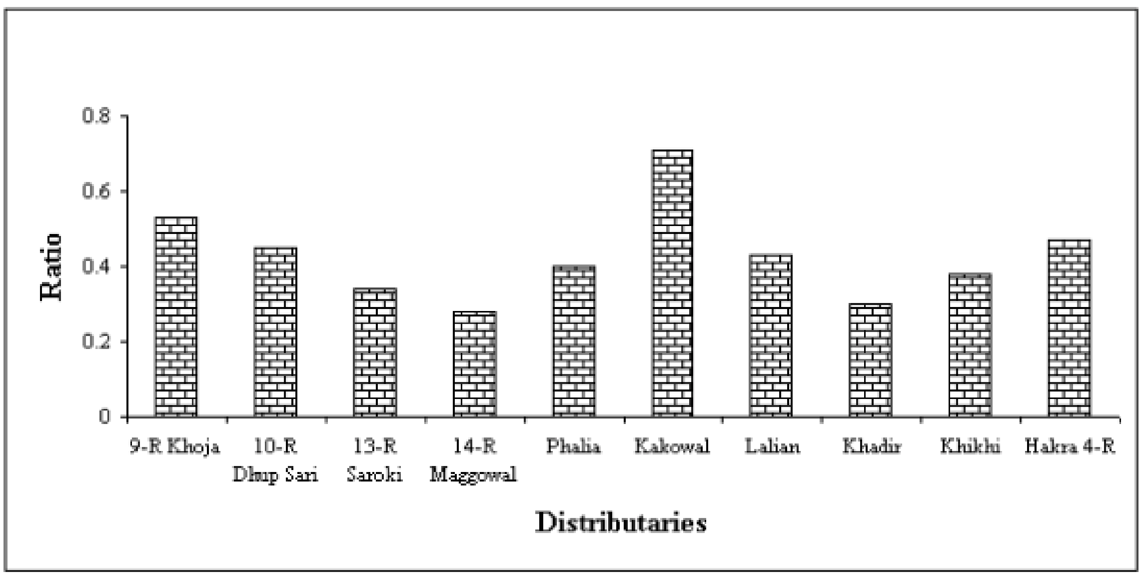
Figure 3.5.15. Water delivery performance of selected distributaries in the study area.



viii) Overall System Efficiency

Overall system efficiency is defined as the ratio of annual crop water requirements[8] and the total inflow into canal system (with 40% losses). This indicator explains the efficiency of the irrigation system and indicates what proportion of crop water requirement and surface water irrigation supplies are matched. Overall system efficiency of the Kakowal Distributary was found to be 0.71, which was the highest amongst all the ten selected distributaries showing system inefficiency of 29 percent in fulfilling the water requirements of the Kakowal Distributary command area. On the other hand, the system efficiency was estimated to be 0.28 for the 14-R Maggowal Distributary showing a 72 percent gap in supplies that needs to be supplemented by groundwater supplies or rainfall. As the cropping pattern and cropping intensity varied across the distributaries, so was the annual crop water requirement. For instance, the annual crop requirement for Kakowal Distributary was estimated as 44771 cubic meters while that of 14-R Maggowal Distributary was 4946 cubic meters. The overall system efficiency of selected distributaries is shown in the Figure 3.5.16.

Figure 3.5.16. Overall system efficiency of selected distributaries in the study area.



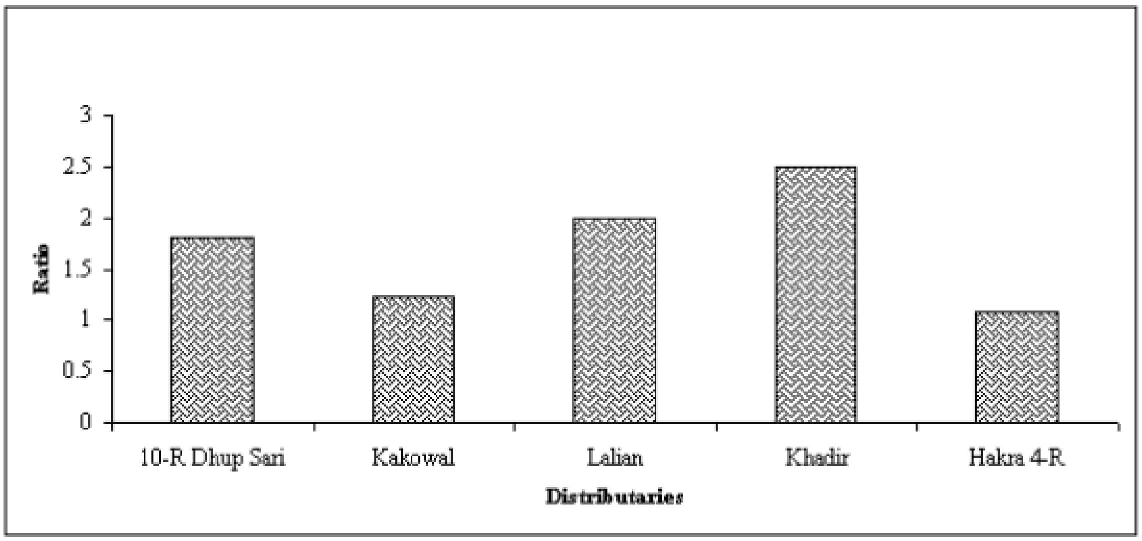
ix) Head-Tail Equity with Respect to Discharges

Head-tail equity with respect to discharges is defined as the ratio of water delivery performance (ratio of actual discharge to design discharge) of head reach watercourses to water delivery performance of tail reach watercourses. This indicator was estimated for five out of ten distributaries, due to the non-availability of required data, and showed significant variation across distributaries. The discharges of the selected watercourses at the head and tail reaches of the selected distributaries were compared to calculate this indicator. The highest value of 2.50 was

[8] It is the aggregate of individual annual crop water requirement of all crops cultivated in the study area.

estimated for the Khadir Distributary, indicating higher inequity in water distribution when compared with 1.09 for Hakra 4-R Distributary showing a highly equitable distribution of water at various reaches of the distributary. The head-tail equity estimate higher than the perfect equality estimate of 1 was due to differences prevailing in the actual and designed sizes of the outlets. This could be possible by unauthorized or illegal modification in size of outlets. The Hakra 4-R Distributary showed an excellent example of head-tail equity ratio with respect to discharge, as the estimate computed was around 1.08. It confirmed that outlets at the head reach were drawing almost same volume of water as the outlets at the tail reach . Figure 3.5.17 shows the variation in head-tail equity with respect to discharges for the selected distributaries in the study area.

Figure 3.5.17. Head-tail equity with respect to discharges for selected distributaries in the study area.



Sustainability Related Indicators

A number of sustainability indicators were estimated that throw light on economic, environmental and infrastructure related performance of the selected distributaries in the study area. The results are presented in Table 3.5.5 and discussed below.

a. Economic Indicators

i) Gross Value of Farm Production per Hectare

It represents the gross value of produce (GVP) on per hectare basis. The highest value of GVP per hectare was estimated for 13-R Saroki Distributary to be Rs.31355 when compared with the lowest estimate of Rs. 14,446 for 9-R Khoja Distributary. The differences are due to differences in cropping patterns, cropping intensity, quantity and quality of groundwater applied at the time of need along with a complex mix of social, economic and institutional factors that played an important role in ascertaining it. The highest estimated value at 13-R Saroki Distributary was due to the fact that 70 percent of farmers cultivated rice during Kharif season and 60 percent wheat during Rabi season. Moreover, rice crop cultivation was the highest among all the selected ten distributaries with cropping intensity of 183 percent, which was also the highest among all the selected distributaries. In addition to this, selling of fodder was also found more common in this distributary than in any other distributary. On the other hand, lower GVP per hectare at 9-R Khoja was due to the fact that only 27 percent of the selected farmers cultivated rice during Kharif season, which could not bring better market returns. The situation was further aggravated due to non-availability of required volume of canal irrigation water and relatively poor quality of groundwater. The variation in gross value of farm production per hectare across selected distributaries in the study area is shown in Figure 3.5.18.

Table 3.5.5. Various sustainability indicators across distributaries in study area.

Sustainability indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R
Economic										
Gross value of farm production per ha (Rs.)	14446	22565	31355	26986	25919	17671	25326	17292	30153	22710
Net value of farm production per ha (Rs.)	5036	7903	15361	10407	9928	5309	9458	5817	8007	3875
Net value of farm production of total HH income (%)	13.98	28.23	49.21	43.15	52.04	25.29	60.58	45.45	52.57	43.81
Irrigation benefit per unit area (Rs.)	2617	5484	12942	7987	7509	2889	7039	3397	5588	1456
Irrigation benefit per unit of water (Rs./m^3)	-	-	-	-	-	-	0.71	0.24	-	-
System level profitability (including irrigation cost in gross margin)	2.00	1.78	2.74	2.31	2.26	1.36	2.72	1.79	1.69	1.80
System level profitability (excluding irrigation cost in gross margin)	3.00	2.78	3.74	3.31	3.26	2.36	3.72	2.79	2.69	2.8
System Level profitability with respect to per unit cost of water	-	-	-	-	-	-	2.02	1.04	-	-
Water charges collection performance	0.99	0.99	0.80	0.80	0.80	0.80	0.87	0.87	0.94	0.91
System financial self sufficiency	1.62	1.65	0.79	0.62	0.50	1.13	0.66	0.81	0.36	0.39
O & M financing gap	1.18	1.09	1.00	1.02	0.92	1.33	1.07	0.95	0.99	0.99
Environmental										
Tube well bore depth (ft) mean	111	81	71	82	86	113	131	119	60	120

ii) Net Value of Farm Production per Hectare

Net value of farm production per hectare is defined as the gross value of product minus the cost of production on per hectare basis. It shows the profitability of agricultural crops across different distributaries. The highest estimate is worked out as Rs. 15361 for 13-R Saroki Distributary while the lowest is estimated as Rs. 3,875 for Hakra 4-R Distributary. Moreover, significant variation in net value of farm production per hectare was observed across selected distributaries. Apart from the gross value of produce, cost of production varied significantly across distributaries. It was dependent on types of crop grown, fertility of land, cost of irrigation as well as of other inputs used for cultivation of crops. However, in those areas where groundwater was of poorer quality or where cultivation of crops basically depended on groundwater, cost of production was higher, consequently lowering the level of profitability. For instance, the lower profitability on the Hakra 4-R Distributary was due to poorer quality of groundwater while higher extraction of relatively poor quality groundwater at the Khadir Distributary was the main limitation that resulted in higher costs and less profitability. The comparison of the net value of farm production per hectare for selected distributaries is shown in Figure 3.5.19.

Figure 3.5.18. Gross value of farm production per hectare for selected distributaries in the study area (Rs).

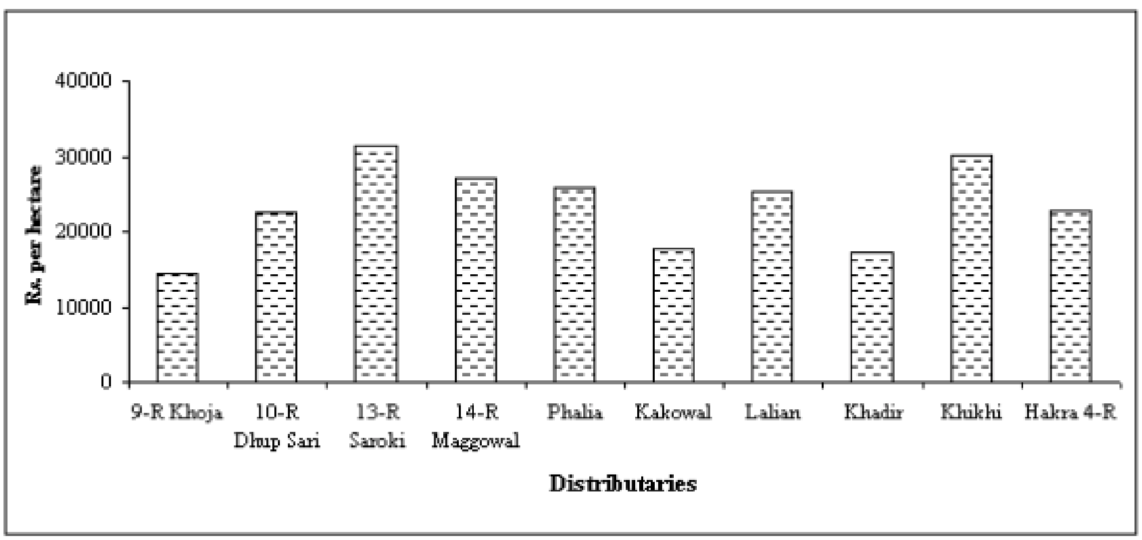
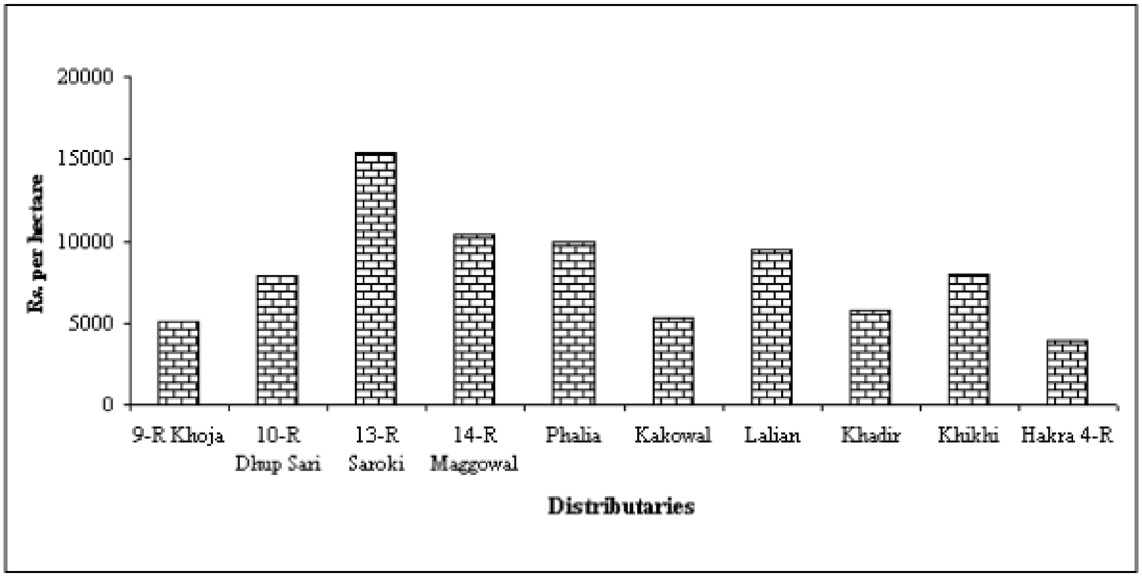


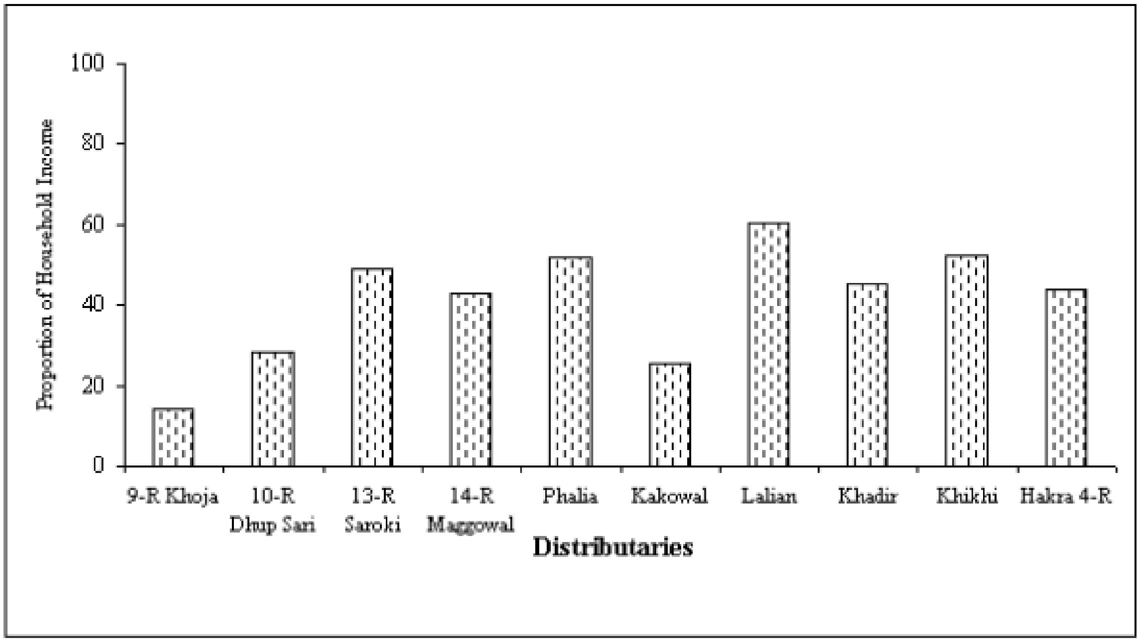
Figure 3.5.19. Net value of farm production per hectare for selected distributaries in the study area (Rs).



iii) Net Value of Farm Production as Percentage of Total Household Income

It is the ratio of net value of farm production to the total annual average income of households in the study area. It indicates the importance and dependence of farming community on crops for income in a year. At Lalian Distributary, 61 percent of the annual income was from crop sector indicating how sensitive these households were to better or poor performance of agricultural production. Moreover, it was made possible due to cultivation of cash crops like sugarcane, citrus orchards and wheat on vast area when compared with other distributaries. On the other hand, the likely share of 14 percent was estimated for households at the 9-R Khoja Distributary indicating their heavy dependence on non-crop income. It was found that at 4 out of the 10 sampled distributaries, 50 percent or more of the household income was from crop sector. The comparison of net value of farm production as a percentage of total household income across selected distributaries is graphically presented in Figure 3.5.20.

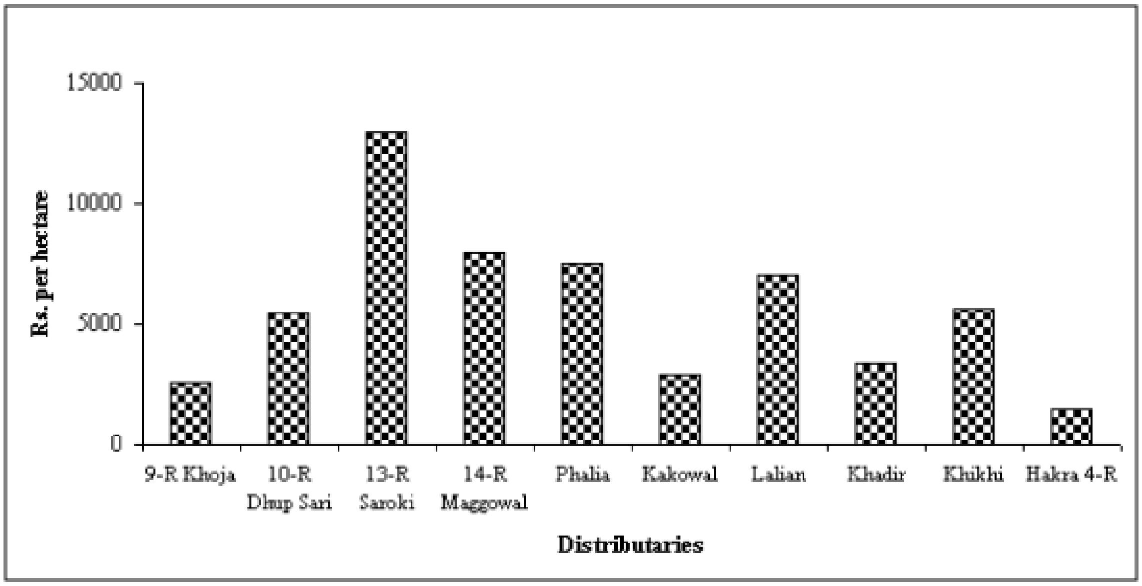
Figure 3.5.20. Net value of farm production as a % of total household income for selected distributaries in the study area.



iv) Irrigation Benefit per Unit of Area

Irrigation benefit per unit area is defined as the net value of farm production per unit area from irrigated area minus the net value of farm production per unit area in rain-fed area. The estimated irrigation benefits per unit area for 13-R Saroki Distributary had the highest value of Rs.12,924 per ha when compared with Hakra 4-R Distributary with the lowest value of Rs. 1456 per ha. This was due to the fact that the net value of farm production per hectare of 13-R Saroki Distributary was the highest (Rs. 15,361) among all distributaries, while that of Hakra 4-R Distributary was the lowest (Rs. 3,875) as shown in Figure 3.5.21.

Figure 3.5.21. Net value of farm production as a % of total household income for selected distributaries in the study area.



v) Irrigation Benefit per Unit of Water

Irrigation benefit per unit of water is defined as the net value of farm production per unit area from irrigated area minus the net value of farm production per unit area from rain-fed to total amount of water diverted (aggregate of canal water supplies and groundwater draft). This indicator could be calculated for two distributaries (Lalian and Khadir) only, due to non-availability of required data for the other distributaries. Lalian Distributary has a value of 0.71 Rs/m^3 and the Khadir Distributary showed a value of 0.24 Rs./m^3. The farmers of the Lalian distributary command area were obtaining relatively more benefits than the farmers of the Khadir Distributary. At the Lalian Distributary, irrigation benefits per unit area were calculated to be Rs.7,039 per ha and at the Khadir Distributary, irrigation benefits per unit area were estimated to be Rs.3,397 per ha. At Lalian Distributary, cropping intensity was estimated to be 138 percent and about 47, 16 and 20 percent of the area was cultivated with wheat, sugarcane and citrus, respectively. On the other hand, at Khadir Distributary, the cropping intensity, area under wheat, sugarcane and citrus orchards were found to be 124, 47, 17.6, and 1.7 percent, respectively. Additionally, irrigation costs were higher at Khadir Distributary due to the higher proportion of groundwater extracted to meet the irrigation needs.

vi) System Level Profitability (Including and Excluding Irrigation Cost in Total Costs for Gross Margins)

System level profitability is defined as the ratio of gross margin per unit area to irrigation cost per unit area. Three different ratios were estimated including and excluding irrigation costs in the calculation of gross margins. By using gross margins per hectare including the irrigation cost in the total cost for calculating gross margins, the command area of the 13-R Saroki Distributary was found as a highly profitable area where every rupee spent on irrigation returned Rs. 2.74 in terms of gross margins while Kakowal Distributary was found to be the least profitable command area with an estimate of Rs. 1.36 of gross margins per rupee spent on irrigation. As evident, higher cost of irrigation means lower profitability of production. Agriculture in the Khadir Distributary command area is dependent upon a higher proportion of groundwater in the total water applied which increases the cost of water. The higher gross margin was also directly dependent on the quality of irrigation water applied, productivity and costs of other inputs used per hectare for crop cultivation. Areas with more land covered by cash crops and timely availability of canal water supplies were found to bear a higher value as compared with other. The variation in system level profitability is shown in Figure 3.5.22.

Using the gross margins per hectare excluding the irrigation cost in the calculation of gross margins resulted in the highest profitability for the 13-R Saroki Distributary (Rs. 3.74 per rupee spent on irrigation) when compared with the least level of profitability for Kakowal Distributary (Rs. 2.36 per rupee spent on irrigation). However, significant variation was observed across distributaries as shown in Figure 3.5.23.

Using the ratio of irrigation benefits per cubic meter to the total irrigation expenses per cubic meter of water applied as shown in Figure 7.24, a higher level of profitability was estimated for Lalian Distributary (2.02) when compared with that for Khadir Distributary (1.04). The system level estimates of profitability were calculated only for Lalian and Khadir distributaries due to the unavailability of the required data for other distributaries. It was found that each rupee spent on irrigation water brought benefits worth Rs. 2.02 at Lalian Distributary, while irrigation benefits of Rs. 1.04 were obtained at Khadir Distributary. This was mainly due to the reason that the total cost of groundwater was much higher at Khadir Distributary when compared with Lalian Distributary, as reflected by the proportion of groundwater in the total water applied i.e 89 percent and 66 percent, respectively. Moreover, the total amount of water applied in Khadir Distributary was significantly higher than in Lalian Distributary (double when compared with Lalian Distributary).

Figure 3.5.22. System level profitability (including irrigation cost in gross margins) across selected distributaries in the study area.

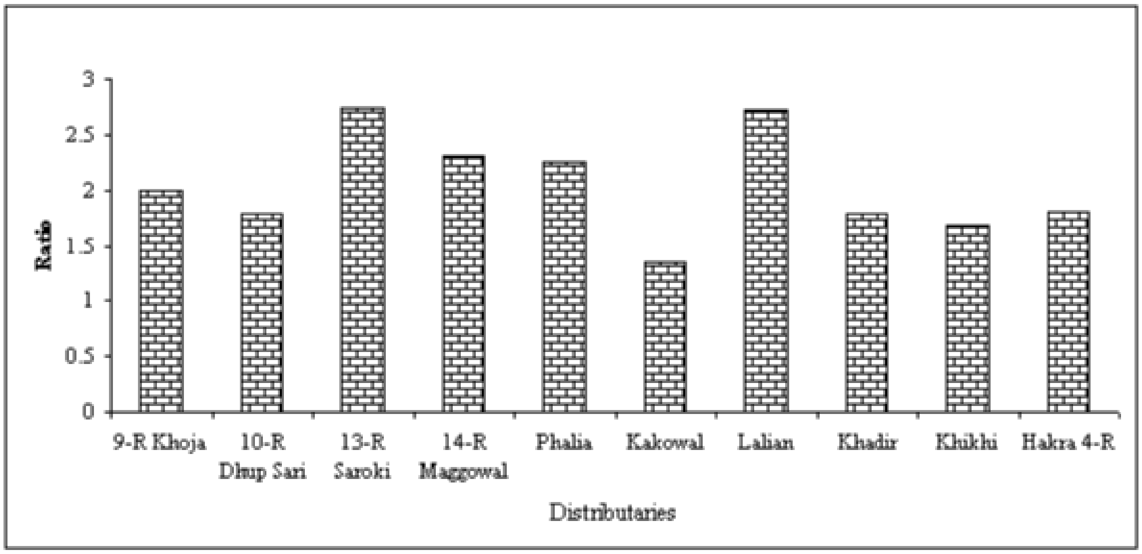


Figure 3.5.23. System level profitability (excluding irrigation cost in gross margins) across selected distributaries in the study area.

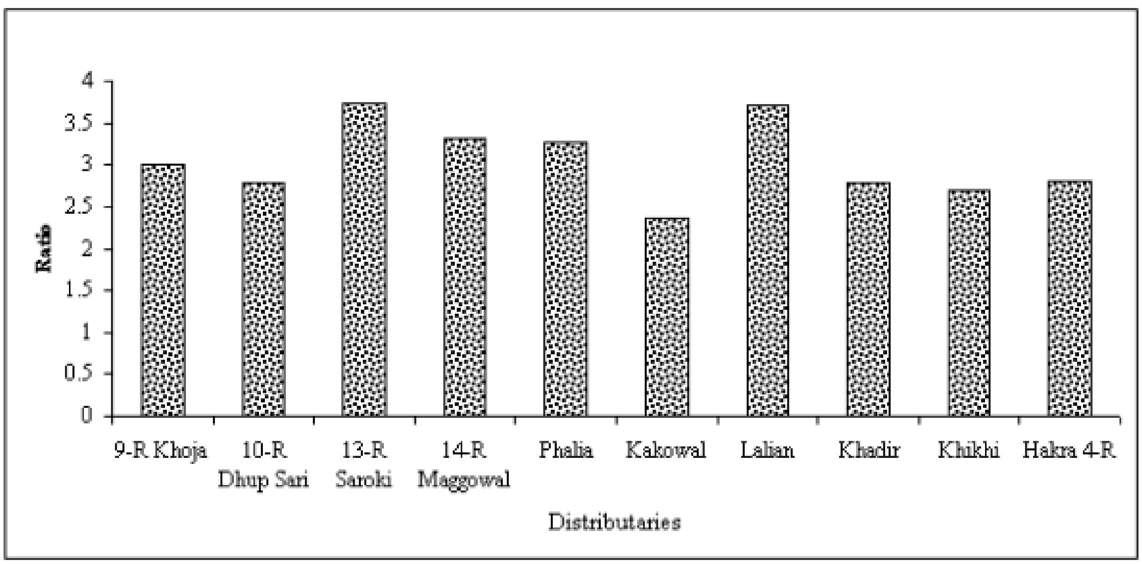
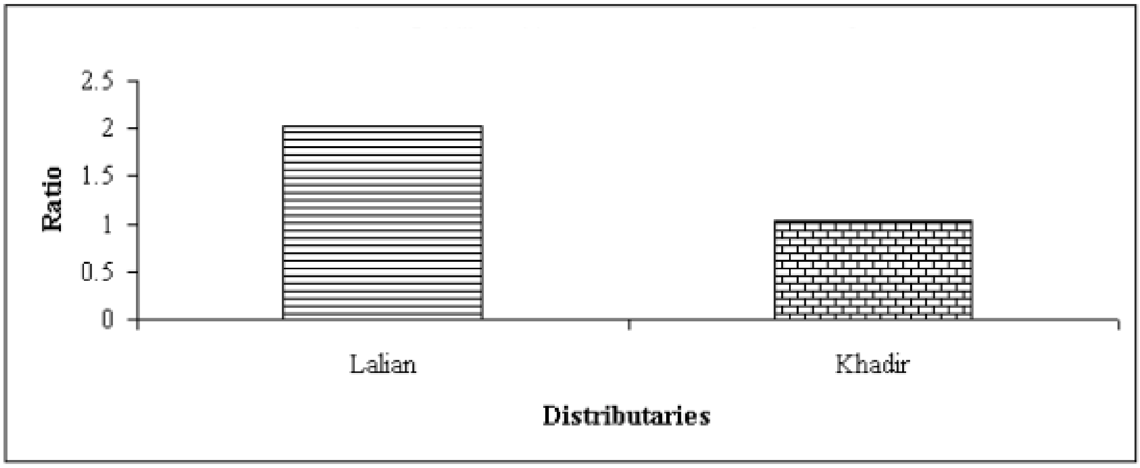


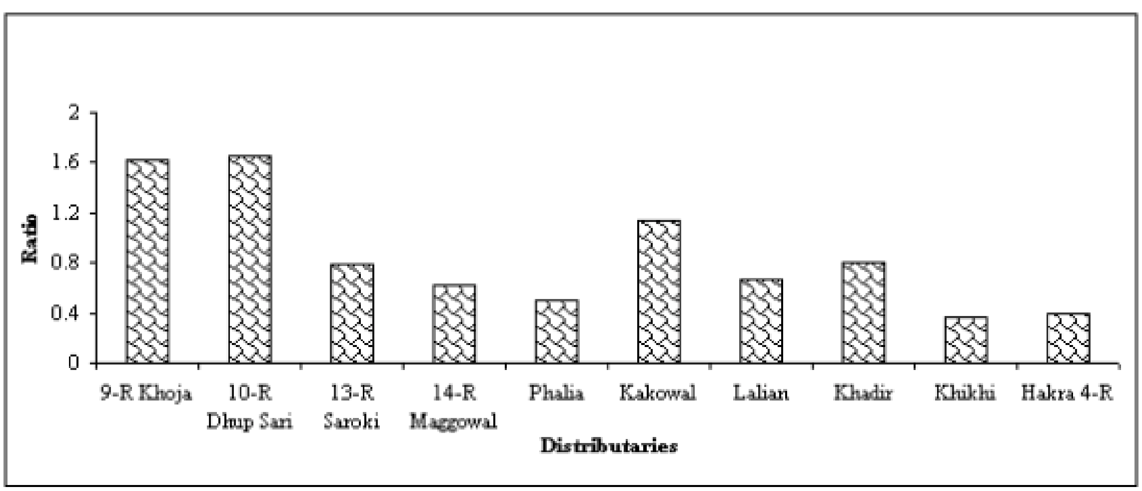
Figure 3.5.24. System level profitability with respect to per unit cost of water at Lalian and Khadir distributaries in the study area.



vii) System Level Financial Self-Sufficiency

System financial self-sufficiency is defined as the ratio of total annual income from water charges (abiana) collection to the actual total annual operation and maintenance (O&M) expenditure incurred. The 10-R Dhup Sari Distributary had the highest estimate, indicating that each rupee spent on the distributary as O&M expenditure resulted in water charges worth Rs. 1.65. On the contrary, the lowest estimate was worked out for Khikhi Distributary (Rs. 0.36). The estimates show that only three (9-R Khoja, 10-R Dhup Sari, and Kakowal) out of ten selected distributaries were able to generate more resources than what was actually spent on them as O&M expenditure. However, O&M expenditure accounted for expenditure incurred only at the distributary level, no account was made for the contribution for operation and maintenance of upstream irrigation system that made possible the supplies of water in a particular distributary. The comparison of system level financial self-sufficiency across distributaries is graphically shown in Figure 3.5.25.

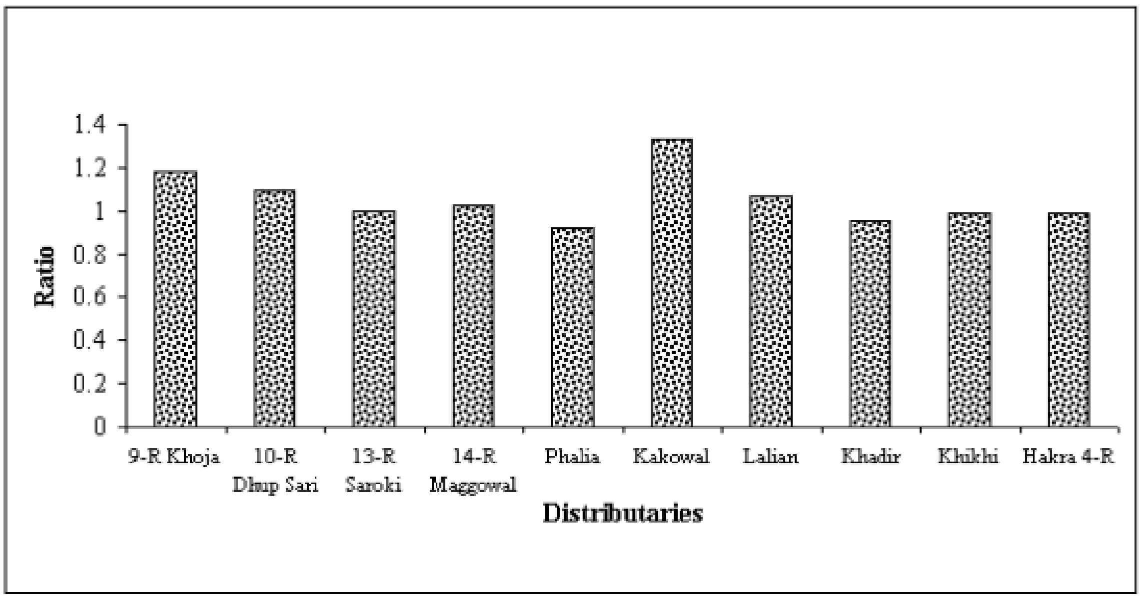
Figure 3.5.25. System level financial self-sufficiency across selected distributaries in the study area.



viii) *O & M Financing Gap*

O&M financing gap is defined as the ratio of annual O&M[9] expenditure incurred to maintain the distributary to the actual expenses that are required to run the system smoothly. The highest estimate for O&M financing gap was 1.133 calculated for Kakowal Distributary indicating more expenditure than what was required. On the other hand, the lowest estimate was worked out to be 0.92 for Phalia Distributary showing an O&M financing gap of 8 percent. It indicates that 8 percent less O&M expenditure was incurred on Phalia Distributary than what was perceived necessary. However, estimates show that O&M financing for the rest of the distributaries was fairly sufficient to meet the requirements. This is shown in Figure 3.5.26 for all the selected distributaries in the study area.

Figure 3.5.26 O & M financing gap across selected distributaries in the study area.



b. Environmental Indicators

Concerns are growing that a higher agricultural productivity should not pose any threat to environmental sustainability of the irrigation systems. With canal water becoming scarce with the passage of time due to higher demand and competition between its agricultural and non-agricultural uses, greater drafting of groundwater takes place wherever the groundwater is of acceptable quality. This is resulting in significant lowering of the groundwater table. Consequently, old tubewells installed at lower depths are increasingly becoming useless and new tubewell installations at higher depths are becoming inevitable. The situation may aggravate if the groundwater aquifers are not recharged by ample surface water irrigation availability and rainfall

[9] O&M expenditure includes the Operational expenditure (such as POL and staff salaries) and maintenance expenditure incurred on a particular distributary.

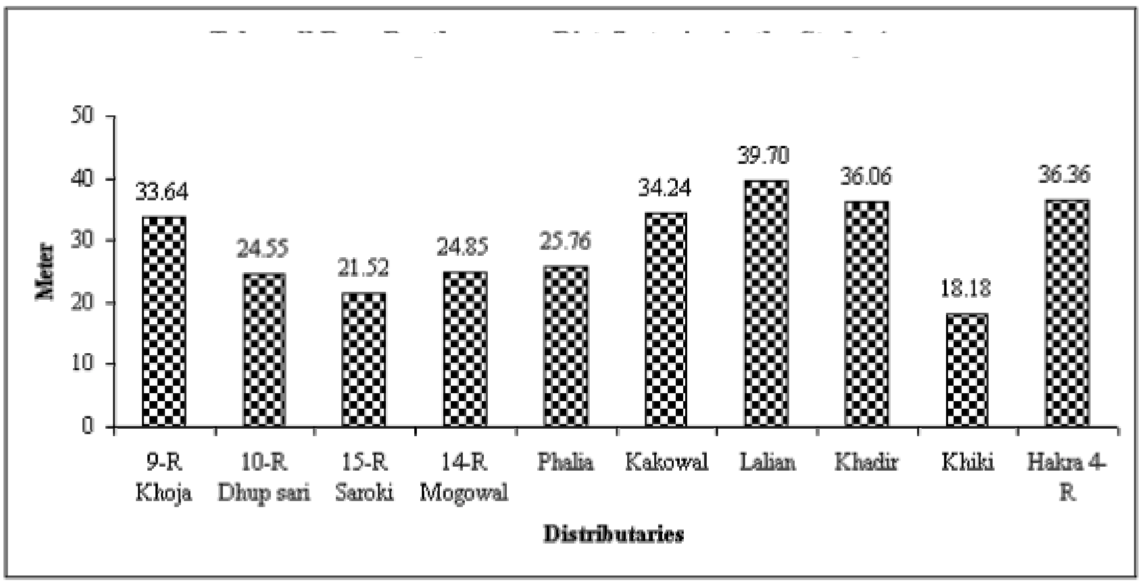
water run-off. This situation demands a careful use of groundwater resources for supplementing surface water supplies in achieving high productivity levels.

Taking into consideration that environmental costs and benefits are difficult to quantify with the state of the art techniques available to researchers, analysts and policy makers, the depth of tubewell bore was used as an indicative proxy of this environmental concern.

i) Tubewell Bore Depth

Average bore depth for tubewells in the study area as shown in Figure 3.5.27, compared with the average tubewell bore depth across different selected distributaries in the study area. The highest bore depth was found at Lalian Distributary (around 40 m) while the lowest estimate was calculated for Khikhi Distributary (around 16m).

Figure 3.5.27. Average tubewell bore depth across selected distributaries in the study area.



c. Infrastructure Related Indicators

Presence of better infrastructure helps the better operation and management of the irrigation system by the controlling authorities. Moreover, certain types of infrastructures like control structures, embankments and strong bridges also facilitate the smooth operation of the irrigation system as well as provide linkage to closer villages and settlements. Different infrastructure related indicators are presented in Table 3.5.6 and discussed below.

Table 3.5.6. Various sustainability indicators across distributaries in study area.

Sustainability indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R
Infrastructure										
No. of infrastructure (VR bridge, DR bridge, foot bridge, X drainage, Railway bridge) per km	0.69	0.64	0.44	0.42	0.35	0.16	0.52	0.52	0.23	0.73
Total control structures (O\L, head regulators, falls, weirs) per km	5.03	3.56	1.68	3.20	2.25	1.70	3.60	2.19	3.37	3.75

i) Number of Available Infrastructure facilities

It measures the number of infrastructure facilities (village-road (VR) bridges, district road (DR) bridges, foot bridges, cross drainage, railway bridges) that are built across the canals/distributaries to facilitate the movement across villages, towns, and cities. The highest number of such infrastructures was estimated as 0.73 per km for Hakra 4-R Distributary when compared with the lowest estimate of 0.16 per km for Kakowal Distributary.

ii) Number of Control Structures (Outlets, Head Regulators, Falls, and Weirs) per km

The average number of control structures across distributaries per km of a distributary are measured too. These control structures help in better operation and management through discharge regulation, etc. The estimates show significant variation across distributaries. The highest estimate was 5.03 control structures per km for the 9-R Khoja Distributary while the lowest was 1.7 control structures for the Kakowal Distributary. The higher value of estimated coefficient for the 9-R Khoja Distributary indicated higher number of structures per unit of length across this distributary. The length of the 9-R Khoja Distributary is around 10 km while the Khadir Distributary is about 88 km long.

d. Formal Irrigation Agency and Community Indicators

These indicators show the degree of staff availability for the proper operation and maintenance of the irrigation system. It also throws light on the degree of involvement of the stakeholders in the day-to-day operation and maintenance that would eventually result in better performance of the individual system. The estimates are shown in Table 3.5.7 and discussed below.

Table 3.5.7. Various institutional/management indicators across distributaries in study area.

Institutional/management indicators	9-R Khoja	10-R Dhup Sari	13-R Saroki	14-R Maggowal	Phalia	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R
Formal irrigation agency and community										
Number of management group employees per 1000 ha	0.08	0.08	0.09	0.08	0.07	0.13	0.12	0.17	0.15	0.06

Number of operation and maintenance group employees per 1000 ha	1.54	1.63	1.81	1.55	1.3	2.37	2.01	2.87	1.78	1.78
Number of water user associations	0	0	0	0	0	0	5	0	0	124
Number of farmer organizations	0	0	0	0	0	0	1	0	0	1
Tail gauge committees	0	0	0	0	0	0	11	12	0	0
Gender performance	0	0	0	0	0	0	0	0	0	0

i) Number of Management Group Employees per 1000 ha

This shows the number of employees (XEN, SDO, Sub-Engineers) that are responsible for the management of an irrigation system. The highest estimate was calculated for Khadir Distributary (0.17) while the lowest was estimated as 0.06 for Hakra 4-R Distributary because of small number of executive members in FO.

ii) Number of Operation and Maintenance Group Employees per 1000 ha

This shows the number of employees (Zilladar, Patwaris, Mates, Masons, Baildars, Signalers, Gauge readers, Postmen, Chowkidars, etc.) that are responsible for proper operation and maintenance of the irrigation systems. A higher estimate of 2.87 was found for Khadir Distributary while the lowest was estimated for Phalia Distributary (1.3).

iii) Number of Water Users' Associations (WUAs)

Water users' associations act only on two out of ten selected distributaries.The highest number of water users associations at watercourse level was at Hakra 4-R Distributary (124) as compared to 5 on Lalian Distributary. Moreover, the active water user associations were present only at Hakra 4-R Distributary.

iv) Number of Farmers' Organizations (FOs)

A number of farmers' organizations were present only on one out of ten distributaries, namely Hakra 4-R Distributary.

v) Tail Gauge Committees

A number of tail gauge committees were present only on two out of ten distributaries, namely Lalian and Khadir distributaries. The higher estimate of 12 tail gauge committees was present at Khadir Distributary while the lower number of 11 was found for Lalian Distributary. These tail gauge committees were meant to check the flow of water at tail of the distributaries at the tail gauge points.

vi) Gender Performance

No active gender participation was found in any of the selected distributaries.

Irrigation System Performance and Its Impacts on Poverty

In order to determine the effect of irrigation system performance on poverty, Logit modeling was employed. It is already mentioned that the Logit modeling technique is used when dependent variable is binary with values 1 or 0. The coefficients of independent variables indicate the probability of occurrence of one of the two possibilities of the dependent variable. Furthermore, instead of normal regression analyses, recursive-modeling technique was employed. The gross value product per hectare in thousand rupees was used as performance indicator across distributaries. The model specification is as follows:

Specification of the Model:

In the first step, simple linear regression equation was estimated with gross value product per hectare as dependent variable. The specification of the model is as follows:

$$GVP = \beta_0 + \beta_1 * CI + \beta_2 * Irri\_Cost + \beta_3 * Crd\_Ann + \beta_4 * VAg\_Asst + e$$

Where:

GVP	= Gross value of production per hectare (000 rupees)
CI	= Cropping intensity (ratio)
Irri_Cost	= Total cost of irrigation in Rs.
Crd_Ann	= Annual credit borrowed from institutional as well as non-institutional sources (Rs).
VAg_Asst	= Total value of agricultural assets owned by the household (Rs).
β_0	= Constant term
$\beta_{1...}\beta_4$	= Coefficients to be estimated
e	= Error term

Cropping Intensity

It is expected that higher cropping intensity is directly linked with higher gross value of production. Every farmer is assumed rational and supposed to be inclined to extract as much as he could in terms of farm production. A positive correlation of cropping intensity is expected with gross value of product indicating positive sign for coefficient to be estimated.

Total Cost of Irrigation

Irrigation water is the key input in crop production. Farmers were always found complaining about unavailability of irrigation water in required volume and at proper time indicating this as a major hurdle in achieving higher productivity levels. So, the cost of irrigation water is used as a proxy to the quantity of irrigation water applied crop cultivation. A positive impact of irrigation cost is assumed on gross value of production per hectare. So, a positive sign for the coefficient to be estimated is expected.

Annual Credit Borrowing

Borrowing, from institutional and non-institutional sources, enhances the ability of the farm households to buy required inputs at proper time. It is expected that borrowings have positive impact on gross value of production per hectare. Therefore, expected sign of the coefficient would be positive.

Total value of Agricultural Assets

A higher value of agricultural assets owned by the farm household is indicative of the greater resourcefulness of a household. More agricultural machinery means that a household can timely accomplish its cultivation process and other field operations that require machinery and tools of different kind. It is expected that the total value of agricultural assets has positive impact on gross value of production per hectare and the sign of the estimated coefficient is expected to be positive.

Regression Results for System Performance and Its Impacts on Poverty

The results of the estimated regression equation are presented in Table 3.5.8. The R^2 showed that 40.5 percent of the variation in gross value of product is explained by the independent variables. It is found that coefficients for cropping intensity, total cost of irrigation, and total value of agricultural assets are significant at 99 percent significance level. However, the coefficient of annual credit, though positively signed is insignificant. It is estimated that one unit increase in cropping intensity would yield an increment of Rs. 17,293 in terms of gross value of product per hectare. Additional irrigation water applied worth Rs.1 would result in an increment of Rs. 0.17 in gross value of production per hectare. One rupee increase in annual credit would result in an increase of Rs. 0.0053 in gross value of production per hectare. Similarly, an increment in agricultural assets worth one rupee would result in an increment of Rs. 0.0113 in gross value of production per hectare. Based on this estimated regression equation, predicted values are also estimated and used in the next regression equation.

Table 3.5.8. Regression results depicting impact of system performance on poverty.

Variables	Coefficients	Std. Error	t-value	Sig.
(Constant)	-6.741	1.315	-5.127	0.00
Cropping intensity	17.293	0.863	20.033	0.00**
Total cost of irrigation	0.0001746	0.00	8.843	0.00**
Annual credit	0.0000053	0.00	1.213	0.226
Total value of agricultural assets	0.0000113	0.00	3.04	0.002**
F-statistics = 150.995	Sig. = 0.00			
N = 890	R2 = 0.405	df = 4		

** Significant at 99 percent significance level

System Performance across Different Reaches of the Distributaries and its Impacts on Poverty

The following equation was used to estimate the relationship between system performance across different reaches of distributaries and its impact on poverty :

$$Poverty = \beta_0 + \beta_1 * FS + \beta_2 * DR + \beta_3 * Edu\_HH + \beta_4 * NLH + \beta_5 * GVP\_Ha + \beta_6 * D_M + \beta_7 * D_T + e$$

Where:

Poverty	= if poor, then 1, otherwise 0
FS	= Family size in number
DR	= Dependency ratio (defined as the ratio of number of household members below 16 years and above 60 years divided by family size)
Edu_HH	= Number of formal schooling years completed by household head
NLH	= Net landholding (hectares)
GVP_Ha	= predicted values of gross value of production per hectare (in thousands rupees)
D_M	= Dummy for the middle Location
D_T	= Dummy for the tail Location
β_0	= Constant term
$\beta_{1...}\beta_7$	= Coefficients to be estimated
e	= Error term

Family Size

It is expected that larger the family size, greater is the probability of the household to be poor. Estimated coefficient for family size is expected to be positive.

Dependency Ratio

Dependency ratio is defined as the ratio of the number household members below 16 years and above 60 years divided by the family size. A positive sign for the coefficient of dependency ratio would indicate that the probability of the households to be poor increases with higher dependency ratio.

Education of Household Head

More education is supposed to lead to higher earning potential as the educated households are assumed to take better management decisions regarding the better use of household resources. The coefficient for the household's education is expected to have a negative sign.

Net Landholding

It is expected that an increase in net landholding would decrease the probability of a household to become poor. So, a negative sign is expected for the coefficient of net landholding indicating its inverse relationship with poverty.

Gross Value of Production per Hectare

Gross value of production is indicative of the performance of individual farm households. Higher land productivity will result in higher annual income of a household that would eventually improve the ability of the household to provide all the basic needs to its members by spending more. It is expected that with an increase in gross value of production per hectare, poverty will decrease. Therefore, a negative sign is expected for the coefficient of gross value of production per hectare.

Location of the Households

The location along the irrigation system reflects access to irrigation water in the presence of inequities prevailing in the distribution of this vital input. It is expected that households at the head and middle reaches of the irrigation system will have better agricultural production and income leading to decreased probability of households to be poor compared with those located the tail ends.

Regression Results for System Performance across Different Reaches of the Distributaries and its Impacts on Poverty

The results of the Logit regression are presented in Table 3.5.9. It was found that coefficient for the family size was positive and statistically significant at 99 percent level of confidence. It shows that one member increase in the family size would increase the marginal probability of being poor by 0.026. The coefficient for dependency ratio was also positive and statistically significant at 99 percent level of confidence. The coefficient for dependency ratio shows that one unit increase in dependency ratio would increase the marginal probability of being poor by 0.246. The regression equation shows that the coefficient for household head's education was negative and statistically significant at 99 percent level of confidence, indicating that each additional completed year of household head's education would decrease the marginal probability of household being poor by 0.017. The coefficient for net landholding carried negative sign and it was statistically significant at 99 percent level of confidence, indicating that one-hectare increase in net landholding would reduce the marginal probability of being poor by 0.035. The coefficient for GVP was found to be negative and statistically significant at 99 percent level of confidence, suggesting that an increase of one thousand rupees in gross value of production per hectare would diminish the marginal probability of being poor by 0.009. The regression equation showed no significant difference in poverty levels between the household located at the head and middle reaches as the dummy coefficient for the middle reach was non significant. However, it was found that marginal probability of being poor would increase by 0.096 (significantly at 95 percent level of confidence), if the household was located at the tail reach area, instead of the head reach area.

Table 3.5.9. Regression results depicting impact of system performance on poverty with respect to the location of the distributaries.

Variables	Coefficients	Std. Error	Sig.	Marginal Probability
Constant	0.643	0.233	0.006**	0.143
Family size (number)	0.118	0.022	0.00**	0.026
Dependency ratio	1.107	0.276	0.00**	0.246
Education of the household head (years)	-0.077	0.015	0.00**	-0.017
Dummy for middle reach	0.052	0.166	0.752	0.012
Dummy for tail reach	0.433	0.172	0.012*	0.096
Net landholding (ha)	-0.155	0.021	0.00**	-0.035
Gross value of production per hectare (thousands)	-0.042	0.006	0.00**	-0.009
-2 log likelihood = 1274.416				
Cox & Snell r square = 0.220				
Nagelkerke r square = 0.302				
chi-square = 299.39	df = 7	Sig. = 0.00**	N =1205	

* Significant at 95 percent significance level
** Significant at 99 percent significance level

Summary and Conclusions

- Distributaries with lower irrigation intensity were facing a higher degree of surface water scarcity and they were also prone to the poor quality of groundwater.
- The irrigation system with relatively higher surface water availability and good quality groundwater experienced higher cropping intensity. The cost of groundwater inversely affects the cropping intensity.
- The irrigation systems, where the proportionate share of groundwater in total irrigation water was lower, experienced higher productivity on per hectare basis.
- Higher head-tail equity ratio in output per hectare was experienced in irrigation systems where groundwater quality was very poor with higher inequities in surface water supplies. However, cropping pattern and management skills also play a critical role when other factors remain constant.
- Relative irrigation water supply with respect to diverted water was found higher where groundwater quality was good for irrigation purposes.
- Water delivery capacity with respect to design discharge was higher for irrigation systems where surface water supplies were relatively higher and cropping pattern as well as cropping intensity did not result in very high peak consumptive demand.

6. ANALYSIS OF CONSTRAINTS ON CROP PRODUCTIVITY ENHANCEMENTS IN IRRIGATION SYSTEMS

In this chapter we present an analysis of constraints on productivity enhancements in the selected irrigation systems. The constraints vary spatially making it difficult to address them by single solution. Table 3.6.1 shows various constraints on crop productivity faced by farmers in the study areas. For simplifying the analysis, these constraints were subdivided into five sub-groups related to water, other production inputs, marketing, technical matters and credit constraints.

Water Related Constraints

Shortage of canal water was perceived as the single most important constraint affecting crop production in the study areas. Around 27.48 percent of the farmers were of the view that an increase in the supply of irrigation water would help them in increasing the productivity of land and water. The farmers in the Upper Jhelum Canal (UJC) were facing this problem least (only 24.08 percent) when compared with those in the other three irrigation systems. It was due to this reason that many distributaries in UJC irrigation system were non-perennial, encouraging farmers to extract good quality groundwater to meet the deficiency in surface water supplies. Water available through canal water supplies or groundwater extraction was good in quality for agricultural purposes. In Lower Jhelum Canal area, the availability of surface water was not sufficient to meet the demand and also, the groundwater quality was poor. So, farmers were of the view that surface water supplies should be increased. On the other hand, water allowance of the other distributary was low due to better quality groundwater, encouraging them to use it. The highest number of farmers (31.23 percent) who indicated shortage in canal water supplies, belonged to Hakra Canal area due to the fact that surface water supplies were insufficient to meet the requirements. Additionally, poor quality of groundwater left the limited option for farmers to augment the canal water supplies with ground water extraction.

Around 7.6 percent of the farmers were of the view that unimproved irrigation facilities were one of the reasons for reduced canal water supplies to them. The farmers were of the view that watercourses must be lined in order to decrease the losses, which is conventionally around 25 percent in case of unimproved watercourses. In the case of LJC irrigation system, the majority of farmers (10.06 percent) were of the view that the irrigation facilities must be improved to overcome these losses in order to improve the availability of water at farm gate. The higher proportion of the farmers in UJC and LJC reported these because many of the selected distributaries in UJC and Khadir Distributary in LJC were not lined which increased the farmers' concern over losses of precious canal water in canal and watercourses due to seepage and conveyance losses.

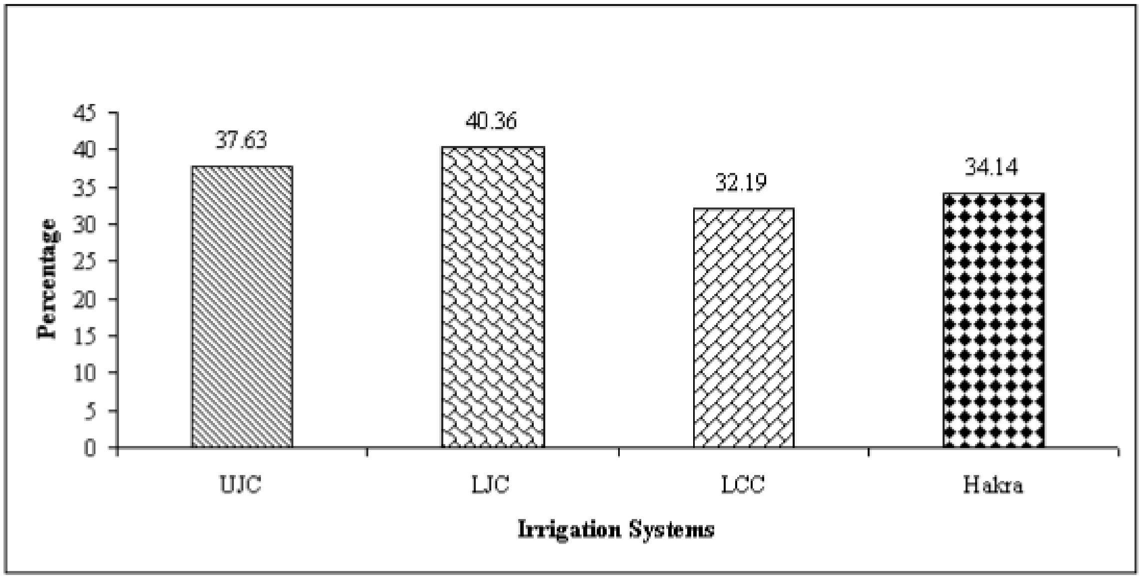
A small percentage of farmers (about 2.01 percent) attributed less canal water to the prevalent drought conditions. Majority of these farmers belonged to UJC irrigation system, where many of the distributaries were non-perennial in nature .

Overall, around 37.09 percent of the farmers indicated that irrigation water was the main constraint on their crop productivity. The proportion of farmers indicating this was found similar in all the selected irrigation systems, though it was slightly high in LJC irrigation system (40.36 percent) as shown in Figure 3.6.1.

Table 3.6.1. Constraints on crop productivity across irrigation systems in the study area.

		Irrigation systems				
	Problems	UJC	LJC	LCC	Hakra	Overall
Water constraints	Shortage of canal water	24.08	30.18	28.33	31.23	27.48
	Unimproved irrigation facilities	8.85	10.06	3.86	2.91	7.60
	Drought problem	4.70	0.12	0.00	0.00	2.01
	Group total	37.63	40.36	32.19	34.14	37.09
Input constraints	Expensive farm inputs	17.70	17.08	18.03	20.58	17.97
	Adulterated farm inputs	0.00	8.07	22.75	27.60	9.67
	High cost of diesel/electricity	0.00	15.67	8.58	5.33	6.56
	Difficulty in obtaining inputs	4.39	0.00	0.21	0.48	1.94
	Labor shortage	1.12	0.12	0.00	0.24	0.54
	Group total	23.21	40.94	49.57	54.23	36.68
Marketing constraints	Marketing problems for crops/low prices of crops	3.91	2.11	4.08	2.18	3.18
	Lack of farm to market roads	1.67	2.46	0.21	0.73	1.54
	Other marketing related problems	1.99	3.98	2.79	0.97	2.54
	Group total	7.57	8.55	7.08	3.88	7.26
Technical constraints	Low yield of crops	5.26	1.87	1.93	1.94	3.31
	Damage of pests and diseases	5.58	0.35	1.72	0.48	2.78
	Weed damage	3.67	1.17	1.07	0.73	2.14
	Salinity	3.03	1.17	1.29	0.73	1.91
	Difficulty in renting farm machinery	0.64	1.87	1.93	1.45	1.31
	Other technical problems	9.41	1.87	1.50	0.97	4.85
	Group total	27.59	8.30	9.44	6.30	16.30
Credit constraints	Loan problems	3.99	1.87	1.72	1.45	2.68
	Group total	3.99	1.87	1.72	1.45	2.68
	Total	100.00	100.00	100.00	100.00	100.00

Figure 3.6.1. Proportion of farmers reporting water related constraints on productivity across selected irrigation systems.

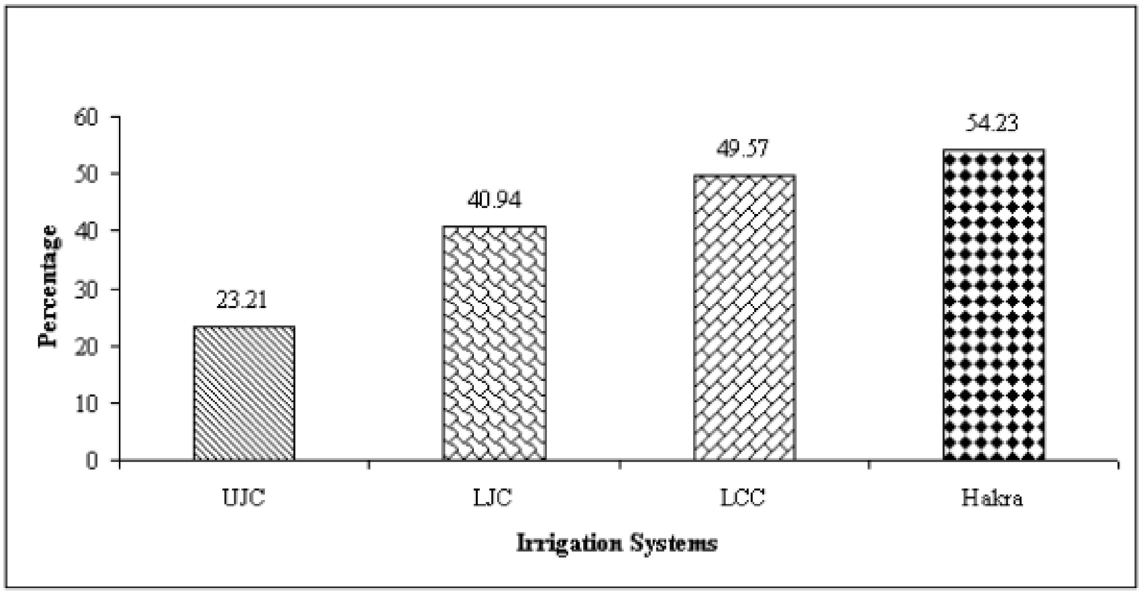


Non-water Input Constraints

The second major constraint on productivity with respect to inputs was expensive farm inputs. About 17.97 percent of the farmers reported this problem, with greater proportion of farmers from Hakra irrigation system where around 20.58 percent of them indicated this issue, while the lowest proportion of those confronting this issue belonged to LJC system. However, this problem was reported by almost the same number of farmers in all four selected irrigation systems. Around 9.67 percent of the farmers were concerned about adulteration of inputs such as fertilizer and pesticides. This problem was mainly reported in LCC and Hakra irrigation systems, though higher in the latter (27.60 percent). Around 6.56 percent of the farmers complained about the high prices of diesel/electricity that limited their ability to extract groundwater for augmenting the insufficient surface water supplies. Majority of these farmers belonged to LJC irrigation system, especially in Khadir Distributary area where most of the farmers had to rely heavily on groundwater extraction for irrigation purposes. The extent of this problem was lower in LCC and Hakra irrigation systems due to limited options for groundwater extraction. It was mainly due to poor quality of groundwater in most of the areas in these irrigation systems, especially in the tail reach areas. A small proportion of the farmers also indicated unavailability of inputs and labor at required times in sufficient quantities. The farmers mainly reported it in UJC system, which was adjacent to industrial areas that were absorbing the excess labor, that could possibly be working in the fields otherwise.

Overall, 36.68 percent of the farmers complained various input related problems as a major cause of low productivity. Figure 3.6.2 shows that around 54.23 percent of the farmers in Hakra irrigation system complained about these problems while the farmers in the UJC irrigation system area encountered lesser of such problems (23.21 percent).

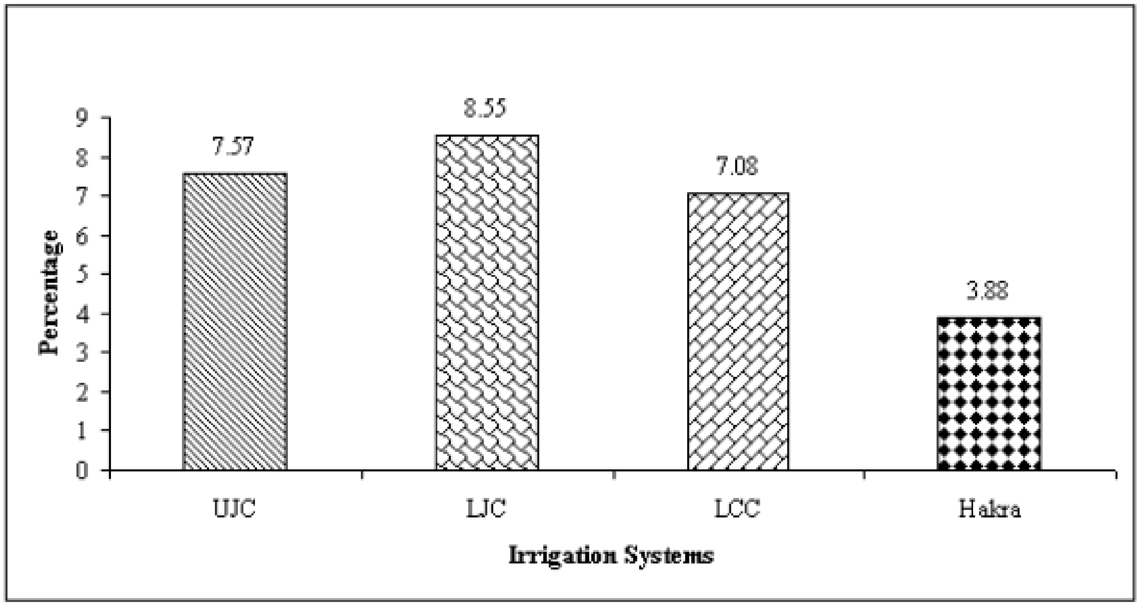
Figure 3.6.2. Proportion of farmers reporting input related constraints to productivity across selected irrigation systems.



Marketing Constraints

Around 3.18 percent of the farmers complained about marketing problems and low prices of the output in the market. Majority of farmers who indicated this constraint belonged to LCC irrigation system areas while the lowest proportion belonged to LJC areas. The delayed payment was more important for sugarcane farmers who had to sell directly to the sugar mill owners. A small proportion of the farmers also complained about lack of storage facilities and delayed payment for the produce as the major marketing problems. Overall, around 7.26 percent of the farmers indicated various marketing problems that hindered the farmers' efforts to improve productivity. It is obvious that if output does not bring sufficient income, then it discourages the farmer to produce more. Majority of farmers complaining about various marketing problems belonged to LJC irrigation system area (8.55 percent) while the lowest proportion of them belonged to Hakra irrigation system area (3.88 percent) as shown in Figure 3.6.3.

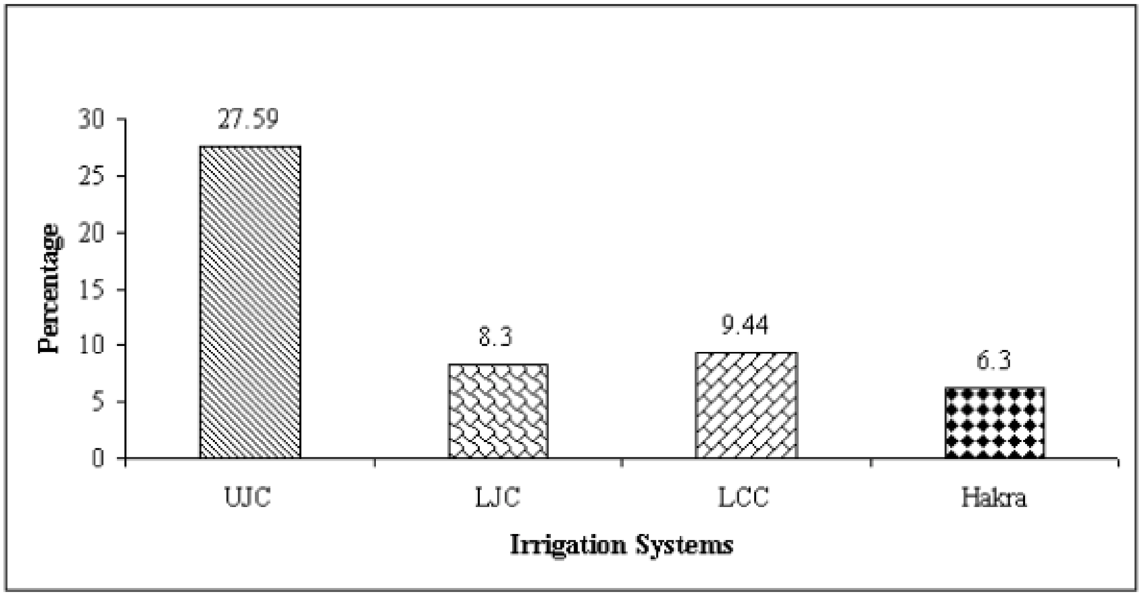
Figure 3.6.3. Proportions of farmers reporting marketing constraints on productivity across selected irrigation systems.



Technical Constraints

A variety of technical constraints were also disclosed by the farmers, which were restraining their productivity enhancing efforts. Around 3.31 percent of the farmers were unable to understand the reason for the low yield of crops despite their best efforts. This was of main concern in the UJC area where around 5.26 percent of farmers reported this while the same problem was reported by around 2 percent of the farmers in each of the other three selected irrigation systems. This clearly indicates that in addition to inputs availability, farmers must be provided with quality extension services that would educate and help them in boosting up their current productivity levels. Around 2.78 and 2.14 percent of the farmers reported the damage due to pests and diseases as well as weeds, respectively. Both of these problems were reported by a higher proportion of farmers in UJC area when compared with farmers in other irrigation systems. Some other reasons included salinity of land, difficulty in renting of farm machinery, crop damage by wild animals, waterlogging, saline underground water, and poor access to extension services provided by the Agricultural Extension Department. Overall, around 16.30 percent of the farmers' reported various technical problems that inhibited them to achieve higher crop productivity. Majority of farmers (27.59 percent) reporting these problems belonged to UJC irrigation system area as shown in Figure 3.6.4.

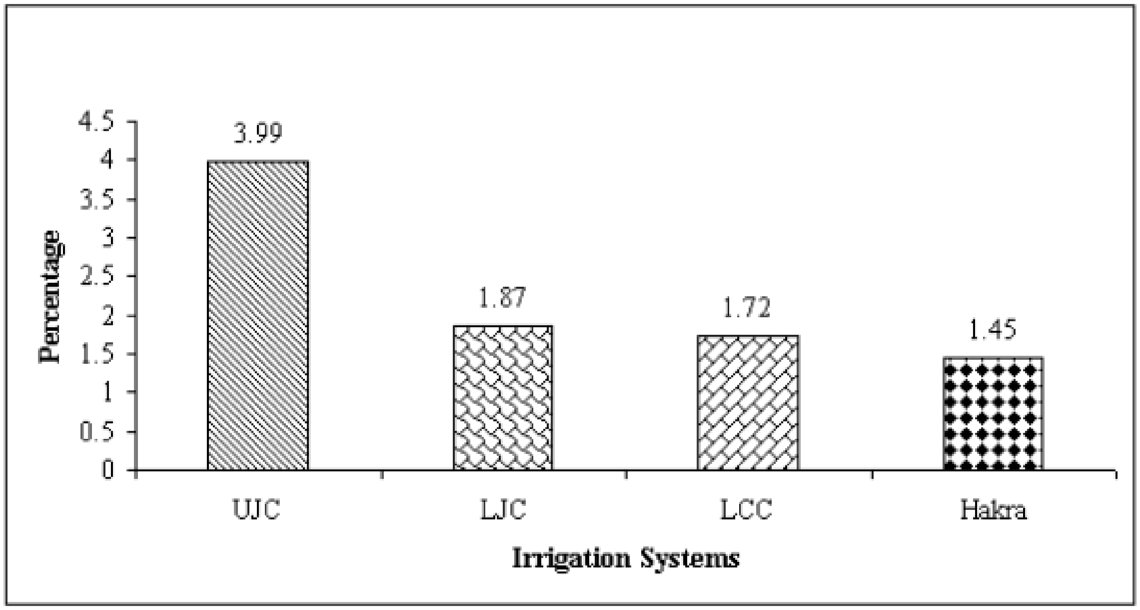
Figure 3.6.4. Proportions of farmers reporting technical constraints to productivity across selected irrigation systems.



Credit Constraints

As discussed above on the one hand, due to various technical, water, and inputs related constraints, farmers were experiencing low crop productivity, and on the other hand, low prices of output and poor access to market had limited their ability to buy the necessary inputs at the required time in required quantity. This financing deficiency could be bridged only by the provision of credit to farmers for improving their access to inputs. On this reason, small and poor farmers were eager to have access to institutional credit. Around 2.68 percent of the farmers reported lack of access to credit for purchasing necessary inputs. The proportion of the farmers reporting this was higher in UJC irrigation system area (3.99 percent) when compared with other irrigation systems as shown in Figure 3.6.5.

Figure 3.6.5. Proportions of farmers reporting credit constraints to productivity across selected irrigation systems.



Constraints on Crop Productivity: Case of Wheat Productivity

Apart from these general constraints on productivity, the various constraints to wheat productivity were analyzed. Wheat crop was selected because it was cultivated in all areas and is regarded as the main staple crop contributing towards the food security of particularly the households of poor and small farmers.

Table 3.6.2. shows a wide variation in yields obtained by the wheat growers in various irrigation systems. Average yield was the highest (3.47 t/ha) in the LCC area where the climatic conditions suit wheat production the most as compared with other areas. Average yield was the lowest in the Hakra irrigation system where farmers were facing less water availability coupled with poor quality groundwater that limited the scope to augment the irrigation water supplies through increased groundwater pumping. The highest yield obtained was 6.52 tons per hectare in the UJC irrigation system area while the lowest yield obtained was found in the LJC irrigation system area. Overall, an average wheat yield around 2.61 tons per hectare was found with the maximum and the minimum of around 6.52 and 0.20 tons per hectare, respectively.

Table 3.6.2. Mean, maximum, and minimum yield (t/ha) of wheat across different irrigation systems in the study area.

	Irrigation systems				
	UJC system	LJC system	LCC system	Hakra system	Overall
Mean	2.43	2.72	3.47	2.05	2.61
Maximum	6.52	6.42	5.08	4.94	6.52
Minimum	0.59	0.20	1.30	0.28	0.20

Fertilizer application showed positive relationship with yield as shown in Figure 3.6.6. Majority of the farmers spent up to Rs. 6000 per ha on fertilizers application. However, wide variation in yield could be observed with an increase in expenditure on fertilizers. Figure 3.6.7 shows positive correlation between yield and cost of irrigation. It implies that due to scarce canal water supplies, variable quality of groundwater, and high cost of fuel used in groundwater extraction, farmers were unable to tap the maximum yield and by increasing the expenditure on good quality irrigation, gains in productivity could be achieved. It is clear from the figure that majority of the farmers had incurred an expenditure of around four to five thousand rupees per hectare on irrigating the wheat fields. Similarly, the use of weedicides and yield also showed positive relationship as shown in Figure 3.6.8. It was found that farmers who used weedicides were able to reap a higher average yield when compared with those farmers who did not use weedicides for weed control. This pattern was found consistent in all four irrigation systems in the study area. The highest difference in average yield was found in the case of LCC irrigation system where farmers who used weedicides were able to obtain around an additional 0.75 ton per ha than those who did not use weedicides. On overall basis, an average yield difference of 0.51 tons per ha was observed between the farmers who used weedicides to control weeds with an average yield of 2.86 tons per ha and those who did not use weedicides with an average yield of 2.35 tons per ha.

Figure 3.6.6. Relationship between wheat yield (t/ha) and cost of fertilizers (Rs/ha).

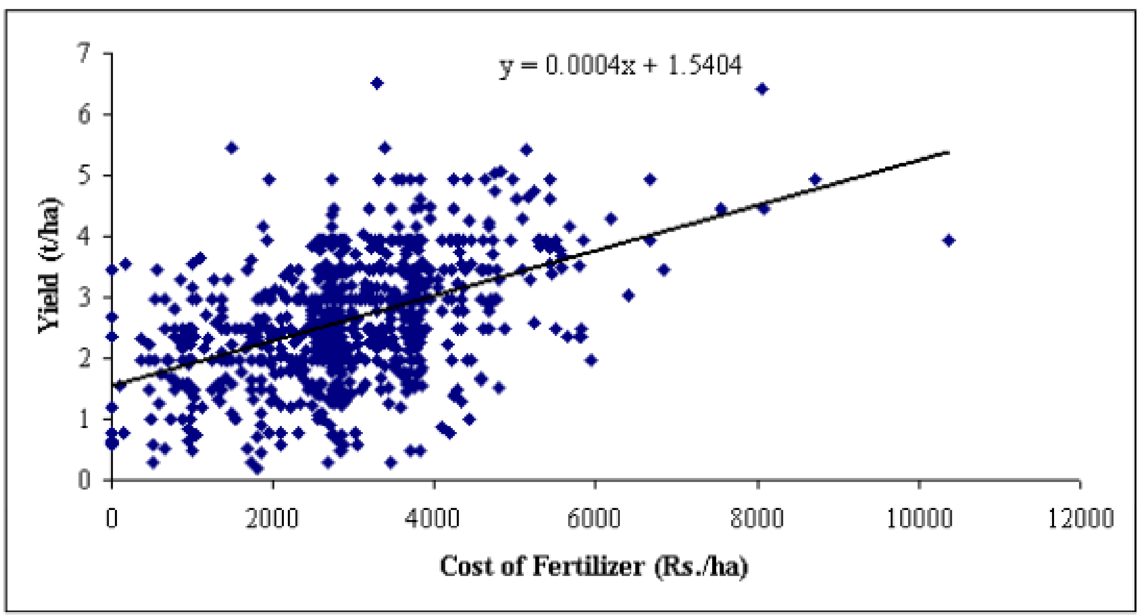


Figure 3.6.7. Relationship between wheat yield (t/ha) and cost of irrigation (Rs/ha).

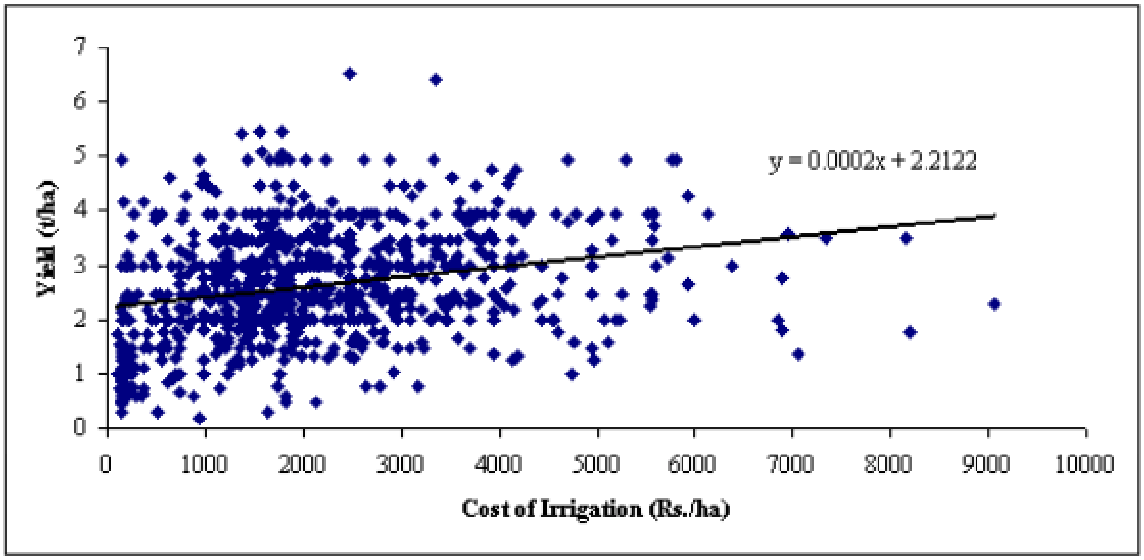
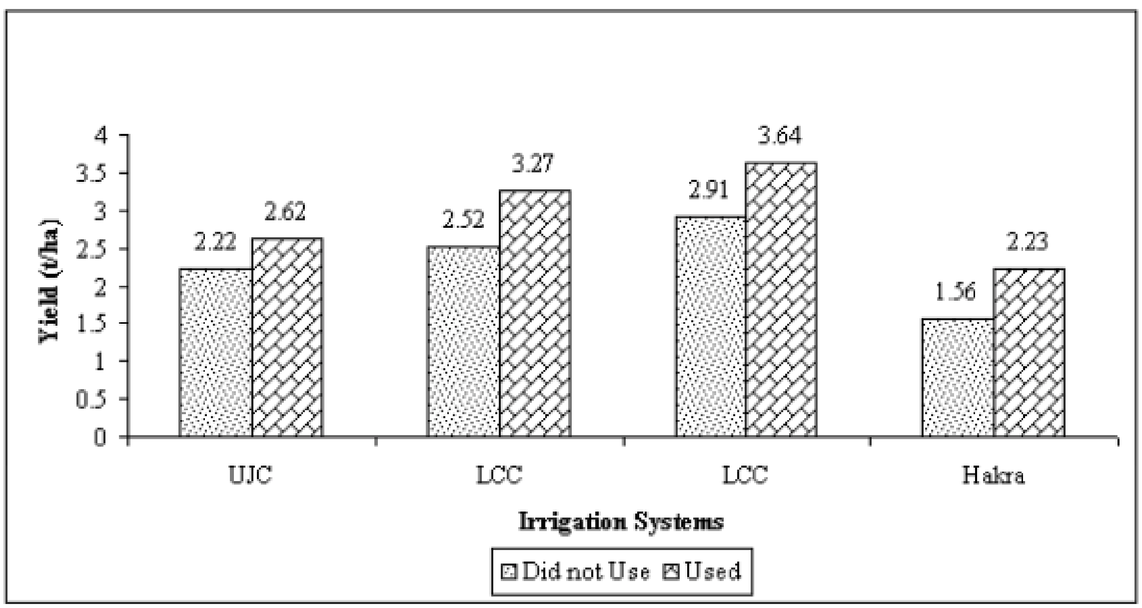
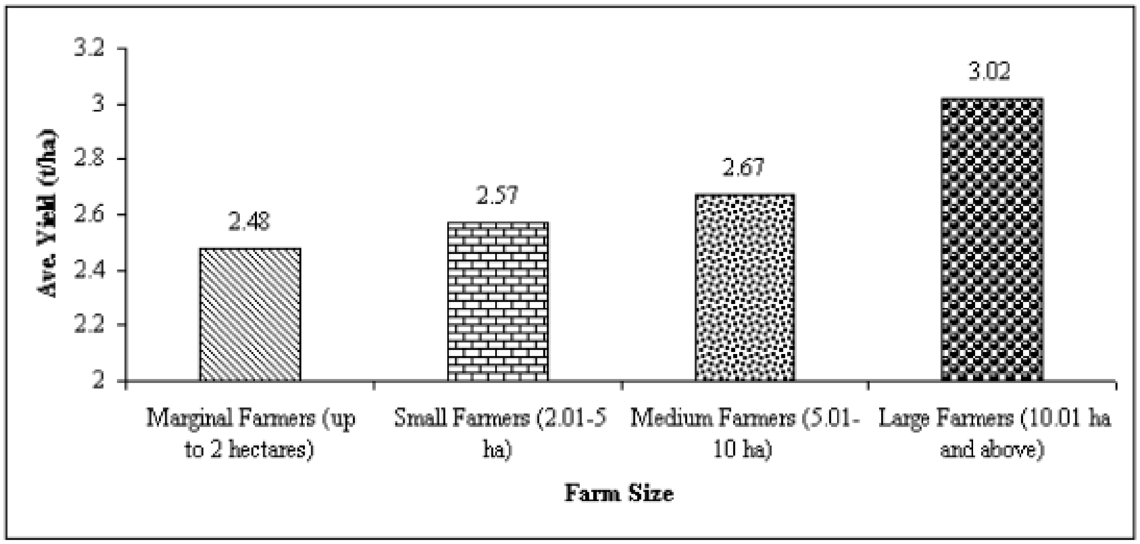


Figure 3.6.8. Impact of weedicide use on wheat yield (t/ha).



In addition to different inputs that affect the wheat productivity in the study area, it was found that the size of landholding also contributed to variation in yields. An increase in the size of landholding would lead to increase the average yield as shown in Figure 3.6.9. It was found that average productivity of marginal farmers was significantly low than that of large farmers. It was due to the fact that large farmers being financially strong were able to purchase inputs in required quantity and at right times. Moreover, due to the large size and the relatively small portion used for wheat production, large farmers were able to divert additional water to the wheat fields for increasing the gains in productivity. Additionally, they were able to exploit the groundwater aquifers according to the need. The average productivity of small farmers was also found less than that of medium farmers, though it was higher than that of the marginal farmers.

Figure 3.6.9. Impact of farm size on wheat yield (t/ha).



Not only the input and farm size but also the quality of management was found to be an important factor leading to increase wheat productivity as shown in Figure 3.6.10. It was found that illiterate farmers obtained significantly less wheat yield (2.47 t/ha) when compared with the farmers who had completed more than 10 years of formal education (2.92 t/ha). Farmers with education level between 6-8 years and 9-10 years did not show any significant variation, though it was higher than the illiterate farmers and lower than more educated farmers. It was due to the fact that educated farmers were able to manage the available resources in more productive manner than the illiterate farmers.

Figure 3.6.10. Impact of farmer's education on wheat yield (t/ha).

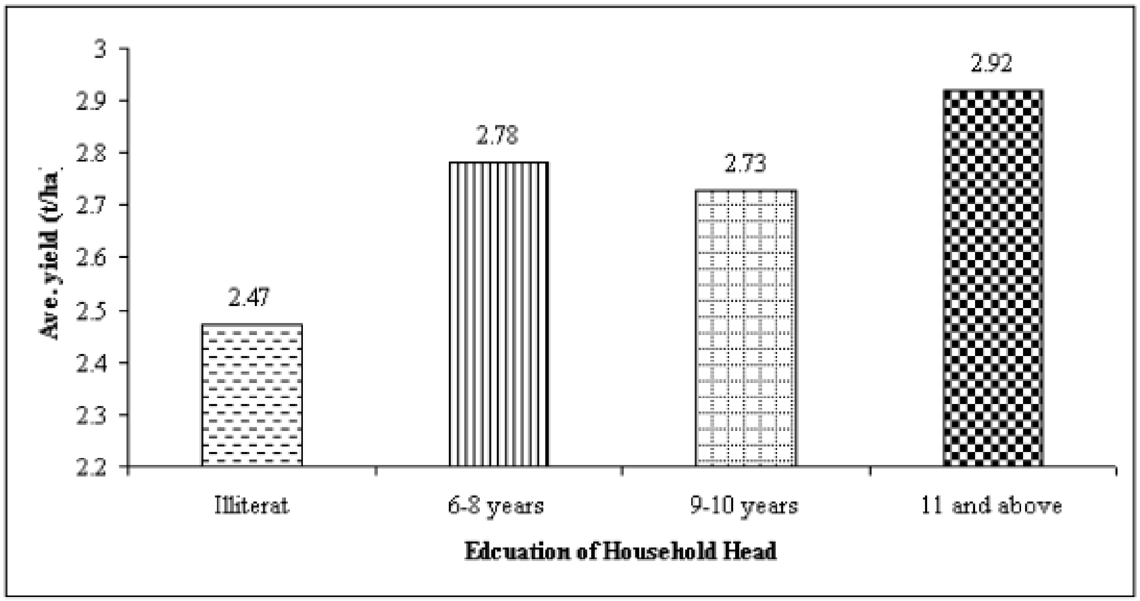
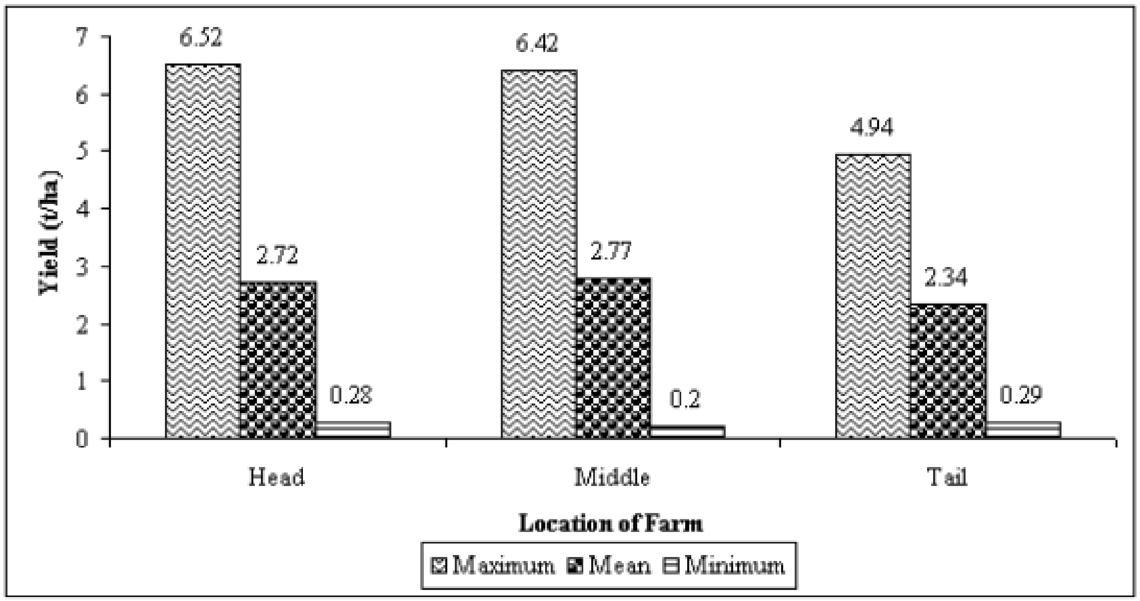


Figure 3.6.11 shows the relationship between the location of farms along the distributary and their respective yield level. It was found that, on an average, the lowest yield was achieved by the farmers at the tail reach areas, which was significantly lower than the yield obtained by the farmers at the head and middle reach areas. However, the farmers in the middle reach areas obtained a slightly higher average yield though not significantly different from head reach farmers. It was due to the head reach areas becoming more prone to the problem of waterlogging while the tail reach areas were facing the problem of low surface water availability, poor and continuous degradation of land due to rising salt level, and poor access to good quality groundwater aquifers. It was also found that the maximum yield obtained showed a decreasing trend from head to the tail reach. Here again, the variation in maximum yield obtained was not significantly different between head and middle reach areas. Moreover, a very high variation in yields achieved within each head, middle and tail reach was found due to a variety of factors indicating high untapped potential which could be exploited by decreasing this variation.

Figure 3.6.11. Impact of farm location on wheat yield (t/ha).



Regression Analysis Relating Different Factors Affecting the Wheat Productivity

In order to evaluate the impact of different factors affecting the wheat productivity, various regression models were estimated with linear, linear-log, and double log forms. Based on the R^2, the best model was chosen with following form and specification.

$\ln(\text{Yield}) = b_0 + b_1 * \ln(\text{Land}) + b_2 * \ln(\text{Educ}) + b_3 * \ln(\text{Lprep\_cst}) + b_4 * \ln(\text{Sd\_qnt}) + b_5 * \ln(\text{Irri\_cst}) + b_6 * \ln(\text{NPK\_qnt}) + b_7 * \ln(\text{Weedi\_cst}) + b_8 * \text{Dum\_LJC} + b_9 * \text{Dum\_LCC} + b_{10} * \text{Dum\_Hakra} + b_{11} * \text{Dum\_Mid} + b_{12} * \text{Dum\_Tail} + e$

ln (Yield)	=	Natural log of yield in tons per hectare
ln (Land)	=	Natural log of size of landholding in hectare
In(Educ)	=	Natural log of education of head of the household in number of completed years of formal education
ln(Lprep_cst)	=	Natural log of cost of land preparation in rupees per hectare
ln(Sd_qnt)	=	Natural log of quantity of seed used in kilograms per hectare
ln(irri_cst)	=	Natural log of cost of irrigation per hectare
ln(NPK_qnt)	=	Natural log of quantity of NPK used in kilograms per hectare
ln(Weedi_cst)	=	Natural log of cost of weedicides used inrupees per hectare
Dum_LJC	=	Dummy for LJC irrigation system (1 if farm is located in LJC command area otherwise O)
Dum_LCC	=	Dummy for LCC irrigation system (1 if farm is located in LCC command area otherwise O)
Dum_Hakra	=	Dummy for Hakra irrigation system (1 if farm is located in Hakra command area otherwise)

Dum_Middle	=	Dummy for middle location watercourse along distributary (1 if farm is located at middle location along the distributary,otherwise O)
Dum_Tail	=	Dummy for tail location watercourse along Distributary (1 if farm is located at tail location along the distributary, otherwise O)
$b_0 \dots b_{12}$	=	Co-efficients to be estimated
e	=	Error term

Explanatory Variables

Size of Landholding

As mentioned earlier, the size of the landholding was also an important factor in explaining the variation in wheat productivity. Large farmers were relatively wealthy and had better access to different factors of production when compared with the marginal and small farmers. It was expected that an increase in size of landholding would have positive impact on the wheat yield. The sign of co-efficient of landholding size was expected to be positive.

Education of Household Head

Education of the household head was used as a proxy to the quality of management. It was found that farmers with a better education level were able to reap better harvest as shown in Figure 3.6.10. A well-educated farmer was expected to use the factors of production more effectively and efficiently. He/she was also expected to utilize the available agricultural information in a more useful manner than illiterate farmers. The sign of co-efficient for the education of household head was expected to be positive.

Cost of Land Preparation

Cost of land preparation was used as an indicator of the better cultivation of land. A better land preparation includes proper ploughings and leveling of field that not only reduces the volume of water needed to apply on each irrigation but also improves its equal spread throughout the fields. It also helps in improving the ability of soil to conserve the moisture contents available for crop use. It was expected that better land preparation would lead to improvement in wheat productivity. The sign of co-efficient was expected to be positive.

Quantity of Seed

No crop would be expected with seed and better harvest requires the use of healthy and viable seed in appropriate quantity. Conventionally, farmers used seeds from the previous harvest for sowing without paying heed to its viability, germination percentage, and its health. Poor quality seed could fail all the efforts of farmers on the part of other inputs for improving wheat productivity. It was expected that quantity of seed would have positive correlation with yield. The expected sign of co-efficient for quantity of seed was positive.

Cost of Irrigation

In the absence of required volume of water applied to wheat crop during the whole season, cost of irrigation was used as proxy variable. Keeping in view the limited cost of canal water (abiana), it mainly reflects the cost of groundwater extraction. It was expected that with increased cost of irrigation the yield would increase. It indicated the exploitation of good quality groundwater wherever available or its conjunctive use with the canal water to bridge the gap due to limited availability of surface. The sign of the co-efficient for cost of irrigation was expected to be positive.

Quantity of fertilizers

The high yielding varieties demand the use of fertilizers in right quantity, which is the task most often ignored by the common farmers. It was found that increase in the application of fertilizer would lead to enhancement of wheat productivity. It was indicated that the use of the fertilizer was not up to the recommended level and still a part of increased productivity could be tapped alone by applying the fertilizer in right quantity. The sign of the co-efficient for the quantity of fertilizer used was expected to be positive.

Use of Weedicides

One of the most common constraint on wheat productivity was the competition of weeds with wheat plants in using the soil nutrients. Being labor surplus agriculture, the farmers conventionally conduct weed manually. However, it was found that those farmers who used weedicides were able to reap a better harvest than those who did not use weedicides. So, the cost of weedicides was used as a proxy for the quantity of weedicide and was expected to be correlated positively with wheat productivity. The expected sign of the co-efficient was positive.

Location of Farms across Selected Irrigation Systems

As shown in Table 3.6.2, the wheat productivity varied significantly across different selected irrigation systems. The intercept dummies were used to quantify the impact of location of farms across selected irrigation systems.

Location of Farms across Head, Middle and Tail Reach Areas

Head, middle and tail reaches along the distributary represent three different environments. Head and middle reach areas were usually conceived better with respect to canal water availability and land quality when compared with the tail reach areas. It was expected that wheat productivity in the tail reach area would be significantly lower than the head and middle reach areas. In order to quantify the impact of location of farm along the distributary at head, middle and tail reach areas, dummy variables were used in the regression equation.

Regression Results Relating to Different Factors Affecting the Wheat Productivity

The results estimated through double log regression equation are given in Table 3.6.3. The R-square value shows that the estimated regression equation explained 37.2 percent of the variation in the dependent variable due to explanatory variables. The co-efficients in double log form of the regression equation represent elasticities. The signs of the coefficients were according to the expectations. The coefficients for the size of land-holding, education of the household head, irrigation cost per hectare, quantity of NPK, cost of chemical, dummy for LCC, the dummy for Hakra, and the dummy for tail reach areas were found significant at 99 percent confidence level. The co-efficient of cost for the land preparation was found significant at 95 percent confidence level while the co-efficient of dummy for LJC was found significant at 90 percent confidence level. The co-efficients of seed quantity used and dummy for middle reach were non-significant.

The estimated results show that one percent increase in the size of landholding would increase the wheat yield by 0.04 percent. It indicates that large farmers were able to reap a better harvest than the small farmers due to their ability to purchase and use inputs at the proper time and in proper quantities and also due to better management as well. One percent increase in the cost of land preparation would result in an increase of 0.014 percent in yield. Quantity of seed used per hectare also showed positive relationship with yield though it was insignificant. Co-efficient for the cost of irrigation showed a positive relationship with productivity and indicates that one percent increase in the cost of irrigation applied to wheat crop would result in an increase of 0.103 percent in yield. It was also estimated that one percent increase in the quantity of NPK used per hectare would result in 0.107 percent increase in the wheat yield. One percent increase in the cost of weedicides used for controlling weeds would result in an increase of 0.022 percent in yield. The dummy for LJC shows that on an average, farmers in LJC irrigation system areas obtained 0.06 percent higher wheat yield when compared with the farmers in UJC irrigation system areas. It was also found that farmers in the LCC irrigation system areas were able to get 0.145 percent more yield than farmers in UJC irrigation system areas. Dummy for Hakra indicates that farmers located in Hakra irrigation system areas were getting 0.35 percent less yield when compared with the farmers in UJC irrigation system areas. The dummy for middle reach areas of the distributaries indicates that there was no significant differences in the yields obtained by the farmers at the head and middle reach areas of the distributary. However, the dummy for tail reach areas indicates that the farmers in the tail reach areas obtained 0.15 percent less yield when compared with the farmers in the head reach areas.

Table 3.6.3. Regression results relating wheat yields with different inputs.

	Co-efficients	Std. error	t-statistics	Sig.
(Constant)	-1.1190	0.4400	-2.5410	0.0110**
Landholding (ha)	0.0400	0.0150	2.6270	0.0090***
Head of the households education (years)	0.0328	0.0120	2.6380	0.0080***

Cost of land preparation	0.0145	0.0060	2.5330	0.0110**
Seed quantity per ha	0.1120	0.0940	1.1950	0.2320
Irrigation cost per ha	0.1030	0.0170	6.1250	0.0000***
NPK kg/ha	0.1070	0.0150	7.1140	0.0000***
Cost of weedicides per ha	0.0227	0.0050	4.9710	0.0000***
Dummy for LJC	0.0662	0.0380	1.7460	0.0810*
Dummy for LCC	0.1450	0.0470	3.1120	0.0020***
Dummy for Hakra	-0.3520	0.0450	-7.8480	0.0000***
Middle reach of distributary	0.0073	0.0310	0.2330	0.8160
Tail reach of distributary	-0.1550	0.0320	-4.8620	0.0000***
N = 852				
F-Statistics = 41.467***	R^2 = 0.372			

* Significant at 90 percent confidence level
** Significant at 90 percent confidence level
*** Significant at 99 percent confidence level

Crop and Income Diversification and Rural Poverty

Crop diversification is a strategy, which may lead farmers to reduce risk, increase their income and move out of poverty. The idea behind this strategy is to let profits from one type of crop or livestock enterprise more than offset losses in another enterprise. Diversification also let the farmers use labor and other resources more effectively throughout the year. The income variability also dwindles while the farmer diversifies his farm business. In general, crop diversification includes the growing of multiple crops i.e., cereals, cash, fodder, fruits, vegetables, and other crops during one-year by the same farmer. In case of income diversification, it shows expansion in the resources and opportunities from where households draw income for their livelihoods. It includes crop income, income from sale of animals, income from renting of agricultural machinery, non-crop farm income and non-farm income.

As mentioned above, the purpose of diversification is to minimize the fluctuation or increase stability in household earnings. Farmers practice diversification to avert the risk of crop failure, reduce labor demand and consumption, ensure the staple food availability, earn high returns, and ensure sustainability of current living standards (Deb et al, 2002).

The crop diversification index was constructed by counting the number of crops grown by the farm household divided by the maximum number of crops grown by a farm household among the selected sample farm households. The income diversification index was also constructed in the similar manner by counting the number of income sources divided by the maximum number of income sources of a farm household in the selected sample of farm households.

Crop Diversification

Figure 3.6.12. shows that majority of the farmers grow 4-5 crops per season in the study area. However, around 20 percent of the farm households grow six or more crops.

Figure 3.6.12. Sample farm households and number of crops grown on farm.

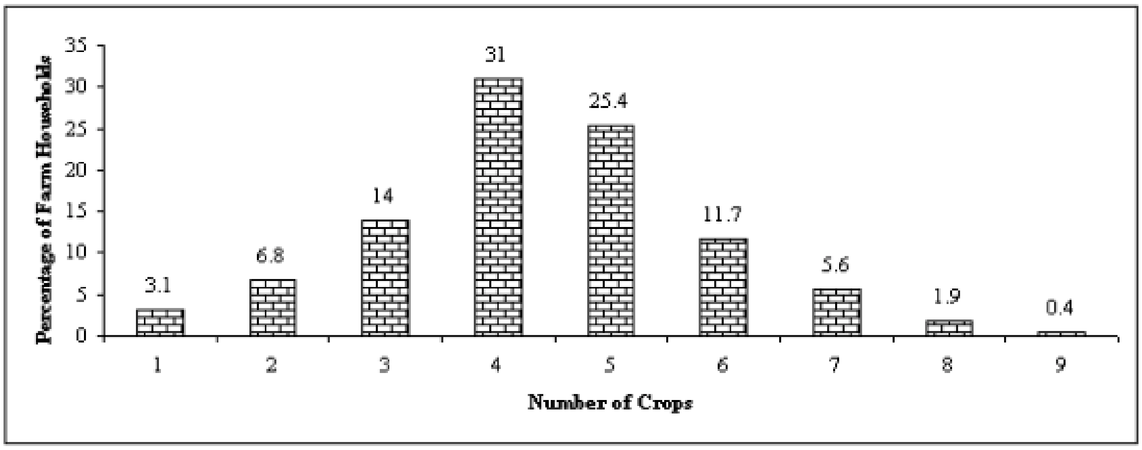


Figure 3.8.13 shows the distribution of poor and non-poor farm households according to the number of crops grown. It is evident that the majority of poor households grew up to six crops per year. A higher number of poor farmers grew up to six crops per year when compared with non-poor households. However, the number of non-poor farmers growing more than six crops was found higher than poor farmers. It indicates that there exist a linkage between poverty and increased crop diversification. Figure 3.6.14 shows the same indicating that on the average non-poor households were growing more number of crops when compared with poor households.

Figure 3.6.13. Number of crops grown across farm households in the study area.

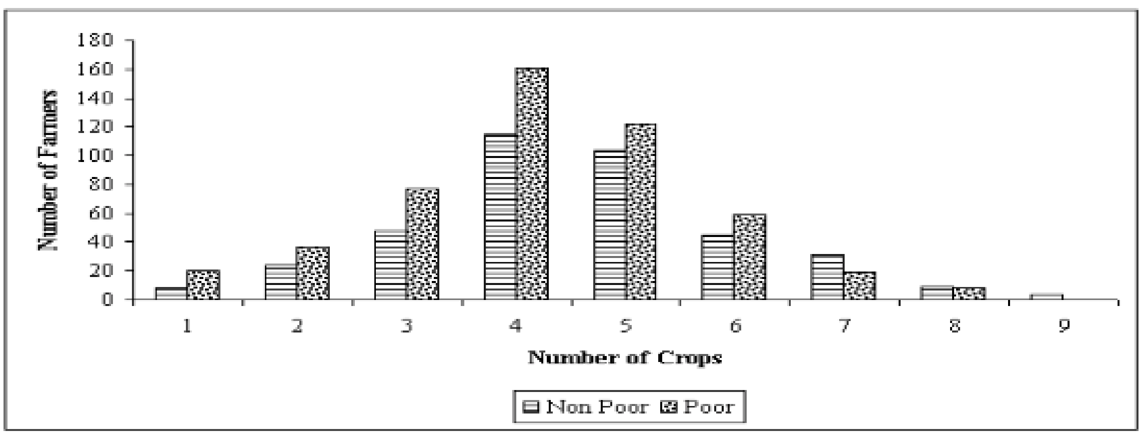
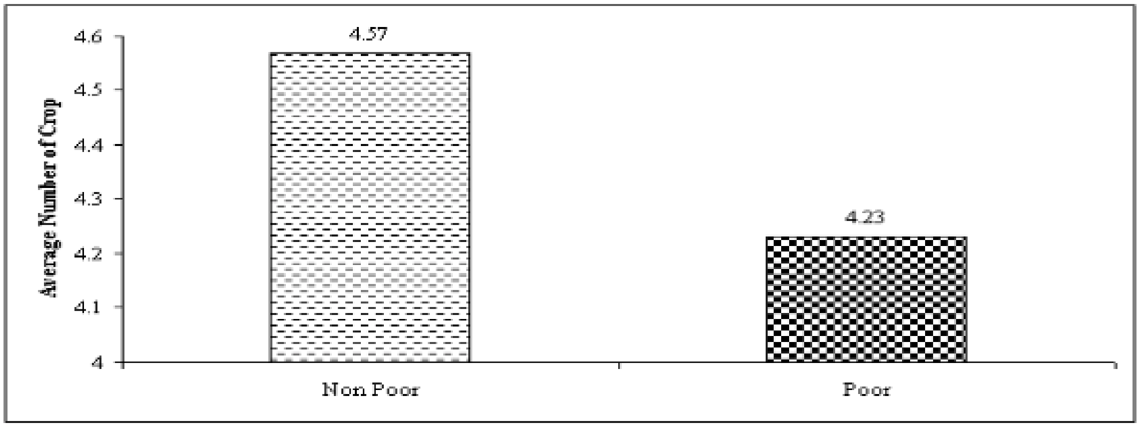
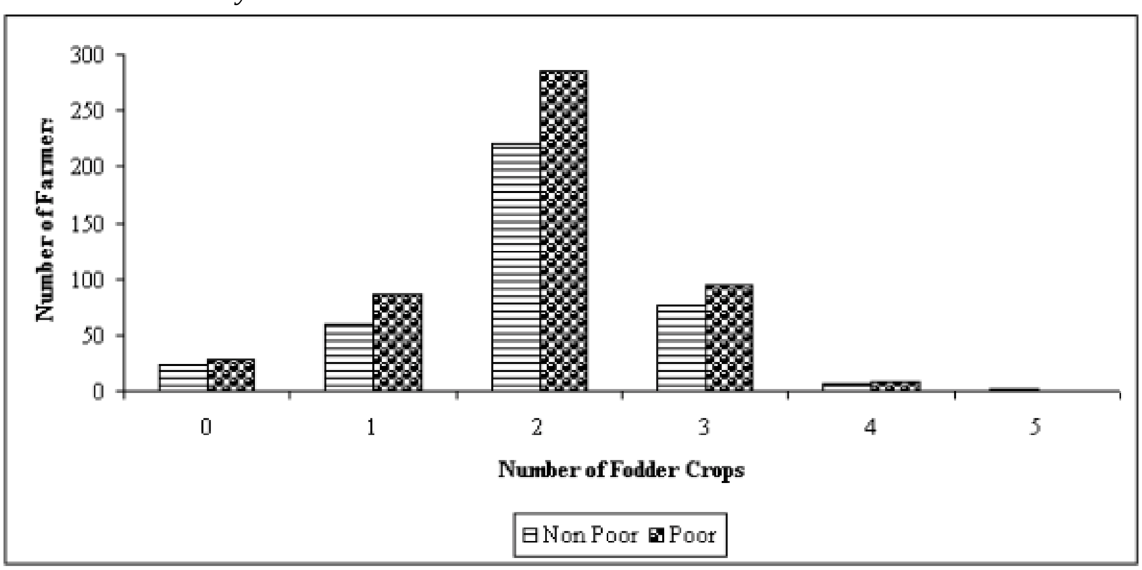


Figure 3.6.14. Average number of crops grown by poor and non-poor households in the study area.



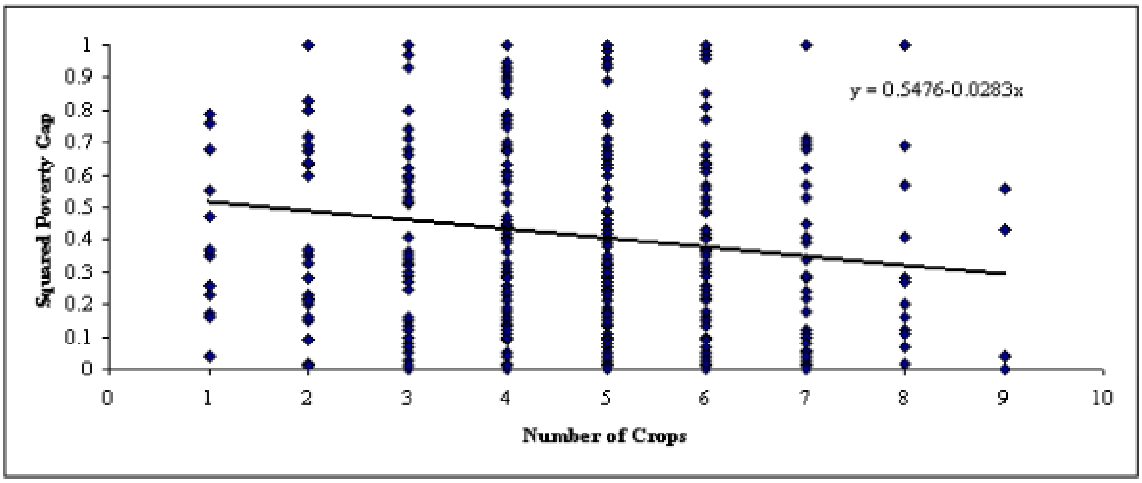
The vulnerability of a household to fall in the poverty trap could be less with the increase in the number of crops grown. The underlying assumption for crop diversification is that it leads to increase household's income. However, this situation becomes complicated when fodder crops are introduced in the cropping pattern. Fodder crops are not usually meant for sale but to feed the livestock kept by the farmers. These crops help the farmers to rear of livestock that could be a source of livelihood and generate livestock products that are a continuous source of income for farming community in the current setting. Figure 3.6.15 shows that majority of farmers in the sample area cultivated up to 3 fodder crops in the study year. It is also clear from the figure that higher number of poor farmers grew fodder crops when compared with the non-poor farmers. It is seen that poor households try to minimize the risk of crop failure through rearing livestock and the sale of its products to get continuous stream of income.

Figure 3.6.15. Number of fodder crops grown across poor and non-Poor households in the study area.



Based on the above discussion, it seems more appropriate to include the sale of livestock and livestock products in analyzing the impact of diversification on poverty. In order to assess the vulnerability of farm households to poverty, squared poverty gap was used for the analysis purpose. Figure 3.6.16 shows that there exists an inverse relationship between the vulnerability of households to fall into poverty and higher crop diversification (including sale of livestock and livestock products).This indicates that squared poverty gap tended to decline with increase in number of crops. However, this relationship was found weak because crop income was not the only single determinant of poverty.

Figure 3.6.16. Vulnerability of poor households to become poor and the number of crops grown in the study area.



Income Diversification

Income diversification implies that the rural community tends to generate income from agricultural as well non-agricultural sources in order to attain sustainable livelihoods. In order to analyze the impact of income diversification on poverty, the sources of household income were categorized into five categories. Crop income includes the net crop income from all the crops grown by the farm household in one year including net land rent. Non-crop income includes income from livestock products, income from working as agricultural labor, etc. Non-farm income includes income from business entrepreneurs, salaries, pensions, remittances, and other similar means of income. Income from the sale of livestock includes the net income earned by the households through the sale and purchase of livestock. Income from the rent of farm machinery like trolley, tractor, etc. to other farmers, constitute the last category.

Figure 3.6.17 shows the proportion of farm households generating income from diverse sources. As expected, all the farm households were engaged in raising crops for at least meeting their food and fiber requirements. It was found that around 52.6 percent of the farm households were also engaged in other non-crop activities in order to generate additional household income. Similarly, around 59.1 percent of the farm households were drawing a part of household income through non-farm activities. Around 58.7 percent of the farm households were engaged in rearing livestock. About 8.5 percent of the farm households were also earning a part of their household income through renting out their agricultural assets to other farmers. This situation clearly indicates that under prevailing conditions, majority of farm households were generating a part of their income from non-crop sector for better livelihood.

Figure 3.6.17. Distribution of all households having diverse sources of income.

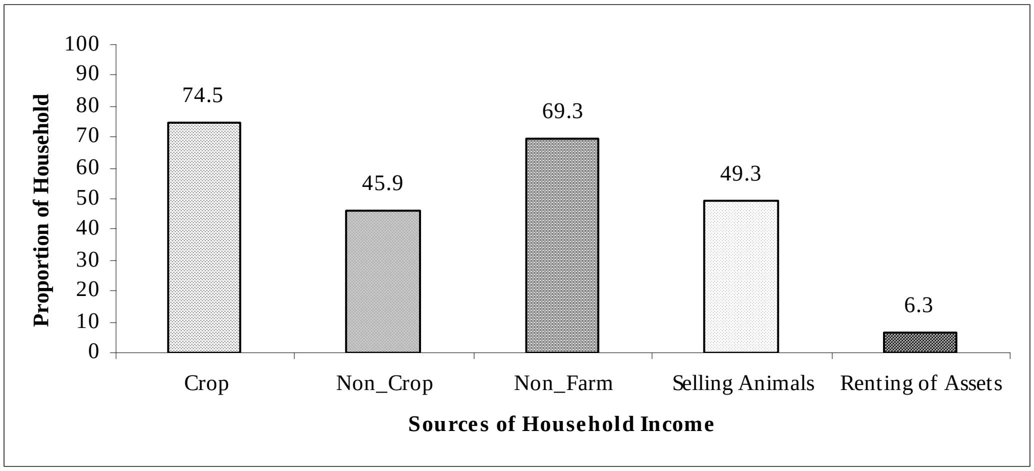


Figure 3.6.18 and 3.6.19 show the distribution of poor and non-poor farm households and all households, respectively according to the income diversification index. According to this index, the majority of poor households were found in the range of 0.4-0.6 while the majority of non-poor households fell in the range of 0.6-0.8. It indicates that non-poor households depend on more number of sources for income generation when compared with the poor households.

The households' income diversification index depicts an inverse relationship with vulnerability of poor households to fall in poverty trap as shown in Figure 3.6.20 and 3.6.21 for farm households and all households, respectively. It shows that household with low level of diversification were more vulnerable to severe poverty when compared with those with highly diversified income base. The poor households with low level of diversification score showed a tendency to be clotted closer to the highest severity of poverty ratio (that is one). As the diversification index improves, the households tended to be closer to the lowest severity level (that is zero). The trend line indicates that there was significant and inverse relationship between increased income diversification and increase in the severity of poverty. Figure 3.6.22 and 3.6.23 show the average of squared poverty gap value with respect to different levels of household income diversification for farm households and all households, respectively. It indicates that on an average, severity of poverty decreased with an increase in the level of income diversification. Relatively insignificant variation in severity of poverty was observed for households with income diversification index of 0.4 and 0.6. However, with further increase in income diversification index, the average poverty gap index decreased significantly showing that in order to get out of poverty trap, farm households needed to be engaged in maximum possible farm and non-farm activities to absorb the shocks due to low level of income generation through various enterprises.

Figure 3.6.18.Income diversification index across poor and non-poor farm households.

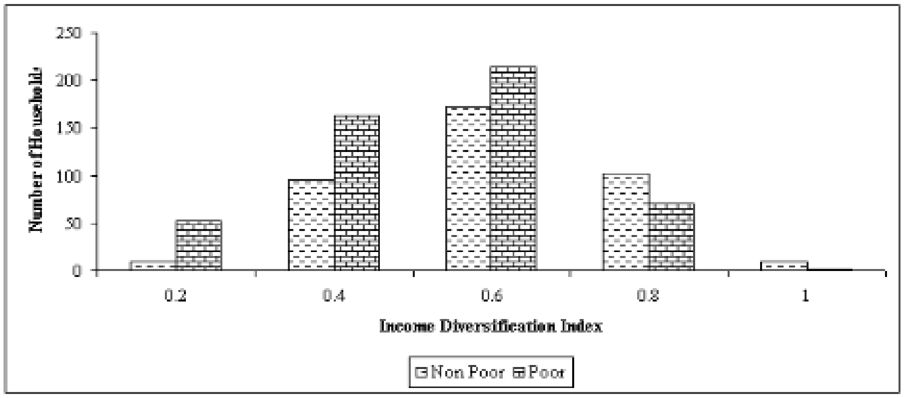


Figure 3.6.19. Income diversification index across all poor and non-poorl households.

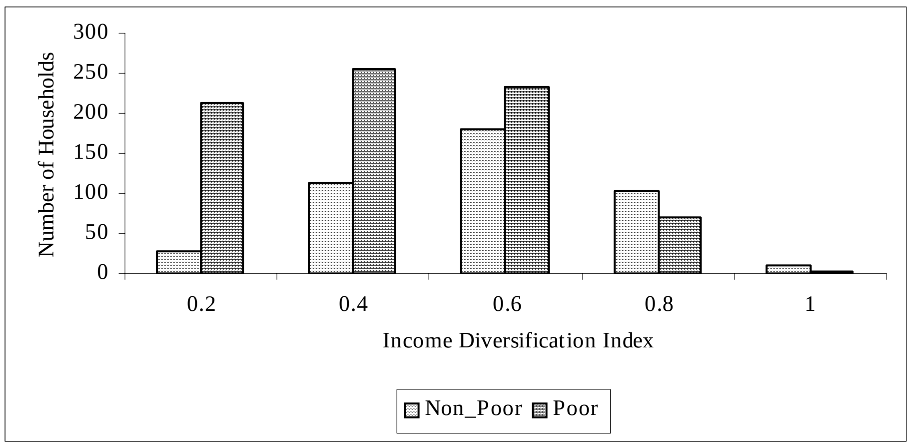


Figure 3.6.20. Relationship between income diversification index and severity of poverty for poor farm households.

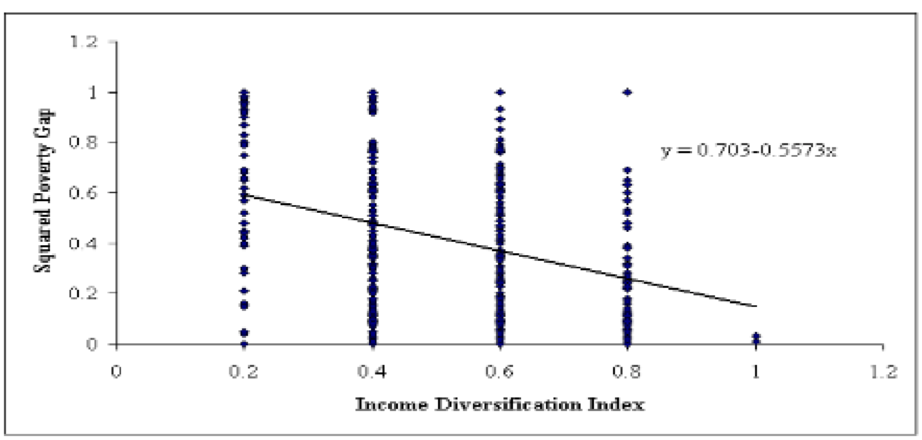


Figure 3.6.21. Relationship between income diversification index and severity of poverty for all poor households.

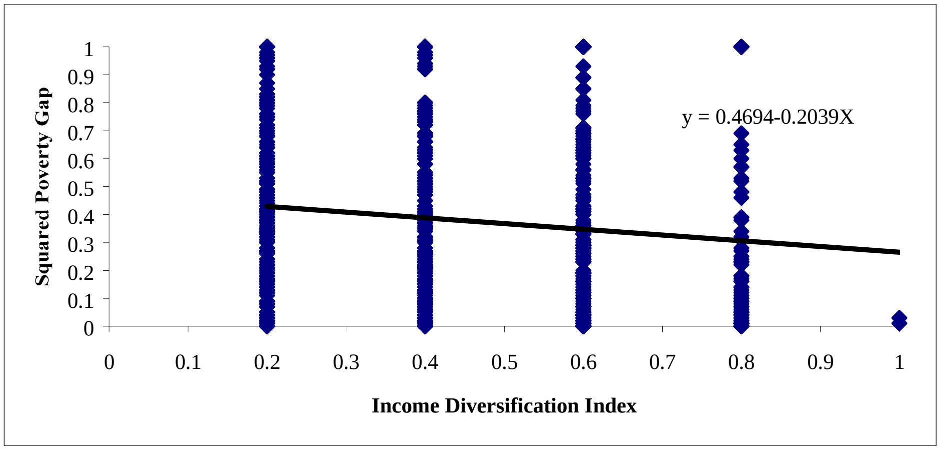


Figure 3.6.22. Relationship between income diversification index and average severity of poverty for poor households.

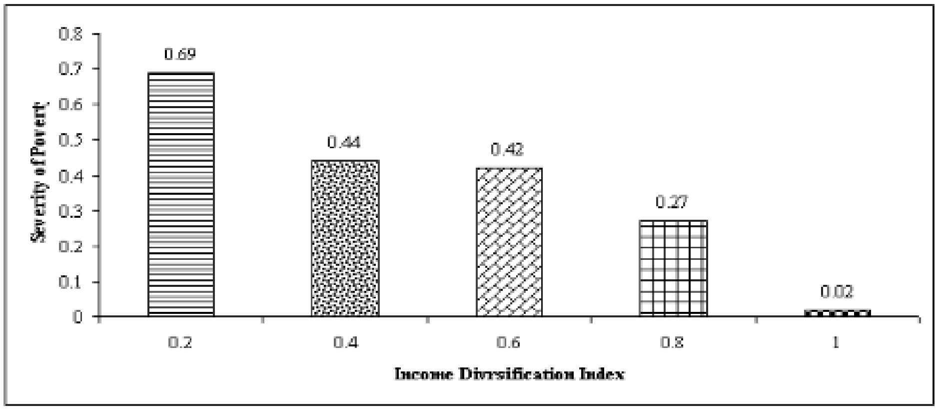
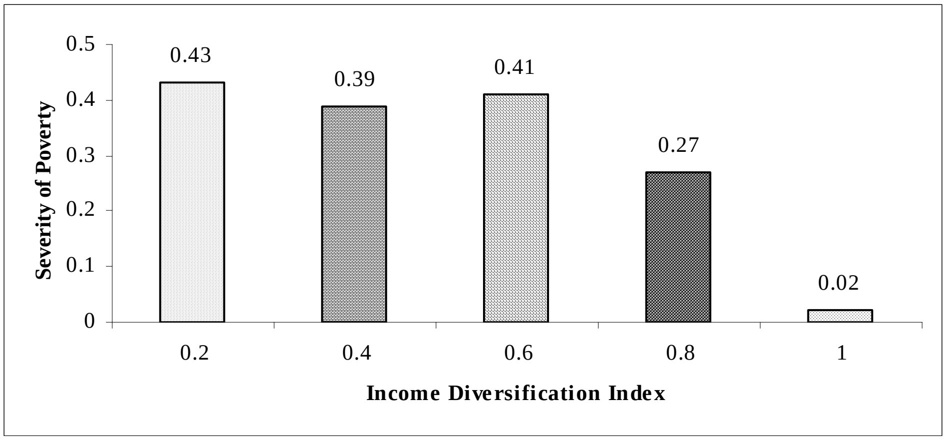


Figure 3.6.23. Relationship between income diversification index and average severity of poverty for poor households.



Implications

- The major share of farm households' income is attributed to crop income and its increase invariably depends upon the enhanced availability of surface water under current crop production technology, which is difficult under the current situation. Conjunctive water management must be enhanced.
- Groundwater poses quality problems that vary temporally as well as spatially. Farmers must be provided with guidelines about its best use for enhancing productivity/income as well as minimizing adverse impacts of its unwise use.
- The need to alter the current technically inefficient crop production technology is obvious. Widespread use of improved seed and compatible latest technology are the required to boost the productivity of various factors of production/inputs for appreciation of sustainable farm income.
- Smaller land units are found less productive compared to larger units.
- Further breakthrough in agricultural productivity would come only through the provision of a package of inputs and machinery backed by quality extension services. Significant impact on productivity is less likely to occur if subsidies, etc are offered for one or two inputs only.
- In general, crop diversification has a negative impact on poverty by increasing household income. However, optimal type and level of diversification varies spatially.
- Expansion in the non-farm income base is essential to diminish the productivity risk in agriculture for averting the probability of being hooked in the poverty trap, on sustainable basis.

Conclusions

- The most important constraints on the productivity of crops were found to be water related constraints according to 37.09 percent of the farmers. The main reason was shortage of surface water supplies due to a variety of reasons.
- Next to water, inputs related constraints like unavailability, high cost, and adulteration of inputs were the important ones as reported by 36.68 percent of the farmers.
- Around 26.23 percent of the farmers indicated various technical, marketing, and credit related constraints that limit the farmer's ability to tap the crop productivity potential to its best.
- Land preparation, irrigation, fertilizers and weedicides showed positive relationship with the yield. The proper and efficient use of these inputs would lead to rise in productivity.
- An increased size of landholding and improvement in the quality of management through increase in education level would lead to higher wheat productivity.
- Improved access to surface water irrigation and better quality groundwater would help in increasing wheat productivity.
- Use of fertilizers needs to be improved according to the requirement by keeping land fertility in view. This could help in boosting wheat productivity and production in all areas.
- Quality of management was found an important factor affecting the wheat yield.
- Use of weedicides would have significant and positive impact on the wheat yield.
- Farmers in the tail reach areas were getting lower yields when compared with the farmers at head and middle reach areas.
- The yield of the farmers in Hakra irrigation system was the lowest when compared with the yield of the farmers located at other three irrigation systems in the study area.

7. ASSESSMENT OF INSTITUTIONAL INTERVENTIONS IN IRRIGATED AGRICULTURE

In this section, assessment is made of the impacts of recent institutional interventions in irrigation and irrigated agriculture in general in selected irrigation systems. Sub-section-1 provides assessment of impacts of irrigation management transfer at Hakra-4R Distributary in lower Punjab. Sub-section-2 assesses the impact of integrated services provision in a pilot project implemented by FAO in the upper Punjab.

A. Impact of Institutional Interventions in Irrigation Sector: Irrigation Management Transfer (IMT) at Hakra 4-R Distributary

As mentioned earlier, the Punjab Irrigation and Drainage Authority (PIDA) was established through an act of provincial legislature in 1997. Establishment of the authority was a preliminary step towards the implementation of the institutional reforms under the National Drainage Program (NDP), which was aimed at Irrigation Management Transfer (IMT) from the government to farmers' organizations. The main objective of these institutional reforms was to improve the overall efficiency of the irrigation system in the province.

IMT was implemented at the Hakra 4-R-distributary, which is the largest pilot experiment relating to farmer's participation in irrigation management in Pakistan. Hakra 4-R Distributary was handed over to the Farmers' Organization (FO) on 20th May 2000. Since then, FO is responsible for carrying out all the operation and maintenance activities.

In order to assess the performance of the distributary, the first base line study was conducted by IWMI (Cheema et al. 1997) during the transition period when FO was partially involved in the management of Hakra 4-R in collaboration with the Provincial Irrigation Department (PID) and the second assessment was done after effecting the full transfer of the management to the farmers (Action-Aid 2001). The primary aim of these studies was to evaluate the performance with respect to different indicators and suggest the possible measures to counter the hurdles that are stumbling upon FO. These assessments were done to assist the planners and researchers to evolve improved models and methodologies for enhancing the effect of farmers' involvement in the irrigation management decisions.

The present study is focused on evaluating the performance of the Farmers' Organization in two ways. First, Hakra 4-R Distributary is being evaluated with respect to gains in agricultural productivity, water supply, and economic performance. Second, the working of FO is being evaluated under institutional/management criteria. A number of indicators related to agricultural productivity, equity, and water supply were estimated for a comprehensive comparative view of selected distributaries in the study area.

Productivity and Equity Indicators

Table 3.7.1 shows various productivity indicators estimated to evaluate the performance of IMT. A comparison of Hakra 4-R Distributary is made with some other selected distributaries in order to get further insights. The irrigation intensity and cropping intensity in Hakra 4-R Distributary were reported to be 151 and 152 percent, respectively. Irrigation intensity in Hakra 4-R Distributary was the highest among all the selected distributaries managed by Irrigation Department while cropping intensity was the second highest. This was mainly attributed to different cropping patterns and higher level of water supply with respect to the command area at other distributaries when compared with those of Hakra 4-R Distributary. However, it also indicates the presence of reliability and equity in the distribution of surface supplies, as the command area of the Hakra 4-R Distributary was significantly higher than 9-R Khoja and Kakowal distributaries while it was closer to the command area of Lalian Distributary. Higher cropping intensity was only possible due to reliable and equitable surface water supplies in Hakra 4-R Distributary where the quality of groundwater is very poor. Furthermore, output (GVP) per unit of irrigation water costs was much higher at Hakra 4-R Distributary when compared with that of other canal commands.

Table 3.7.1. Various productivity indicators across distributaries in the study area.

Productivity indicators	9-R Khoja	Kakowal	Lalian	Khadir	Khikhi	Hakra 4-R
Irrigation intensity (%)	137	145	135	124	136	151
Cropping intensity (%)	152	153	138	124	137	152
Total production in command area (million Rs.)	85.94	163.76	1060.65	802.52	998.64	407.21
Out put per unit of irrigation water cost (Rs. ratio)	5.74	4.52	7.28	5.31	6.37	10.56
Upper head 25% GVP / lower tail 25% GVP ratio	6.24	6.20	11.01	9.37	10.03	6.75

A head-tail equity ratio of 6.75 in output (GVP per ha) is estimated for Hakra 4-R Distributary by working out the GVP per hectare for the upper 25 percent farmers (best performers) in the head reach area and GVP per hectare of the lower 25 percent (worst performers) in the tail reach area, which showed that across the distributary there existed high variation in the performance among farm households. It shows that despite higher equity in water distribution, quite high inequity in gross value of production per hectare existed when top 25 percent performers at the head reach were compared with lowest 25 percent performers at the tail reach areas. It implies that the effect of IMT is higher in terms of equity in water distribution than equity in profitability.

Water Supply

Water supply to the poor farmers, particularly at crucial time periods, is very important. The Farmers' responses about different aspects of water supply after IMT are shown in Table 3.7.2. It was hypothesized that Participatory Irrigation Management (PIM)/ irrigation Management Transfer (IMT) leads to improved irrigation system performance.

Water Availability, Reliability and Equity

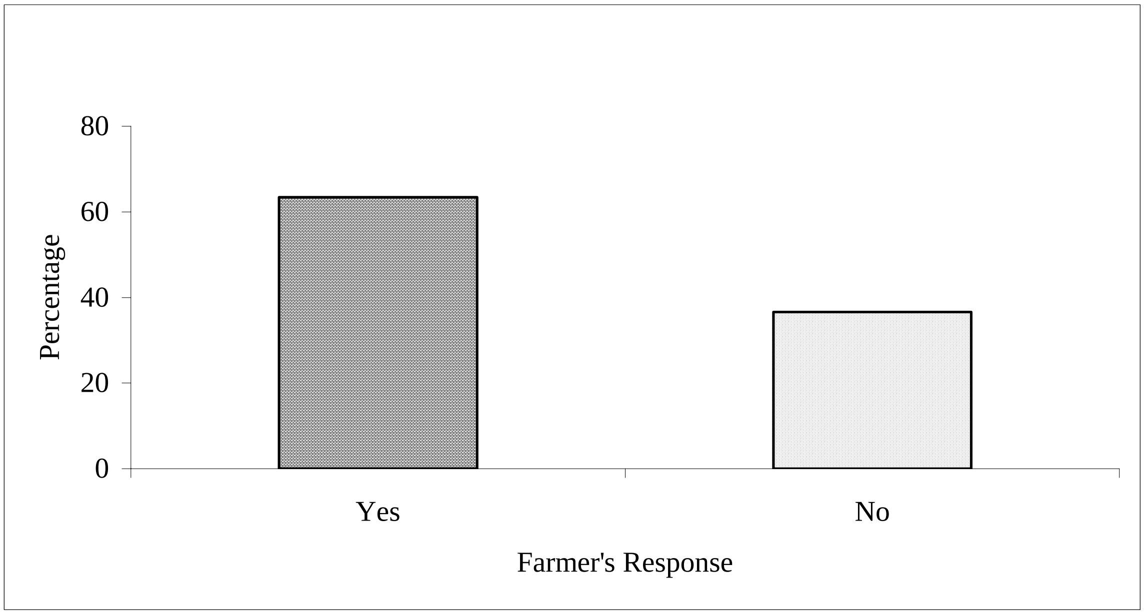
Irrigation water availability in appropriate volume is vital for agricultural crop production. After IMT, an improvement in water availability to farmers was expected. The results in Table 3.7.2 indicate that around 53.70 percent of the respondents asserted that they were experiencing different tangible water related benefits after IMT while 41 percent of the respondents did not feel any additional water related benefits that could be attributed to IMT as shown in Figure 3.7.1. More than 50 percent of the farm households in the head and middle reach areas responded that they were experiencing additional benefits due to IMT while around 47 percent of the sample farm households in the tail reach areas also claimed the same. This clearly shows that after IMT majority of the farm households in Hakra 4-R command area were better off than before IMT. A significant number of farmers have experienced additional water related benefits after IMT in all three reaches of the Hakra 4-R Distributary.

Table 3.7.2.Farmer responses about the water availability, reliability and equity after IMT (%).

Variables		Head	Middle	Tail	Total
Water related benefits	Yes	51.10	62.20	47.70	53.70
	Same	46.70	31.10	45.50	41.00
	Don't know	2.20	6.70	6.80	5.20
	Total	100.00	100.00	100.00	100.00
Availability of share of water	Yes	66.70	64.40	59.10	63.40
	No	33.30	35.60	40.90	36.60
	Total	100.00	100.00	100.00	100.00
Water turns received regularly	Yes	35.60	33.30	34.10	34.30
	No	40.00	48.90	59.10	49.30
	Same as before IMT	22.20	8.90	6.80	12.70
	Don't know	2.20	8.90	0.00	3.70
	Total	100.00	100.00	100.00	100.00
Reasons for non-availability of canal water	Low water supply at canal head	66.67	59.26	29.73	45.21
	More water at head reach outlets	0.00	7.41	21.62	13.70
	Water theft at head reach	11.11	11.11	16.22	13.70
	Level of distributary is not correct	0.00	3.70	10.81	6.85
	Level of outlet at middle reaches are low, getting more water	0.00	3.70	5.41	4.11
	High water fall level	0.00	0.00	2.70	1.37
	Warabandi is not correct	0.00	0.00	2.70	1.37
	Don't know	22.22	14.81	10.81	13.70
	Total	100.00	100.00	100.00	100.00
Increase in reliability of canal water	Increased	46.70	37.80	27.30	37.30
	Remained the same	51.10	60.00	70.50	60.40
	Don't know	2.20	2.20	2.30	2.20
	Total	100.00	100.00	100.00	100.00
Increase in crop area due to improved water availability	Increased	8.90	2.20	6.80	6.00
	Remains same	88.90	93.30	88.70	90.30
	Don’t know	2.20	4.40	4.50	3.70
	Total	100.00	100.00	100.00	100.00

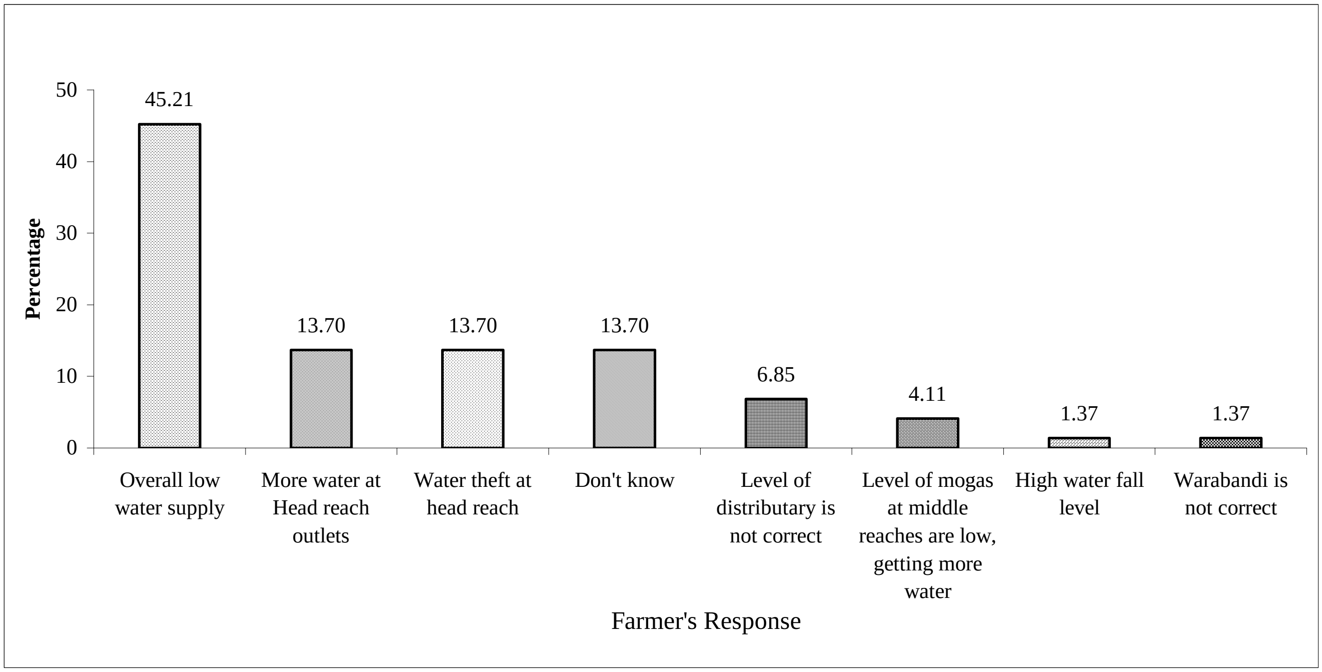
Among these additional benefits, first was the availability of due share of water. Around 63 percent of the sample farm households confirmed that they were receiving their due share of irrigation supplies after IMT. Higher percentage of sample farm households were content in this regard in the head and middle reach areas of Hakra 4-R when compared with those in the tail reach area.

Figure 3.7.1. Canal water availability across different reaches of the distributary.



However, even in the tail reach area, around 59 percent of the sample farm households reported that after IMT they were able to receive their due share of water. This indicates the improvement in water availability situation to farmers after IMT (Table 3.7.3). About 45 percent of the sample farm households responded that non-availability of their due share of water was because of lower water supplies made available to FO by the PID at the head of Hakra 4-R Distributary while 13.70 percent of the farmers responded that this was due to more water drawn by the outlets at head reach areas. Similarly 13.70 percent of the farm households reported water thefts at the head reach, which caused irregular water supplies in the downstream areas of the Hakra 4-R Distributary. It was found that majority of the farmers at the head and middle reach areas were of the view that overall water supply, at the distributary head was reduced after IMT. However, significant proportion of the tail reach farmers indicated that more water withdrawing by outlets at head reach and water theft problem in the head and middle reach areas as the reasons for not receiving water turns regularly. This shows that there still exists inequity in water supply and more efforts are needed by FO to decrease the discrepancies across various reaches of the distributary. Some of the other reasons were problems with the design of the distributary like the low level of distributary crest, higher level of outlets (moghas), and higher levels of fall structures. Only 1.37 percent of the farmers indicated the problem regarding warabandi schedule, as it takes about 24 hours to fill the distributary to its full capacity level. Various reasons for non-availability of canal water as reported by the farmers at Hakra 4-R Distributary are shown in Figure 3.7.2.

Figure 3.7.2. Reasons for non-availability of canal water as perceived by the farmers.

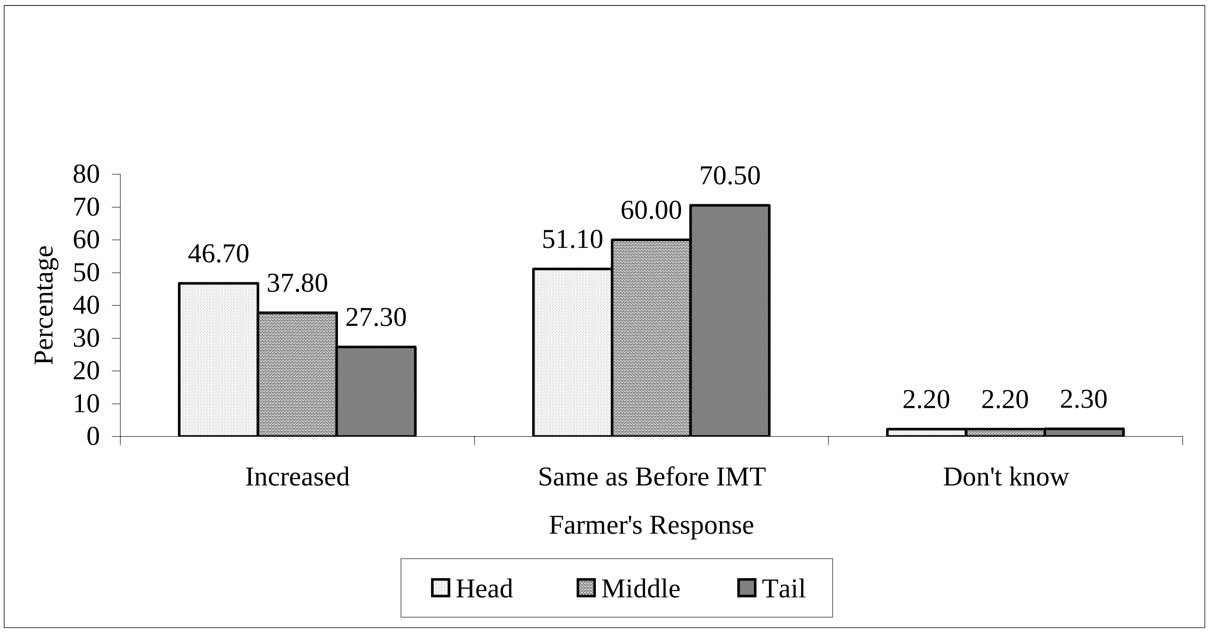


Regarding equity in water distribution, the results showed that the reliability of water had increased in all three reaches of the distributary after IMT. Figure 3.7.2 shows that improvement in water availability was experienced after IMT in all three reaches (head, middle, and tail) of the distributary though it was reported more in the head reach areas when compared with middle and tail reach areas. It showed a decreasing trend in the improvement of reliability of canal water from the head towards the tail reach of the distributary. However, around 27 percent of the sample farm households in the tail reach areas gave positive response regarding the reliability of canal water after IMT.

It is often cited that if the equity and reliability of water distribution system is improved, the improvement in water distribution must be realized by the tail-enders. About 47 percent of the head reach sample farm households responded positively regarding improved irrigation supplies while 38 and 27 percent of the middle and tail reach farmers too responded the same way, respectively (Figure 3.7.3). Moreover, majority of the farmers at all three reaches of the distributary were of the view that after IMT, area under crops did increase. The higher increase in crop area was experienced by head reach farmers when compared with middle and tail reach farmers. However, 27 percent farmers in the tail reach area also experienced an increase in cropped area than the middle reach farmers, which could not be possible without improvement in equity and reliability of canal water supplies. These results clearly support the hypothesis of the study that effective implementation of PIM/IMT leads to improved irrigation system.

Also, it was found that Water Delivery Performance[10] in the Hakra 4-R Distributary had improved after IMT (Figure 3.7.4). The results show that the delivery performance ratio was improved from 0.91 to 1.04 after transfer of management to FO. Overall System Efficiency[11] also improved from 0.47 to 0.52 after IMT. However, the prevalence of drought like conditions during the study period took its toll and Irrigation Department had decreased the water supply considerably. In spite of this, improvement in Water Delivery Capacity[12] with respect to average annual discharge was reported (from 0.41 to 0.45) after IMT. The above-mentioned three indicators show the signs of improvement in water management after the implementation of IMT .

Figure 3.7.3. Improved reliability of canal water across different reaches of the distributary after IMT.

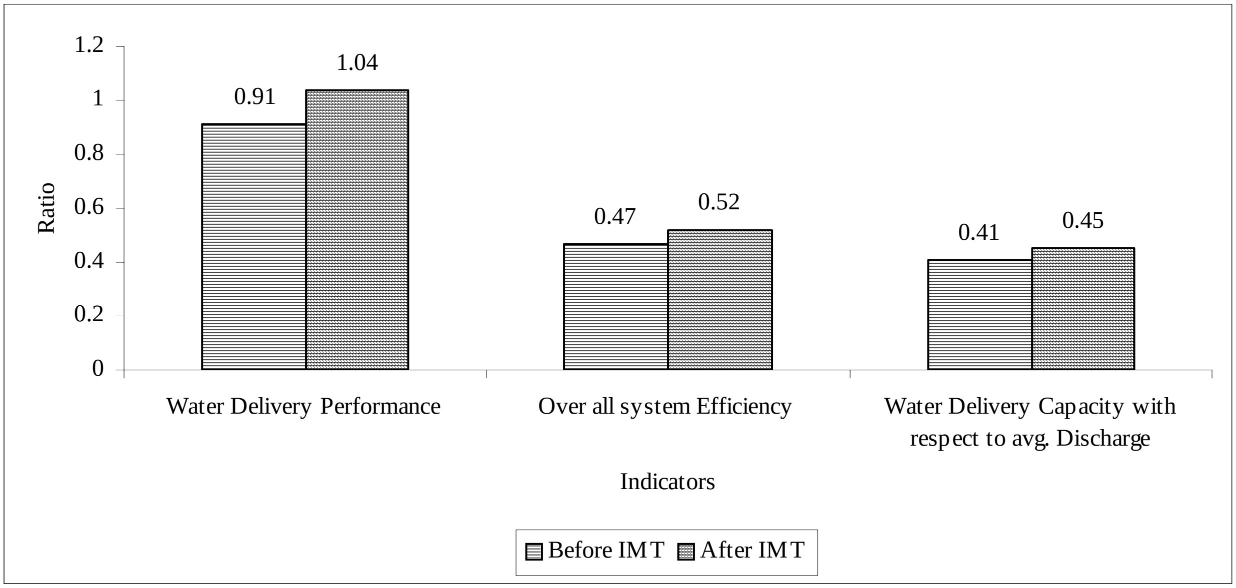


[10] Water delivery performance is defined as the ratio of actual volume to the target volume of water delivered

[11] Overall system efficiency is defined as the ratio of annual crop water requirement and total inflow into canal system (with 40% losses).

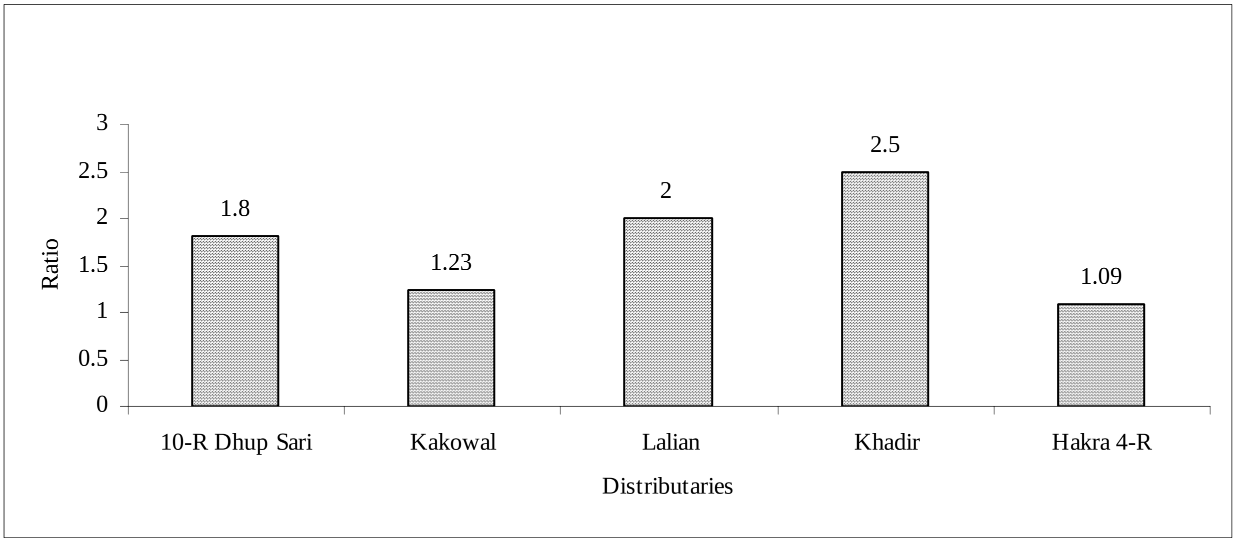
[12] Water delivery capacity with respect to design discharge is defined as the ratio of canal capacity to deliver water at system head (considering 40 percent losses and annual closure days) to the peak consumptive demand.

Figure 3.7.4.Comparison of different indicators of water supply before and after IMT for Hakra 4-R distributary.



Estimates of head-tail equity ratio with respect to discharges for Hakra 4-R was valued as 1.09, indicating a high equity in the distribution of water across head and tail reach areas. Figure 3.7.5 shows the comparison of some selected distributaries in Punjab regarding head and tail equity with respect to discharges. All distributaries except Hakra 4–R are operated and managed by Provincial Irrigation Department (PID). It is clear that a very high level of inequity in discharges across head and tail reach was prevailing in PID operated irrigation systems as shown in Figure 3.7.5, while a highly equitable water distribution was experienced by the farmers at Hakra 4-R Distributary. The inequity in water distribution was the lowest under FO's Management. Thus, the research hypothesis is accepted that IMT leads to improved irrigation system performance.

Figure 3.7.5. Head-tail equity with respect to discharges for selected tributaries.



Water Theft

Since long, it is well noticed that few farmers tend to draw more water than their due share. They do so by various illegal means such as inserting pipes into distributary or making cuts in the distributary, etc. The sample farmers observed that after IMT, water theft has decreased significantly. The results in table 3.7.3 indicate that about 10 percent of the sample farmers reported that water theft has increased after IMT and majority of these farmers (18 percent) belonged to the tail reach areas. Around 81 percent of the farmers opined that water theft has decreased after IMT. It is interesting to note that around 79.50 percent of the farmers at the tail reach perceived that water theft decreased after IMT while around 10 percent of the farmers did not answer the question.

Table 3.7.3. Farmers' perception about present situation of water theft in Hakra 4-R distributary.

Incidence of water theft	Head	Middle	Tail	All
Increased under FO	6.70	4.40	18.20	9.70
Decreased under FO	82.20	80.00	79.50	80.60
Don't know	11.10	15.60	2.30	9.70

Economic indicators

Figure 3.7.6 shows the performance of Hakra 4-R Distributary along with other selected distributaries with respect to gross value of farm production on per hectare basis. The estimate showed GVP/ha of Rs. 22710 for Hakra 4-R Distributary which was higher than the four of the other distributaries. It indicates a better performance of sample households at Hakra 4-R Distributary when compared with other distributaries. Some of the important reasons included timely supply of irrigation water, equitable and reliable supplies which enable a farm households to get better productivity.

Figure 3.7.6. Gross value of farm production per hectare (Rs) for selected distributaries in the study area.

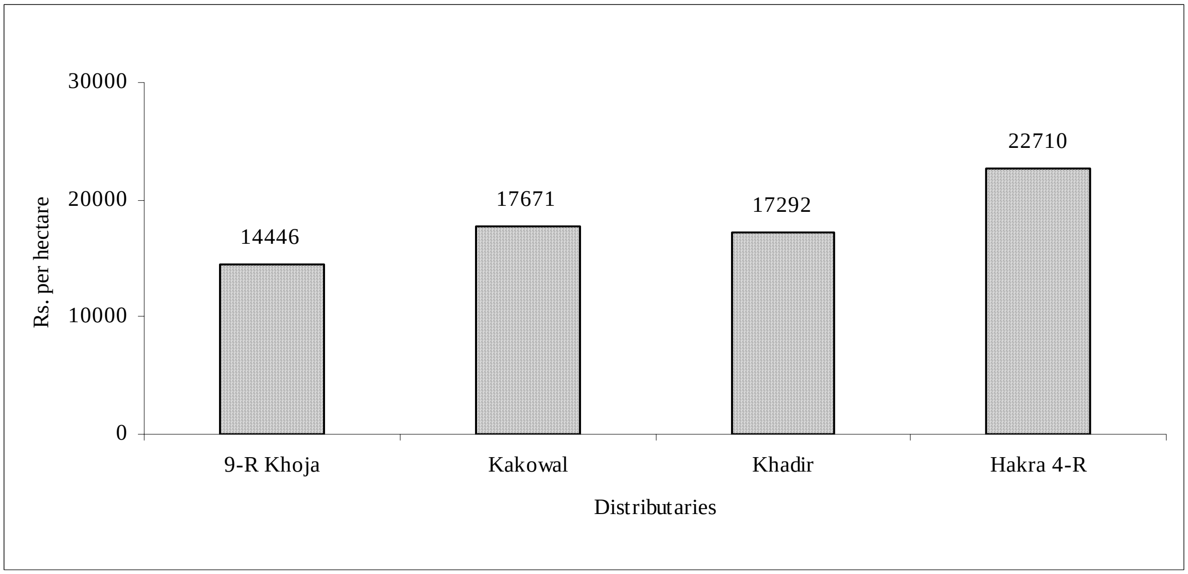
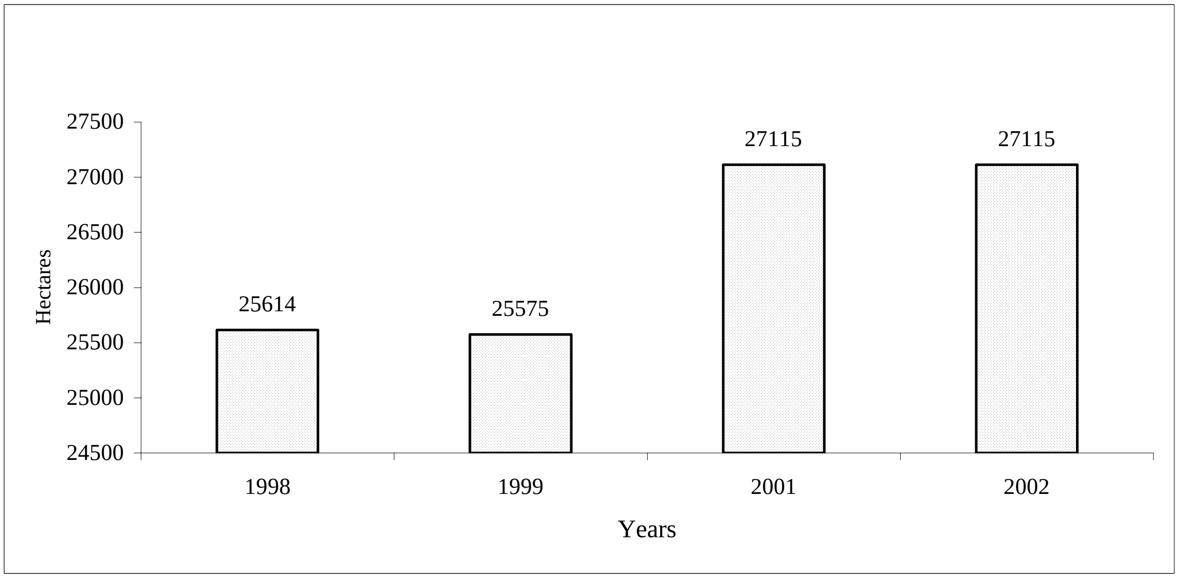


Figure 3.7.7 shows the cropped area over the last four years for Hakra 4-R Distributary. It was found that despite the current drought in the area after IMT, the reported crop area has increased (during 2001-2002) than what was previously reported by the PID before 2000. This increase of cropped area may be attributed to better water supply management at distributary level under FO.

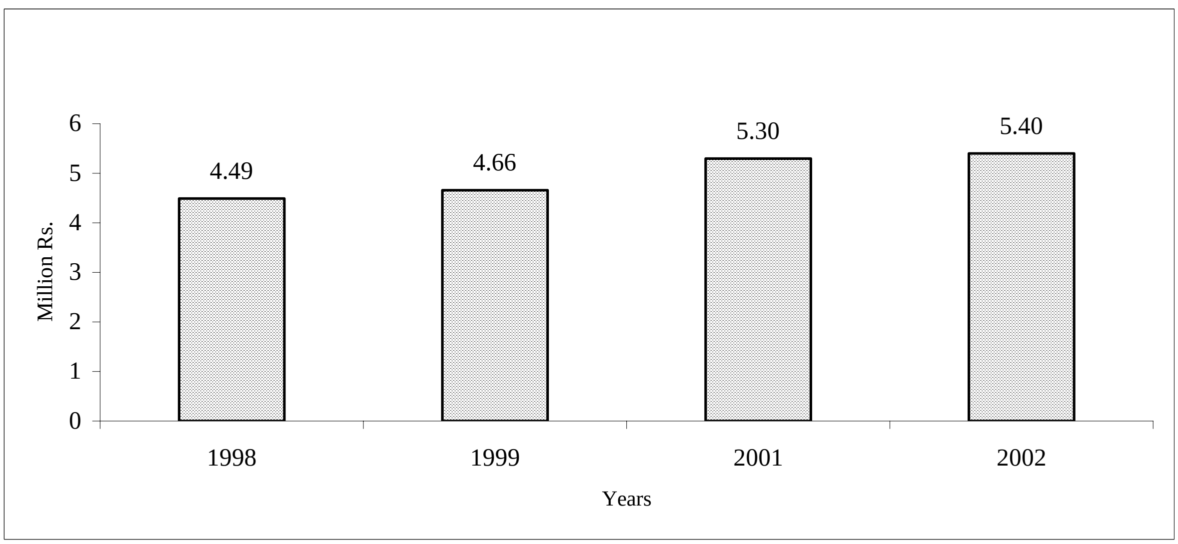
A higher level of Abiana assessment was reported during the years after IMT than before (Figure 3.7.8). It is clear from the figures that after IMT, the total Abiana assessed has increased from Rs. 4.66 million in 1999 to Rs. 5.4 million in 2002, showing a significant increase in Abiana assessment after IMT. It was due to the fact that after IMT, Abiana assessment was done by the FO transparently without favoring any particular farmer by underassessment.

Figure 3.7.7. Cropped area at Hakra 4-R distributary during 1997-2002 (ha).



Source: PID and FO Record 2002.

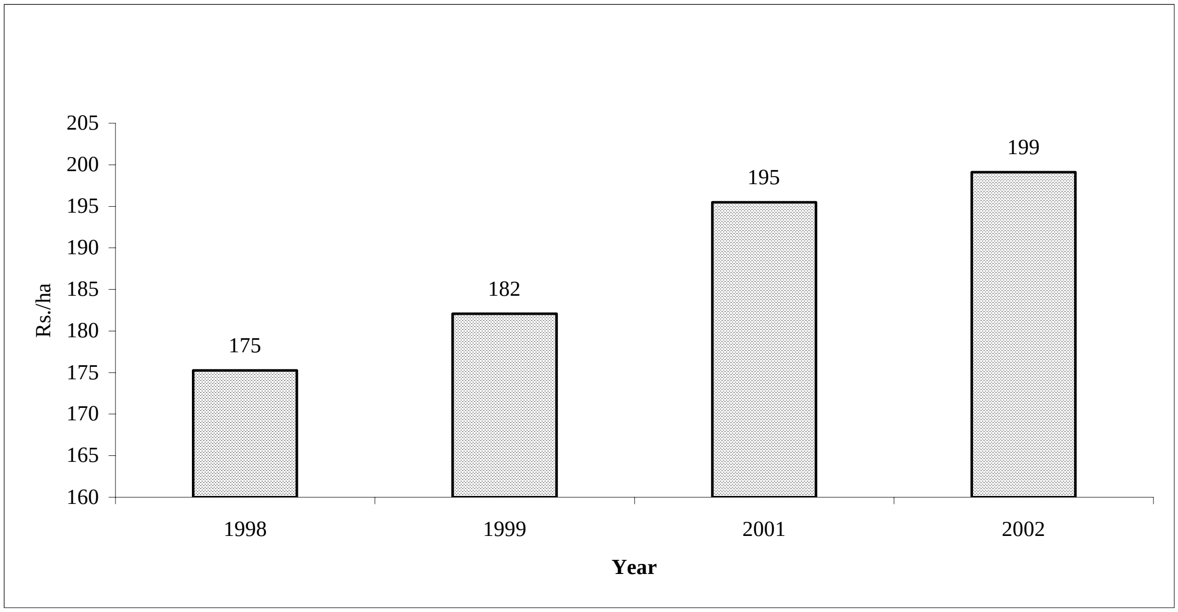
Figure 3.7.8. Abiana assessment in Hakra 4-R distributary during 1997-2002.



Source: PID and FO Record 2002.

Further analysis shows that Abiana assessment per hectare was higher for the years after IMT than before (Figure 3.7.9). During 2001 and 2002, Abiana assessed per hectare was Rs. 195 and Rs. 199 while for the years 1997-2000 (before IMT), it ranged between Rs. 161-182 per hectare. On an average, it was estimated that Abiana assessment per hectare was about 14 percent higher after IMT than in years before IMT. This shows the under-assessment of abiana before IMT, which was usually done by replacing the cropped area under crops having high Abiana rates with those crops having low Abiana rates on per hectare basis. This finding is also supported by Jehangir and Mudasser (1998) who reported that under-assessment of Abiana up to the tune of 20 percent at Hakra 4-R Distributary.

Figure 3.7.9. Abiana assessment per hectare in Hakra 4-R distributary during 1997-2002.



Source: PID and FO Record 2002.

Institutional management

About 53 percent of the sample households reported that they have experienced water related additional benefits after IMT (Table 3.7.2). It is important to consider the problems faced by farmers, to understand the real causes in order to further improve productivity.

Water related benefits to farmers

Table 3.7.2 shows the main benefits of IMT reported by the farm households. Around 68 percent of the farmers believed that there was improvement in equity in water distribution. According to them, it was due to greater control over water theft, which was very common before IMT. Majority of these sample farmers belonged to the middle and tail reach areas of the Hakra 4-R Distributary. About 10 percent of the farmers believed that reliability of water distribution had also improved. Almost the same proportion of farmers at the head, middle and tail reaches of the distributary perceived an improvement in the distribution of water. Majority of these farmers who had experienced more reliability in water distribution was located at the tail reach of the distributary. This shows an improvement in equity and reliability after IMT. Other important benefits gained by the farmers were less number of water disputes, increase in water availability, eradication of rent seeking by PID staff, levying of actual water charges, proper dissemination of information about timings of the canal closure, and approval of nakkas and rotational warabandi programs.

Table 3.7.4. Water related benefits to farmers (%).

	Head	Middle	Tail	All
Equal distribution of water	62.97	70.17	70.21	67.72
Reliability in water supply	9.26	8.77	12.77	10.13
Decrease water disputes	11.11	7.02	6.38	8.23
Increase water availability	5.56	8.77	4.26	6.33
No Bribery	3.70	1.75	2.13	2.53
Correct and in time information about the closure of distributary	3.70	1.75	0.00	1.90
Actual water charges	3.70	0.00	2.13	1.90
Decreased diesel cost of tubewells	0.00	0.00	2.13	0.63
Approval of nakkas and rotational warabandi program	0.00	1.75	0.00	0.63
Total	100.0	100.0	100.0	100.0

Regarding benefits gained by the more equitable and reliable supply of irrigation water, it would be important to explore their impact on small and poor farmers. Table 3.7.5 shows that around 40 percent of the farmers reported that due to the working of FO, small and poor farmers had gained additional irrigation benefits. It was interesting to note that this response mainly came from the farmers at the tail reach areas of the distributary. Around 51 percent of the farmers reported no change in benefits for the small and the poor farmers whereas around 8 percent of the farmers did not answer the question.

Table 3.7.5. Water related benefits to small and poor farmers (%).

	Head	Middle	Tail	All
Increased	40.00	37.80	43.20	40.30
Same	53.40	46.70	54.50	51.40
Do not know	6.60	15.50	2.30	8.20
Total	100.00	100.00	100.00	100.00

Further analyses of the situation showed many ways through which small and poor farmers were benefited after IMT (Table 3.7.6). Around 36 percent of the selected farmers reported that after IMT, further exploitation of farmers by Irrigation Patwaries and PID officials came to an end. Majority of these farmers belonged to the tail reach of the distributary. Similarly, about 18 percent of the farmers indicated a reduction in expenditures for irrigation-related litigation. An additional 12 percent farmers were contented due to actual charging of Abiana for their cropped area due to the presence of FO. About 10 percent of the farmers reported that small and poor farmers were benefited due to increased supply of irrigation water while additional 10 percent of the farmers showed satisfaction on preservation of self esteem and respect when meeting with FO officials than PID officials. About 9 percent of the farmers believed that FO facilitated small and poor farmers in solving their disputes. A small proportion of the farmers reported that increased reliability in water supply and generation of employment opportunities by FO had benefited the small and poor farmers.

Table 3.7.6. Different irrigation related benefits accrued to the small and poor farmers due to active functioning of FO in Hakra 4-R distributary (%).

	Head	Middle	Tail	All
End of rent seeking by PID staff	32.61	36.36	40.00	36.13
Reduced expenses on irrigation-related litigation	13.04	18.18	22.50	17.65
End of overcharging of Abiana	13.04	12.12	10.00	11.76
Increase in irrigation supply	13.04	9.09	7.50	10.08
Feeling of self esteem in farmers	15.22	3.03	10.00	10.08
FO facilitation of farmers in solving their problems	2.17	18.18	7.50	8.40
Reliability in water supply	8.70	3.03	0.00	4.20
Employment opportunities in FO	2.17	0.00	2.50	1.68
Total	100.00	100.00	100.00	100.00

In addition to these, farmers mentioned other ways for providing more benefits to small and poor farmers in order to improve their living conditions, which are listed in Table 3.7.7. Around 23 percent of the sample farmers proposed that adequate volume of irrigation water should be made available to small and poor farmers so that they could increase their productivity while 11 percent anticipated that control over unscheduled closure of canal would help the small and poor farmers to minimize the risk of decrease in their productivity.

Table 3.7.7. Proposed benefits for small and poor farmers (%).

	Head	Middle	Tail	All
Adequate water	14.52	22.03	34.62	23.12
Unscheduled closure of canal should be controlled	12.90	10.17	9.62	10.98
Joint purchase of inputs /acquisition of production loans	11.00	7.00	16.00	11.00
Community tubewells	9.68	6.78	9.62	8.67
In time availability of quality inputs at control price	8.06	6.78	7.69	7.51
Increase in size of outlet	9.68	8.47	0.00	6.36
Use of farm machinery by farmers	1.61	3.39	1.92	2.31
Improvement in the watercourse	4.84	1.69	0.00	2.31
Laser leveling technique	1.61	5.08	0.00	2.31
Farmers' training program	3.23	3.39	0.00	2.31
Increased employment opportunities	0.00	1.69	3.85	1.73
Controlled water charges	1.61	1.69	0.00	1.16
Control over water theft	0.00	1.69	1.92	1.16
Participation of small farmers in executive body	3.23	0.00	0.00	1.16
More frequent visits of office bearer of FO in the area for solving the problems of farmers	0.00	0.00	1.92	0.58
Do not know	17.74	20.34	13.46	17.34
Total	100.00	100.00	100.00	100.00

About 11 percent of the selected farmers proposed that joint purchase of inputs and provision of production loans to small and poor farmers would help them in improving their productivity and economic conditions. Around 9 percent of the farmers believed that installation of community tubewells would benefit the small and poor farmers more whereas 8 percent of the selected farmers believed that FO should ensure the provision of quality inputs in time at control rate to them so that exploitation by the traders be eliminated. In addition to these, a small proportion of the selected farmers proposed increase of the size of outlets, provision of farm machinery, improvement of the watercourses, introduction of laser leveling technique for land preparation, farmers' training program, increased employment opportunities, controlled Abiana rates, control over water theft, participation of more small farmers in the executive body of FO, and frequent visits of FO officials to the area for listening to solving the problems of farmers to augment the benefits to small and poor farm households.

Physical improvements after IMT

Various physical improvements experienced by the farmers after IMT are listed in Table 3.7.8. It was found that 43 percent of the sample households reported that FO had recalibrated/adjusted their moghas after IMT. In fact, after handing over the management of the distributary to FO, all the outlets were recalibrated by them in order to ensure the equal distribution of water to all farmers irrespective of their location at the head, middle or the tail reach of the distributary. Around 27 percent of the farmers responded that banks of the distributary were strengthened to avoid the incidence of breaches in the canal, which may aggravate the situation for the farmers at the tail reaches of the distributary. Around 10 percent of the sample households reported that after IMT, proper de-silting was done and about 5 percent indicated that specific places for animals (for bathing and drinking) were constructed. Other improvements by FO worth mentioning as reported by the farm households were tree plantation along the distributary, lining of distributary and watercourses, repairing of nakkas, and proper maintenance of distributary. It was also found that 3 percent of sample households perceived that no physical improvements after IMT have been done.

Table 3.7.8. Physical improvements after IMT.

Physical improvements	Head	Middle	Tail	All
Adjustment of moghas	42.86	38.46	49.23	43.19
Strengthening of distributary banks	28.57	32.05	18.46	26.76
Proper de-silting activities	14.29	10.26	4.62	9.86
Construction of animals bath and drinking places	0.00	6.41	9.23	5.16
Tree plantation along distributary	0.00	1.28	3.08	1.41
Lining of distributary and watercourse	0.00	2.56	0.00	0.94
Repair of nakkas	0.00	1.28	1.54	0.94
Proper maintenance of canal	0.00	0.00	1.54	0.47
No improvement	7.14	2.56	0.00	3.29
Do not know	2.86	2.56	1.54	2.35
No response	4.29	2.56	10.77	5.63
Total	100.00	100.00	100.00	100.00

Operation and management of distributary

The majority (60 percent) of the sample households did not know where the funds of operation and management were being utilized (Table 3.7.9). Around 20 percent of the farmers believed that O&M funds were being utilized on the operation and management of Hakra 4-R Distributary. About 14 percent of the farmers perceived that some of the O&M funds were utilized on the management expenditures while 4 percent believed that these funds were utilized for the O&M of the distributary. Some other farmers perceived that the funds were used for the office or for the training of farmers. This was reported by the respondents living in the middle reach area, where farmers were given a chance to visit a distributary in NWFP province of Pakistan. Most of the farmers (59.70 percent) were not aware of the utilization of O&M funds, as mentioned above.

Table 3.7.9. Perception about utilization of O&M funds after IMT in Hakra 4-R distributary.

Utilization of O&M Funds	Head	Middle	Tail	All
O&M of the distributary	17.78	17.78	25	20.15
Management expenditure	11.11	17.78	13.64	14.18
O&M of watercourse	6.67	2.22	2.27	3.73
Training of farmers	0	2.22	4.55	2.24
Do not know	64.44	60	54.55	59.7

Functioning of Farmers' Organization

About 57 percent of the sample farmers reported that FO was performing well. However, 33 percent of the farmers ranked the working of FO as not up to the level they expected. Around 8 percent of farmers responded that they did not know about the good or poor performance of FO while 1 percent did not respond to the question at all, as shown in Table 3.7.11.

Table 3.7.10. Perception about the functioning of FO in Hakra 4-R distributary.

	Head	Middle	Tail	All
Good	62.20	62.20	47.70	57.50
Poor	28.90	22.20	47.70	32.80
Do not know	6.70	15.60	2.30	8.20
No response	2.20	0.00	2.30	1.50
Total	100.00	100.00	100.00	100.00

Exploring further the differences in farmers' opinions regarding the success of FO, it was found that majority of the farmers (66 percent) did not know the FO rules and regulations at all. However, 22 percent of the farmers believed that FO was implementing all the rules and regulations properly while 12 percent did not agree. A further scrutiny into the matter revealed that around 36 percent of farmers had complaints against office bearers of FO. Moreover, it was found that 64 percent of the farmers did not have any complaint against the office bearer or management of FO, as shown in Table 3.7.11.

Table 3.7.11. Implementation of rules and regulations, and complaints against FO in Hakra 4-R distributary.

		Head	Middle	Tail	All
Implementation of all the rules and regulations	Yes	26.70	24.40	15.90	22.40
	No	11.10	4.40	20.50	11.90
	Do not know the rules	62.20	71.10	63.60	65.70
	Total	100.00	100.00	100.00	100.00
Complaints against management/office bearers of FO	Yes	39.04	23.07	44.22	35.73
	No	60.96	76.93	55.78	64.27
	Total	100.00	100.00	100.00	100.00

Table 9.7.12. shows different types of complaints against the management of FO. It was found that about 23 percent of the farmers complained against the office bearers of FO for favoring their friends and relatives. Around 15 percent of the farmers rated the behavior of office bearers as discretionary. About 12 percent of the farmers showed their worries that FO was under the control of local influential people. This concern was stronger in the middle and tail reach areas when compared with the head reach area. Around 11 percent of the farmers believed that administrative procedures of FO were complicated and about 11 percent farmers perceived that office bearers were watching their own interests rather than the interest of farmers. Interestingly, 11 percent of the farmers were of the view that office bearers were trying to please everybody in implementing rules and regulations. An additional 11 percent of the farmers indicated that there was a problem in warabandi schedule that needed to be corrected. A small proportion of the farmers perceived that office bearers did not show interest in the proper operation and management of the distributary and there was poor utilization of the funds. A few respondents also indicated that office bearers should have experience in distributary management, which was lacking.

Table 3.7.12. Different complaints against management/office bearers of FO in Hakra 4-R distributary.

Complaints	Head	Middle	Tail	All
Favoring friends and relatives	17.86	15.38	31.25	23.29
Discretionary behavior of FO office bearers	17.86	15.38	12.50	15.07
Under the control of influential people	7.14	15.38	15.63	12.33
Administrative problems	25.00	0.00	3.13	10.96
Watching for their own interest	7.14	15.38	12.50	10.96
FO administration try to please everyone	7.14	15.38	12.50	10.96
Warabandi problem	7.14	23.08	9.38	10.96
Lack of interest for O & M	3.57	0.00	3.13	2.74
Poor utilization of funds	3.57	0.00	0.00	1.37
FO does not have experience in O&M	3.57	0.00	0.00	1.37
Total	100.00	100.00	100.00	100.00

Table 3.7.13. shows the list of different proposed actions by the sample households for resolving the complaints against management/office bearers of FO. It was found that in order to rectify

shortcomings, 15 percent farmers were of the view that a more efficient management would be the solution. Another 15 percent of the sample farmers proposed that the government should take back the distributary from FO. However, 13 percent of the farmers proposed an equal size of outlets to end up the complaints. Around 11 percent of the farmers suggested re-election in FO so that an efficient management could take over and resolve the problems. This suggestion came out mainly from the farmers located at the middle and tail reach areas of the distributary. About 11 percent of the farmers suggested that the relatives of the office bearers created most of the problems, so FO should take measures to control the illegal acts so that office bearers should not favor their relatives. An additional 7 percent of the farmers proposed a check and balance system by the government on the working of FO. A small proportion of the sample farmers also suggested change in office bearers, improvements in warabandi schedule, and equality of Abiana. Around 24 percent of the farmers responded that they did not know how to rectify the problems.

Table 3.7.13. Proposed actions by the farmers for resolving the complaints against management/office bearers of FO in Hakra 4-R distributary.

	Head	Middle	Tail	All
Efficient management	27.78	0.00	10.53	15.22
Govt. control over distributary	22.22	0.00	15.79	15.22
Equal size of outlets/mohga	16.67	11.11	10.53	13.04
Election of new FO	0.00	33.33	10.53	10.87
Management should control nepotism	11.11	11.11	10.53	10.87
Check on FO activities by govt.	0.00	22.22	5.26	6.52
FO personnel should be changed	5.56	0.00	5.26	4.35
Warabandi rotation	5.56	0.00	0.00	2.17
Equality of Abiana	0.00	11.11	0.00	2.17
Do not know	11.11	11.11	31.70	23.91
Total	100.00	100.00	100.00	100.00

As mentioned earlier, around 57 percent of the farmers rated the working of FO to be very good or good. It was further explored that around 51 percent of the farmers believed that FO was able to complete its operations successfully. The lowest proportion of farmers supporting this idea were those located at the tail reach of the distributary as shown in Figure 3.7.10.

Figure 3.7.10. Farmers' perception about successful completion of O&M operations by FO in Hakra 4-R distributary.

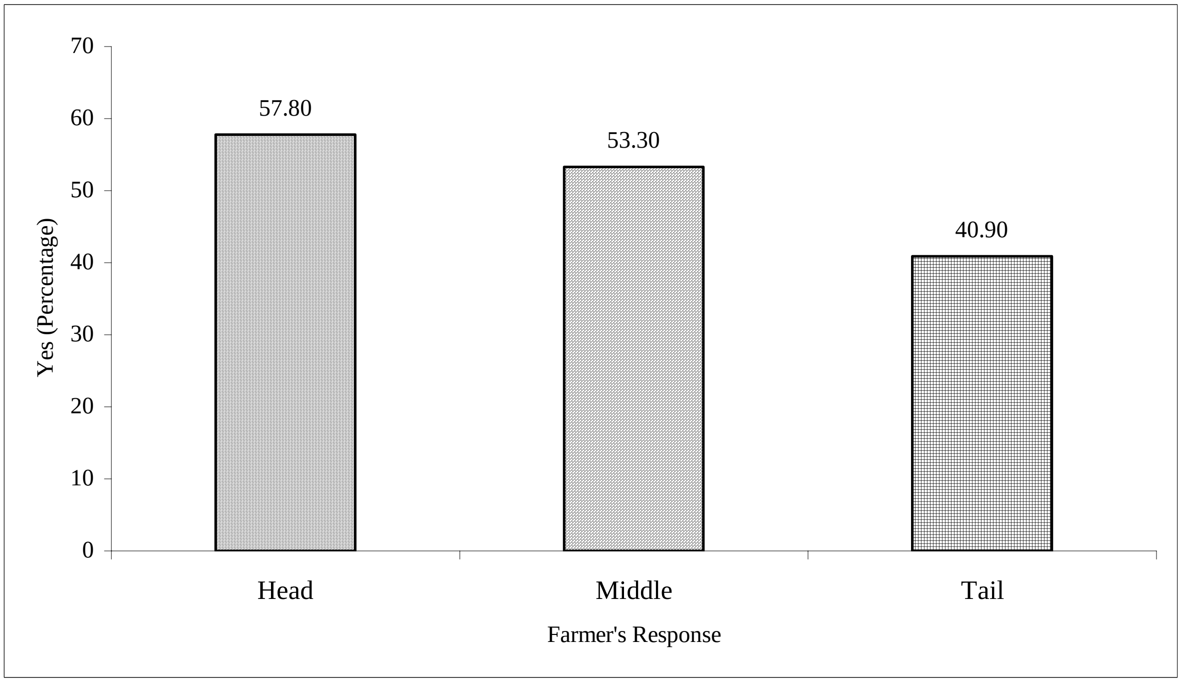


Table 3.7.14 presents various reasons for the successful operations of FO. It was found that around 41 percent farmers were satisfied with the working of FO and the majority of these (53 percent) belonged to the tail reach areas. Another 30 percent of the farmers believed that due to efficient working of FO, farmers had experienced equity in the distribution of water. Around 8 percent of the farmers perceived the control over water theft as the reason for successful completion of operations by FO while for 6 percent of the farmers it was due to mutual understanding among the farmers. About 3 percent of the sample households reasoned that access to government officials of PID would help them in the successful management of the tasks while 13 percent of the farmers did not answer the question at all.

Table 3.7.14. Reasons reported by the farmers regarding successful completion of O&M operations by FO in Hakra 4-R distributary.

Reasons	Head	Middle	Tail	All
Farmers satisfaction	35.71	37.50	52.63	40.85
Equal distribution of water	35.71	25.00	26.32	29.58
Control over water theft	7.14	12.50	5.26	8.45
Mutual understanding	10.71	4.17	0.00	5.63
Access to government official and Irrigation Department	3.57	0.00	5.26	2.82
Do not know	7.14	20.83	10.53	12.68
Total	100.00	100.00	100.00	100.00

Assessing the overall functioning of FO, about 51 percent of the farmers revealed that the performance was below the desirable level while 49 percent of the farmers believed that it was successful in meeting its targets (Figure 3.7.11). It is worth noting that most farmers at the head and middle reaches thought that FO was working up to the mark while majority of farmers at the tail reach areas were not satisfied with the functioning of present FO.

Figure 3.7.11. Perception of farmers about the achievements of desirable performance of FO Hakra 4-R distributary.

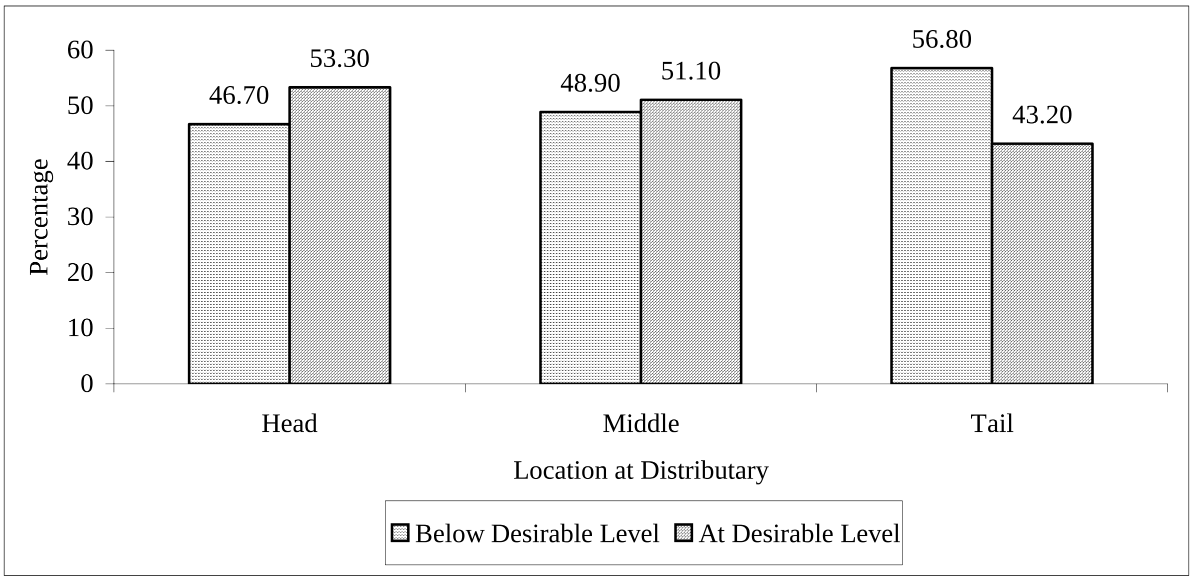


Table 3.7.15 presents various reasons, perceived by the farmers, leading to the functioning of FO below its desirable level of performance at Hakra 4-R Distributary. Around 33 percent of the farmers indicated that the prevalence of inequity in water distribution was the major reason for failure. The higher proportion of the farmers at the tail reach complained about this problem when compared with head or middle reach areas. Around 17 percent of the farmers thought that inefficient working of FO was due to non-cooperation of PID. They perceived that as the distributary was handed over to farmers and PID officials were unable to draw personal benefits from farmers, PID staff did not want that the FO be successful. This idea was further strengthened by the fact that farmers indicated the unscheduled closure of distributary as the water supply at the distributary head was controlled by PID. Another 10 percent of the farmers perceived that, since the small farmers were not much benefited, FO was unable to meet its expected objectives. Moreover, 8 percent of the farmers believed that inefficiency of the FO was the reason for not achieving its objectives. In addition to these, a small proportion of sample farmers indicated powerlessness of FO to control the canal warabandi (as it was in the hands of PID), exploitation by the office bearers of FO, and their discriminative behavior were other reasons why FO was not able to meet its expected objectives. Around 13 percent of the farmers did not respond to the question. It should be noted that for tail-enders, the first three reasons were found more significant than others.

Table 3.7.15. Factors contributing to less than desirable performance of FO.

	Head	Middle	Tail	All
Inequitable distribution of water	21.74	30.43	44.00	32.39
Non cooperation of PID	17.39	17.39	16.00	16.90
Unscheduled closure of canal	8.70	8.70	16.00	11.27
Small farmer is not happy	26.09	4.35	0.00	9.86
Inefficiency of FO	0.00	8.70	12.00	7.04
Powerlessness of FO to control the canal warabandi	4.35	8.70	0.00	4.23
Exploitation of new members	8.70	0.00	0.00	2.82
Discriminatory behavior	4.35	0.00	4.00	2.82
Do not know	8.70	21.74	8.00	12.68
Total	100.00	100.00	100.00	100.00

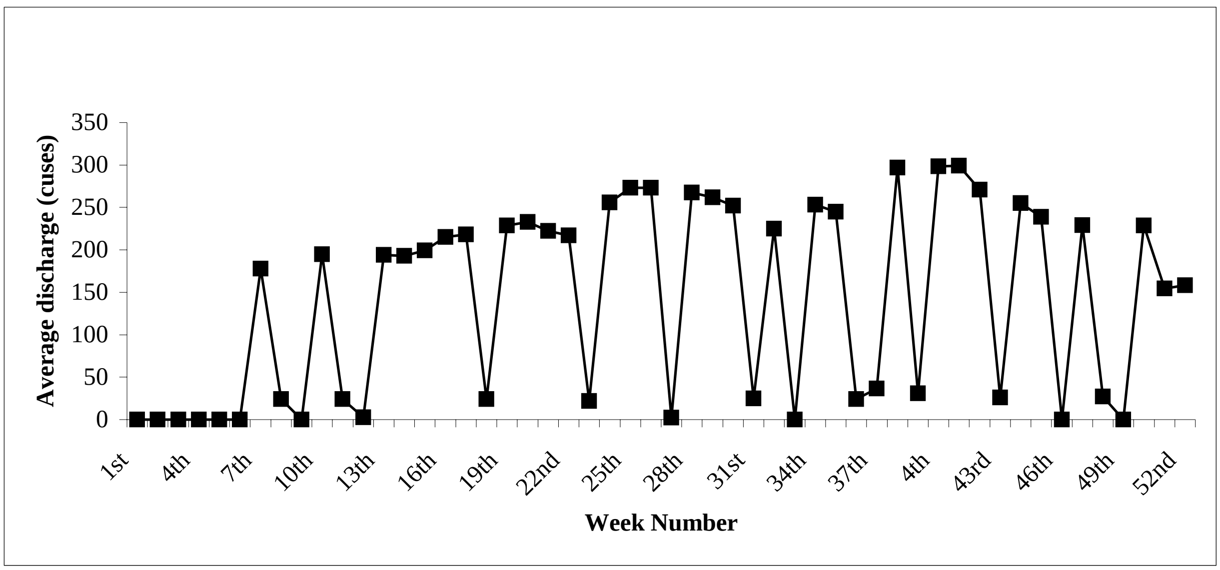
Table 3.7.16 shows different ways and means adopted by PID for failing FO, as perceived by the farmers. It was found that the most important way was unscheduled canal closure by PID. This was perceived by 40 percent of the selected farmers and majority of these was located at the tail reach area, which was the most sensitive area with respect to water availability and distribution. Around 9 percent of the farmers reported that PID officials tried to invoke some farmers against FO with a promise to give them benefits after failure of FO. Based on these intrigues by PID, a boycott by the tail reach farmers took place during Abiana collection. The tail end farmers refused to pay a single rupee unless they were made contented by proving that they were actually receiving their due share as well as the other farmers at all reaches without any discrimination (the middle reach farmers mainly reported this method, which were around 18 percent of the sample farmers). Overall, around 9 percent of the sample farmers perceived that PID intentionally allocated less water to Hakra 4-R Distributary to create problems for FO. About 41 percent of the sample farmers responded that they did not know about any method being applied by PID to put FO under pressure.

Table 3.7.16. Methods of non-cooperation of PID to ensure poor performance of FO in Hakra 4-R distributary.

Methods	Head	Middle	Tail	All
Unscheduled closure of canal	35.56	34.78	52.00	40.15
Irrigation Department enticing the farmers against FO	6.67	17.39	4.35	9.49
Less water allocation	2.22	13.04	10.87	8.76
Do not know	55.56	34.78	32.61	40.88
Total	100.00	100.00	100.00	100.00

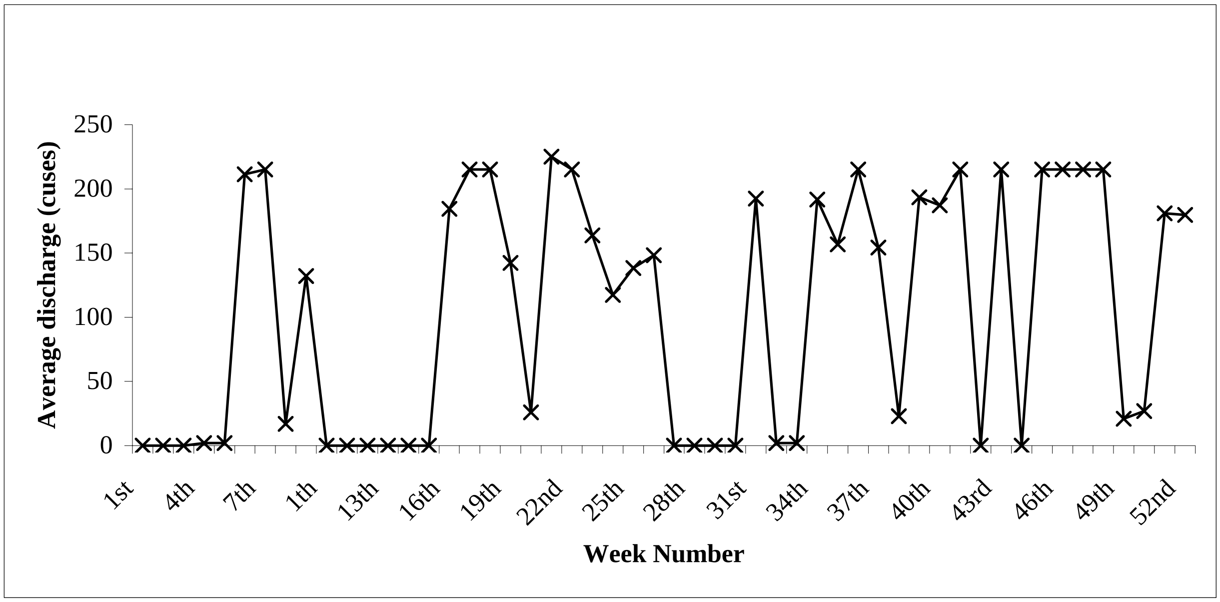
In fact, the average weekly design discharge of Hakra 4-R Distributary for the years before and after IMT reveals that before IMT (in 1999), the distributary was receiving more water than the designed discharge of 193 cusecs. Figure 3.7.12 shows that before IMT, the maximum discharge of the distributary was 299 cusecs, which was significantly higher than the design. Moreover, in 26 weeks out of 52 (a year), it was receiving more water than its discharge. It was mainly because in pre-IMT period outlets were modified, as a consequence of rent seeking behavior of PID officials, which were drawing more water from the distributary. In order to keep all these activities under cover, more water was supplied. On the contrary, Figure 3.7.13 shows that after IMT, the maximum average discharge was 225 cusecs and in 13 out of 52 weeks, the distributary was receiving more water than the design. However, the magnitude of this additional water received was much lower in the year after IMT . About 45 percent of the farmers perceived this change in water availability and reported that canal water availability decreased after IMT because of low water availability at the canal head, which was controlled by PID. That was why, while explaining different methods of non-cooperation by PID in order to fail FO, farmers reported that less allocation of water by PID was used as a tool for failing FO. Groundwater quality of the Hakra 4-R Distributary canal command area was very poor. Additionally, drought like conditions were prevailing for the past 2-3 years when not only the overall surface water supply had reduced but also the area received very few or no rainfalls. In these conditions, a slight reduction in the canal water supply would have become more prominent in the eyes of desperate and needy farmers waiting for their water turns and struggling for survival.

Figure 3.7.12. Average discharge (in cusecs) of Hakra 4-R distributary on weekly basis for the year (1999) before IMT.



Source: PID and FO Record 2002

Figure 3.7.13. Average discharge (in cusecs) of Hakra 4-R distributary on weekly basis for the year (2001) after IMT.



Source: PID and FO Record 2002.

Farmers' suggestions to improve the situation in Hakra 4-R

Various suggestions were made by the farmers for improving the functioning of FO in Hakra-4-R (Table 3.7.17). About 20 percent of farmers proposed better control over water distribution to make it further equitable which would improve the functioning of FO by satisfying the water users. About 17 percent believed that honest and cooperative members of the executive body of FO would benefit the farmers most. Another 4 percent stressed that the working of FO should be free from any political as well as bureaucratic interference from PID. Moreover, about 4 percent were of the view that FO should be entrusted with authority by the government to punish the water stealers; this would improve the popularity of FO and increase the faith of farmers in its working. Small proportions of sample farmers proposed many other improvements including the formation of an accountability committee, which would check the working progress of FO. Government support to FO for improvements in its working was also suggested. An increase in the size of Mogha would provide more water to the farmers and their perception about working of FO would also get better among farmers. The farmers proposed that FO should seek help and cooperation from other NGOs for guidance to further improve its functioning and overcoming the flaws to benefit the farmers more than ever. Also frequent visits should be made by the executive body of FO especially in the tail reach areas of the distributary to consider, understand and rectify problems faced by the farmers. Some of the farmers believed that a new executive body of FO might be an alternative for improvement in the functioning of FO through new elections. Some other suggestions included prohibiting the entry of livestock into the distributary, improved water charges collection, prompt actions on the complaints of the farmers, lining of distributary and watercourses, reduction in water charges, and exclusion of local people from FO in order to make it more effective and free from internal and external intervening forces like relatives, PID, etc. Around 27 percent of the farmers did not propose any suggestion for the improvement in the functioning of FO.

Table 3.7.17. Suggestions for improved functioning of FO in Hakra 4-R.

Suggestions	Head	Middle	Tail	Total
Equal distribution of water	20.00	12.73	25.93	19.51
Members should be honest and cooperative	18.18	14.55	16.67	16.46
No political or irrigation department interference	0.00	7.27	5.56	4.27
Authority to punish the water thieves	3.64	3.64	5.56	4.27
Formation of accountability committee	1.82	5.45	3.70	3.66
Government support	3.64	0.00	7.41	3.66
Appropriate size of outlet/Mogha	3.64	5.45	1.85	3.66
Cooperation with NGOs	1.82	3.64	3.70	3.05
Regular meeting with farmers	1.82	1.82	3.70	2.44
Executive body should visit the tail reach areas frequently	0.00	1.82	3.70	1.83
New election	1.82	1.82	1.85	1.83
Canal should be prohibited for livestock	3.64	0.00	0.00	1.22
Improve water charges recovery	1.82	1.82	0.00	1.22
Immediate actions on the complaints of farmer	0.00	3.64	0.00	1.22
Lining of distributary and watercourse	3.64	0.00	0.00	1.22
Loans without interest / rights of quality control of farm inputs/ reducing the water charges/ local people should not be included in FO	3.64	3.64	1.85	3.05
Do not know	30.91	32.73	18.52	27.44
Total	100.00	100.00	100.00	100.00

Effect on warabandi adjustment

A number of cases were filed in the FO office by the farmers as shown in Table 9.19. They had become optimistic of receiving solutions to their problems. According to the secondary data collected from FO office, out of the total 415 cases, which were reported to FO for decision after IMT, 340 cases were related to warabandi. Out of those 340 cases, decision was given on 243 cases and there were only four cases, which were filed for reconsideration. This high number of warabandi cases indicates that there was not equal distribution of water at field level before IMT. Thus, settlement of 220 warabandi cases was a giant leap towards equal water distribution. The detail of the cases is given in the Table 3.7.18.

Table 3.7.18. Detail of cases registered by farmers' organization in Hakra 4-R distributary.

S. No	Name of cases	Section	Total cases	Settled cases	Decisions taken on cases	Under process
1	Warabandi cases	68	340	130	220	120
2	Command cases	20	38	-	21	17
3	Fine cases	32	37	-	2	35
4	Appeal cases	68	4	-	-	4
Total		-	419	130	243	176

Effect on cropped area

Although there was frequent canal closures because of which water turns of the farmers were missed, taking into consideration the water availability after IMT, the farmers reported that their cropped area had increased (Table 3.7.19). On an average, at the tail end, there was an increase of 1.36 and 0.97 hectares for wheat and cotton in the cropped area after IMT. Most of the increase in the cropped area was due to increased water quantity (Table 3.7.20).

Table 3.7.19. Effect of IMT on cropped area (ha) in Hakra 4-R.

Crops		Head	Middle	Tail
Wheat	Before IMT	3.69	2.83	2.40
	After IMT	4.43	3.87	3.76
Cotton	Before IMT	2.29	3.49	2.72
	After IMT	4.50	3.84	3.69
Rice	Before IMT	3.25	2.33	0.00
	After IMT	0.51	0.00	0.00

Table 3.7.20. Reasons of increase in the cropped area in Hakra 4-R (%).

Reason	Head	Middle	Tail	Total
Increase in water quantity	50	-	66.67	50.00
Control over water theft	-	100	33.33	25.00
Decrease in waterlogging condition	25.00	-	-	12.50
Laser land leveling	25.00	-	-	12.50

Table 3.7.20 shows that among the reasons for the increase in cropped area, the increase in water quantity due to equal water distribution was perceived as most important. On the other hand, the decrease in waterlogging and laser land leveling was also perceived to be contributing towards the increase of cropped area.

Effect on Abiana assessment and collection

During the survey in the sample areas of the study, there was hardly a single village where the farmers knew the actual Abiana rates. No details of the rates, cultivated area and other relevant information were provided to the farmers. Even the Numberdar of the village (who was close to Patwari in official capacity) did not know the actual Abiana rates. The scenario was totally opposite to this in the command area of Hakra 4-R Distributary where majority of the farmers were aware of the Abiana rates. They presented the Abiana receipts to the enumerators on enquiring about Abiana of different crops. There were no chances of corruption in Abiana Assessment by Patwaries after IMT because all the necessary information was provided in the abiana receipts. It was revealed during the interview with the FO executives that Rs. 3/acre were being charged from farmers in addition to Abiana, to cover operation and maintenance cost. Moreover, Abiana collection performance of FO was also good. For the first year after IMT, FO collected about 15 percent more Abiana than the amount of Abiana collected by Irrigation Department before IMT (Table 3.7.21). Farmers were also given ten days for the correction of their Abiana charges if there was any mistake in the calculation procedure.

Table 3.7.21. Comparison of Abiana collection by FO (after IMT) and Irrigation Department (before IMT) Rabi 2000-2001.

(Rs.)

Assessment by FO 2000-2001.	Assessment by Irrigation Department 1999-2000.	Difference	Percentage increase (%)
5245216	4545416	699800	15

Figure 3.7.8 already revealed that after the IMT the FO was able to assess and collect Rs. 5.4 million for year 2001-2 as compared to Rs. 4.66 million for years 1999-2000 (prior to IMT). Through this system of Abiana collection, control over corruption of Patwaries had become possible. The template of that Abiana receipt is given in Appendix -3.

Effect on distributary maintenance

The survey team visited the whole of the Hakra-4-R Distributary along with other nine selected distributies. No other distributary, in the study area of the project, was in such a better physical condition as was Hakra 4-R. Good physical condition of the distributary was the reflection of efficient management. Up to July 2002, total maintenance expenditures incurred on the distributary were Rs. 347070, which shows that the maintenance of the distributary was very much cost effective. This made it clear that there is a difference between the management of the Punjab Irrigation Department and Farmers' Organization.

Effect on conflict resolution

FO at Hakra 4-R adopted the traditional Punchayat system for conflict management. It has been explained already that up till the time of the survey conducted in May 2002, 415 cases in all were reported to FO for decisions related to Warabandi, Command matters and Tawan (fine) matters. Out of those 415 cases filed during 2001-02, FO had decided about 243 and 172 cases were under hearing. It is worth mentioning that out of the 243 cases only four cases have been appealed to the higher authorities. An ordinary case that needs to be filled at the XEN's office involves exorbitant costs (in terms of time spent and expenses incurred till the time it is decided). But in the case of Farmers' Organization at Hakra 4-R Distributary, the same case can be launched in the FO's office with the minimal charges and was decided in minimum possible time.

B. Impact of integrated services provision on productivity in irrigated agriculture

Food and Agriculture Organization (FAO) of United Nations has been supporting a program of Food Security in some parts of Lalian Distributary in Sargodha District to improve the productivity of farmers through the provision of a package of inputs including credit, machinery, as well as quality extension services. Under this package, farmers were provided with LASER leveling technology for precision land leveling. Seed of an improved variety of wheat was also provided and farmers were encouraged to sow the recommended variety. They were provided with credit to facilitate them in purchasing the required inputs. Extension services were also offered for helping farmers to decide about the quantity and time of input applications e.g. fertilizer, irrigation and weedicides. The package was expected to enable farmers to reap good harvest. The data were collected through daily monitoring on inputs used and quantity of irrigation water applied. EC of the groundwater was recorded in order to analyze the impact of quality of irrigation water on the productivity of wheat.

Table 3.7.22 provides key characteristics of the selected watercourses. Gross Command Area (GCA) of selected watercourses varies from around 130 hectares to 247 hectares, with relatively higher GCA at tail end watercourses. Design capacity of the selected watercourses varies from 0.026 to 0.049 cumec. Average discharge measured at the outlet head varies from around 38.7 l/s to 61.6 l/s. The discharge was higher on middle watercourses than on head and tail end watercourses, indicating significant inequities in the distribution of water. Cropping intensities vary significantly across watercourses, from 132 to 162 percent. Cropping intensity decreases towards tail ends. Average farm area varies from 2 to 7.3 hectares per farm and it is larger in the middle reach area.

Table 3.7.22. General characteristics of selected watercourses.

Outlet/Disty/Minor	GCA	DC	AD	CI	Number of selected farms	Average area per farm (ha)
Lalian – head	179.3	0.036	38.7	162	36	2.0
Lalian – middle	129.9	0.026	39.7	135	20	5.2
La1ian – middle (FAO)	189.0	0.038	61.6	140	21	7.3
Lalian – tail	248.1	0.049	32.5	132	36	2.5
Lalian – total	746.3	0.037	43.1	143	113	3.7

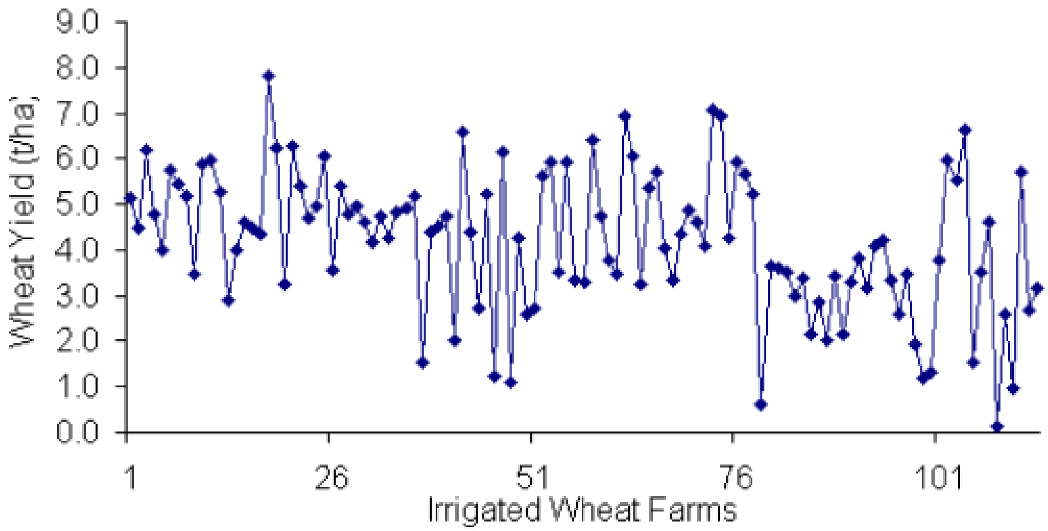
Note: GCA = Gross Command Area in hectares (secondary data from Irrigation department
DC = Design Capacity in Cumec
AD = Average Discharge in l/s (as measured through field data)
CI = Cropping Intensity

Variations in wheat yields

To determine wheat yields, crop-cuts were taken from the selected plots of all 218 farms. In these crop-cuts, two samples were collected from each plot i.e. the crop was harvested from 1 square meter area of each plot. After harvesting, threshing was done manually and grains from each plot were weighed[13].

The results obtained from crop-cuts showed a wide variation in yields across farms and watercourses. The average wheat yield was 4.04 t/ha for all the wheat farms at Lalian Distributary. The minimum and maximum yield obtained by farmers was 0.12 t/ha and 7.82 t/ha, respectively (Figure 3.7.14).

Figure 3.7.14. Farm level irrigated wheat yields at Lalian distributary.



There was a significant difference in wheat yields across head, middle and tail reaches within and across watercourses along the distributary (Figure 3.7.15). In general, yield was higher in head reaches than in tail reaches, reflecting the availability and use of good quality groundwater.

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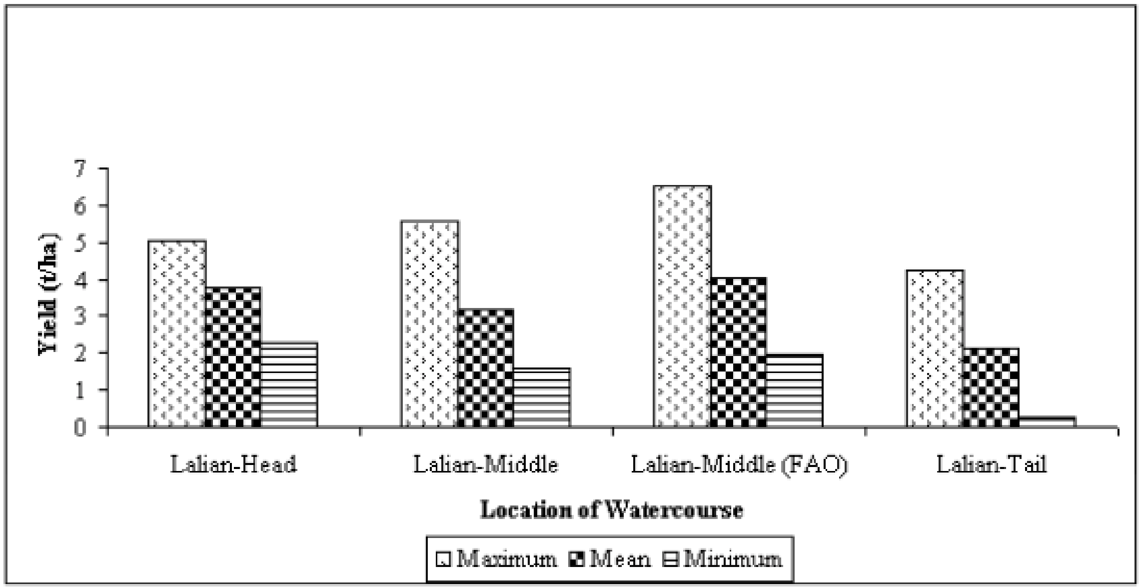
13 Two samples were taken from each selected plot from different places in order to best reflect the average yield of the plot. Where the wheat plants were uniform all over the plot, samples were taken from two places randomly. If there was no uniformity, samples were taken purposively to reflect average of both good and poor parts of the plot. The crop was harvested from 1 square meter area for each sample. Threshing was done manually, grains were separated from the chaff and each sample was weighed.

Figure 3.7.15. Farm level irrigated wheat yields according to location of watercourse at Lalian distributary.



Yield differences across watercourses were much higher than within watercourses (Table 3.7.23). This finding has an important research and policy implication as to what should be the unit of analysis and what type of efforts should be directed and where.

Table 3.7.23. Average wheat yield (t/ha) at different watercourses of Lalian distributary.

Location at watercourse	Lalian distributary			
	Head	Middle	Tail	Middle (FAO)
Head	5.18	4.02	2.96	4.76
Middle	4.92	3.31	3.01	4.62
Tail	4.79	4.5	3.59	5.66
Average	*4.96*	*3.92*	*3.19*	*4.96*

Source: Based on crop cutting experiment 2000-2001

Yield function analysis

In order to analyze the combined effects and significance of various factors affecting the wheat productivity in the FAO project area, the analysis of yield function was undertaken. This analysis was carried out to identify and estimate the combined effects of various factors of production in order to assess their importance in influencing wheat yields. The yield function was a formal representation of a set of hypothese, that the identified production factors influence yields and that their effects on yields were of varying magnitude. The analysis was undertaken for an entire sample of 218 farms. The yield function was specified by using the following variables, and estimated with a set of functional forms including linear, log-linear, log-log (Cobb-Douglas) and quadratic. The popular econometric and statistical criteria i.e. predictive power of the equation, consistency and plausibility of estimated coefficients, algebraic signs and numerical magnitudes and their statistical significance were used to select the functional form that had the best suitability for the given data set. The linear functional form fulfilled the criteria and was finally selected to estimate the set of independent variables as given below.

$$Y_i = \alpha_0 + \alpha_1 D_{Ii} + \alpha_2 S_i + \alpha_3 F_i + \alpha_4 W_i + \alpha_5 NW_i + \alpha_6 T_i + \alpha_7 ECTW_i + \alpha_8 NP_i + U_i \quad (1)$$

Where

Y	=	Wheat yield in tons per hectare
D_I	=	Dummy for watercourse intervened by FAO ($D_I = 1$ if the watercourse was intervened, $D_I = 0$ otherwise)
S	=	Sowing week (first week from Oct 1, 2000)
F	=	Quantity of fertilizers - NPK in kg/ha
W	=	Quantity of irrigation water /ha measured at field outlet (m^3)
NW	=	Number of irrigations to wheat during the entire growing season
T	=	Time gap between pre-sowing and first post-sowing irrigation/watering in week)
$ECTW$	=	Percentage of groundwater in total water applied/ha measured at field outlet (%) times electrical conductivity (*EC*) of groundwater (dS/m)
NP	=	Number of ploughings
α_s	=	Co-efficients to be estimated
i	=	denotes farm
U	=	error term

Each estimated co-efficient measures the change in wheat yield with per unit change in the respective dependent variable holding the others constant. The location of farms at the FAO intervened watercourse along the canal system enters in the yield function as a shift variable and measures the absolute differences in yields between farmers who adopted the FAO package to those who did not use the recommended package.

The results of the estimated equation are presented in Table 3.7.24. In a wide range of factors that could possibly affect wheat yields i.e. the provision of services, quality of groundwater, number and timing of irrigations applied to wheat crop, sowing time, and number of ploughings are found to be significant. The included independent variables in the regression equation explained 45.8 percent of the variation in the wheat yield as determined by the R^2.

Table 3.7.24. Estimated coefficients and their significance.

Dependent variables	Coefficients B_i	Std. error	t-statistics
Constant	3.4520***	0.83	4.14
Groundwater % average EC of groundwater	-0.0059***	0.00	-2.87
Time gap between pre-sowing and post-sowing irrigation in weeks (starting from October 1, 2000)	-0.1150***	0.04	-2.83
Total number of irrigations	0.3060***	0.11	2.70
Sowing week	-0.1120**	0.06	-1.98
Number of ploughings	0.2410*	0.14	1.72
Total NPK	0.0026	0.00	1.34
Total water applied	0.0001	0.00	0.72
Watercourse with FAO interventions	0.7260**	0.35	2.10
	N = 102	R^2 = 0.458	

* Significant at 90 percent confidence level
** Significant at 95 percent confidence level
*** Significant at 99 percent confidence level

The results of the estimated equation suggest that the specified set of variables significantly affect (positively/ negatively) wheat yields. The coefficient for the quality of groundwater indicates that increased application of groundwater decreased the wheat yields. On an average, a 10 percent increase in groundwater would decrease the wheat yield by 59 kilograms per hectare. A delay of one week between pre-sowing and post sowing irrigation would decrease the wheat yield by 115 kg per ha. An additional irrigation would increase wheat yield by 306 kg per ha. One-week delay in sowing would decrease wheat yield by 112 kg per ha. The coefficients for NPK and additional water application were non significant. Dummy for the farms who adopted the FAO package indicates that those who adopted the FAO's package of inputs, machinery, and credit with extension services were able to get an additional 726 kilograms per hectare of yield than others.

Lessons Learned/Policy Implications

- The high O&M costs of irrigation infrastructure and low recovery of Abiana with efficiency issues in the irrigation department led the government decide in favour of IMT/PIM.

- Hakra 4-R was the largest pilot program related to IMT that took place in irrigation management in Pakistan in May 2000. If such types of programs need to be replicated, a strong back up from the government is also required.

- Various productivity, water supply, economic, and institutional management indicators show that the efficiency of the irrigation system has increased after IMT in Hakra 4-R.

- FAO, under its food security program, provided a package of inputs, credit, machinery and extension services in Sargodha area. The results showed that the productivity of wheat increased significantly on those farms that benefited from the program when compared with those farms that were away from the project area. It is evident that if same types of package are provided to other farmers, under similar conditions, their productivity could also be increased.

References

ACE-Associate Consultant Engineers (Pvt) Ltd. 1985. *SCARP transition Pilot Project, Khanka Dogran Unit of SCARP-1*. PC-I, Performa, Government of Pakistan.

ACE-NESPAK-NDC. 1997. *Hydrogeological Studies*. Final Report, Second SCARP Transition Project, Irrigation and Power Department, Government of Punjab, Lahore

Gill, M. A..; B. A.. Solehria; N. H. Bukahri; and M. Ahmad. 2002. *Use of poor quality groundwater through Conjunctive Water Management*. Proceedings of International Workshop on Conjunctive Water Management for Sustainable Irrigated Agriculture in South Asia. Pakistan: IWMI.

Jehangir W. A..; M. Mudasser. 1998. *Irrigation management and its Viability: A Case Study of Hakra –4 R Distributary, Punjab, Pakistan*. Publication No. 188. West Wood Colony, Lahore, Pakistan: International Water Logging and Salinity Research Institute.

Kalwij, I.; Z. I. Mirza; A. Amin; and A. Hameed. 1999. *Disseminating the Bed and furrow Irrigation Methods for Cotton Cultivation in Hakra-4-R distributary with the water User Federation*. Report No. R-83. Lahore, Pakistan: International Water Management Institute.

Malmberg, G. T. 1968. *Reclamation by Tubewell Drainage in Rechna Doab and adjacent Areas, Punjab Region. Pakistan.* USGS water supply paper 1608.

Mundorff, M. J.; P. H. Carrigan Jr.; T. D. Steel; and A. D. Randall. 1976. *Hydrologic Evaluation of Salinity Control and Reclamation Projects in the Indus Plain, Pakistan-A Summary*. US Geological Survey Water-Supply Paper 1608-Q

Memon, M.; and P. Arif. 1993. *Factors Associated with the Deterioration of the SCARP Tubewells*. ISMR Symposium Proceedings, Vol. VI, Lahore.

Rehman, G.; W. A. Jehangir; A.. Rehman; M. Aslam; and G. V. Skogerboe. 1997. *Principal Findings and Implications for Sustainable Irrigated Agriculture: Salinity Management Alternatives for the Rechna Doab, Punjab, Pakistan. Volume I.* Research Report Number R-21.1, Pakistan National Program, Lahore: International Irrigation Management Institute.

8. ANALYSIS OF CONSTRAINTS AND OPPORTUNITIES FOR INCREASING PRODUCTIVITY AND REDUCING POVERTY IN IRRIGATED AGRICULTURE

In order to understand the priorities of the communities and the problems they are facing in their local settings, the Participatory Rural Appraisals (PRA) were conducted in all the selected canal commands of the study areas. At the end of each PRA on each sample site, SWOT analysis was undertaken. System wise results of SWOT analysis are presented in Appendix 2. In this chapter critical issues, gaps and possible areas for interventions and actions are identified. Table 3.8.1 provides summary of critical issues in the selected systems.

Table 3.8.1. Critical issues/gaps based on SWOT analysis.

	Systems			
Critical issues	UJC	LJC	LCC	Hakra
High cropping intensity (>150 %)	Y	N	N	Y
Small holdings (90 % farmers having < 5 Ha)	Y	Y	Y	Y
Fertile soils (loamy)	Y	Y	Y	Y
Adequate rainfall (> 350 mm)	Y	N	N	N
Well-drained soils	Y	Y	Y	N
Traditional ploughing methods	Y	Y	Y	Y
Relative use of modern equipment	N	Y	Y	Y
Use of RCTs i) Laser land leveling ii) Direct sowing of rice iii) Zero tillage	 N N N	 N N N	 N N N	 N N N
Use of certified seed	N	N	N	N
Use of fertilizer	Y	Y	Y	Y
Timely availability of DAP fertilizer	N	N	N	N
Incidence of adulteration in fertilizer	Y	Y	Y	Y
High incidence of insect pest attack (in rice sugarcane and cotton)	N	Y	Y	Y
Lack of awareness about pests scouting	Y	Y	Y	Y
Constraints on adopting measures against insects	Y	Y	Y	Y
Incidence of adulteration in pesticides	Y	Y	Y	Y
Relatively proper O&M of irrigation system (At disty. and WC level)	N	N	N	Y
Tail of the system gets water?	N	N	Y	Y
Water theft	Y	Y	Y	N
Exploitation of groundwater	Y	Y	N	N
Good quality of underground water	Y	N	N	N
Depletion of underground water	Y	N	N	N
Partial use of weedicides to control weeds	Y	Y	Y	Y
Shortage of labour at the time of transplanting and harvesting	Y	Y	Y	Y
Good crop yield i) Wheat (>2.4 T/ha) ii) Rice (>2.4 T/ha) iii) Sugarcane (>32 T/ha) iv) Cotton (>1.6 T/ha)	 Y Y N N	 Y Y Y N	 Y N Y N	 N N N N
Marketing problems related to outputs i) Farm to market roads ii) Low output prices iii) Delayed payments for sugarcane	 N Y Y	 N Y Y	 Y Y Y	 Y Y Y
Adequate health facilities for households	Y	N	N	N
Adequate animal health facilities	N	Y	Y	N

Presence of waterlogging and salinity problem	N	Y	Y	Y
Livestock husbandry	Y	Y	Y	Y
High incidence of animal theft	N	Y	Y	N
Problems associated with institutional credit	Y	Y	Y	Y
Adequate educational facilities	N	N	Y	N
Adequate vocational educational facilities	N	N	N	N
High unemployment rate	Y	Y	Y	Y
Relatively adequate off-farm employment opportunities	Y	Y	Y	N
High incidence of poverty	Y	Y	Y	Y

Note: Y indicates yes and N indicates no.

The policy issues emerging from the SWOT analysis are summarized in Table 3.8.2 along with possible actions to improve agricultural productivity and to ultimately reduce poverty. The issues are categorized into the following groups:

- Land/Natural Resources
- Agricultural inputs/cultural practices
- Livestock
- Irrigation
- Socio-economic

In case of land and natural resources, the main issues emerged were small and fragmented landholdings, issues related to soil fertility, drainage, waterlogging, salinity and rainfall. The possible solution of these problems would be through the enactment of law prohibiting the subdivision of land after a certain level, better O&M of the irrigation systems, construction of drainage system in poorly drained soils and water harvesting during monsoon season. In agricultural inputs and cultural practices, the main issues included the use of impure seeds, unavailability of fertilizers, lack of pest management, labour problems, lack of use of various resource conservation technologies, unavailability of credit, poor infrastructure, problems of output marketing and low productivity of crops. The issues call for the provision of certified seeds to farmers, introduction of pest scouting and quality control standards for pesticides and fertilizers, promotion of local farm machinery suitable to local environment, promotion of various resource conservation technologies like laser leveling, zero tillage, bed and furrow methods of sowing, and direct sowing of rice, provision of agricultural inputs on credit, and establishment of machinery pools for the farmers. This could be made possible through introduction of Integrated Services Provision (ISP), in partnership with the private sector, where by all the agricultural inputs, equipment and services could be made available to the farmers under one roof. There were two major issues related to livestock sector, veterinary health and theft problems. By providing the veterinary facilities to livestock at the union council level and improving the law and order situation, these problems could be solved. The issues mainly concerning irrigation were improper O&M at the distributary level, unscheduled closures of distributaries, improper methods for irrigation application, non-availability of water at tail reaches of the system and unchecked use of underground water. All these issues call for a better O&M of the irrigation systems. Socio-economic issues included high illiteracy rate, unemployment, non-availability of health care facilities, non-existence of vocational institutes and high incidence of poverty. Higher investment in education sector, establishment of health care facilities and vocational institutes, establishment of industry through private sector and special targeted programs for the poor would help solve these problems.

Table 3.8.2. Policy issues and their possible solutions.

Issues	Policies/actions to be taken
Land/natural Resources	
Small and scattered landholdings	There is a need of land consolidation through enactment of law.
Land use (CI)	Increase of cropping intensity through provision of more surface supplies by the construction of new water reservoir and reducing the conveyance losses through better O&M of the secondary and tertiary water channel system.
Soil fertility	Land reclamation, improved irrigation methods.
Drainage	Construction of field drains in poorly drained areas.
Waterlogging & Salinity	Salinity management through introduction of improved irrigation methods (Physical chemical and biological).
Rainfall	Introduction of water management practices in low rainfall areas and rain harvesting improved during monsoon season.
Agricultural inputs/cultural practices	
Impure seeds	Implementation of seed certification standards and provision of certified seed to farm households.
Fertilizers	Proper implementation of quality control and anti-hoarding laws.
Pest management	Introduction of pest scouting and proper implementation of quality control standards.
Farm machinery	Promotion of local farm machinery manufacturing industry through certain incentives.
Labor	Establishment of agro-based industry according to the availability of raw materials to absorb the local labor force. Investment on human capital to provide new skills to the existing labor force.
Use of RCT	Demonstration of RCT for its promotion.
Improved sowing methods	Extension Department has a vital role in the promotion of improved sowing methods i.e. sowing of wheat and cotton on beds and sowing of wheat by zero tillage after rice crop.
Agricultural credit availability	Simplifying the lending procedure. Provision of agricultural inputs on credit through integrated services provision program.
Low crop productivity	Establishment of machinery pools, provision of inputs on credit, ensuring the output prices, controling water theft, purity of inputs.
Road infrastructure	Construction of farm to market roads
Procurement	Persons involved in the corruption at procurement centers should be dealt with iron hands.
Process / procedures	Implementation of laws for the immediate payment for sugarcane crop by sugar mills.
Storage facilities	Encouragement the private sector to come forward for the construction of storage facilities
Livestock	
Animal healthcare	There is a need to provide veterinary health facilities at Union council level.
Animal theft	Improvement of the law and order situation in the irrigated area.
Rearing of animals	Provision of credit and the development of the marketing system.
Irrigation	
Irrigation management	1. Better O & M of the existing irrigation system 2. Rehabilitation of the irrigation infrastructure 3. Imposition of heavy fine and punishment for water theft cases
Irrigation application methods	Involvement of the Extension Department in the demonstration of efficient methods of water application at field level.
Unavailability of water at tail	Improvement of the system for equitable distribution of water.
Groundwater	Regulation for the underground water usage. Provision of continuous supply of canal water in the brackish groundwater areas.
Socio-economic	
Literacy rate	High investment in education sector, especially in the primary sector.
Unemployment	Establishment of industries and training centers
Healthcare facilities	Provision of healthcare centers and provision of medicines for the poor
Vocational institutes	Establishment of vocational institutions for producing skilled manpower
High incidence of poverty	Skill development programs, unemployment benefits for target groups, establishment of industry, vocational education provision

9. SUMMARY, CONCLUSIONS AND THE WAY FORWARD

The Government of Pakistan in the past has made attempts to improve the productivity of irrigated areas through different development programs. The past development efforts were focused on increasing the agricultural productivity to enhance food security. In this respect, various studies evaluated the performance of those programs in irrigated areas but the research efforts have never gone much beyond technical and physical aspects of those schemes. Very little information is available as to how those schemes have affected the economic, financial, institutional, and governance issues in the project areas and how those schemes have impacted poverty in the low-productivity irrigated areas of the country. The agricultural sector in the country is now facing the challenges of increasing food demand under looming water scarcity. It is becoming increasingly difficult to expand irrigated areas, as most accessible water resources have already been exploited. As the single most dominant user of available water resources, irrigated agriculture in Pakistan is facing increasing pressure to produce more food with less water through significant improvements in water use efficiency at the farm and system levels. Low-productivity irrigated areas, in particular, are in stress, as resource-poor farmers in such areas are most vulnerable to water shortages, while there is also a significant need to enhance food production to ensure food security for the growing population.

The latest poverty situation in the irrigated agriculture areas of Pakistan paints a very gloomy picture. According to the Government of Pakistan (2002), the incidence of poverty is higher in rural areas (32 percent) when compared with urban areas (19 percent). The poor generally have access to areas that have high percentage of poor quality lands and scarcity of irrigation water. Pakistan’s agriculture depends solely on irrigation. In the Indus irrigation system, waters flow from rivers to farm gate, through a complex irrigation network. There exists inequity in the distribution of water at all levels of the systems.

The present study was conducted across canal command areas of the Upper Chaj Doab (comprising Gujrat and Mandi Bahauddin Districts) irrigated by Upper Jehlum Canal (UJC), Lower Chaj Doab (comprising Sargodha District) irrigated by Lower Jehlum Canal (LJC), Rechna Doab (comprising Jhang and Toba Tek Singh Districts) irrigated by the Lower Chenab Canal (LCC) East and tail part of the Hakra irrigation system (comprising Bahawalnagar District) irrigated by the Hakra canal system. The total geographic area of the Chaj Doab, Rechna Doab and Hakra area is reported to be 1.2 Mha, 2.98 Mha and 20,000 ha, respectively.

In part 1, agricultural requirements and potential production were discussed along with irrigation interventions, which took place in the form of various programs. The objectives and scope of the study were presented at the end of the chapter. The study had three major objectives. The first was to analyze the impacts of current policies and institutional frameworks along with the impacts of underlying physical and socio-economic conditions including the assessment of opportunities and constraints for improving productivity in the sample areas through improved access to irrigation water. The second objective was to identify and evaluate the range of potential pro-poor economic, financial, institutional, governance, and technical interventions at various levels against a set of criteria under which such interventions could most effectively address poverty reduction in the study areas; and the last objective was to formulate a set of appropriate interventions, policy measures and institutional frameworks, including adequate support systems, which could ensure large-scale uptake, replicability, and higher impacts within and between different irrigated command areas of the country.

The study focused on testing the following specific research hypotheses:

H^o_1 Command areas of specific canal reaches receiving less irrigation water per hectare have lower productivity and a higher incidence of poverty;

H^o_2 Under existing conditions, small, marginal and poor farmers receive fewer benefits from irrigation than large and non-poor farmers;

H^o_3 The greater the degree of O&M cost recovery, the better would be the performance of irrigation management;

H^o_4 Effective implementation of PIM/IMT leads to improved irrigation system performance which in turn reduces poverty; and

H^o_5 There is a scope for improving performance of irrigation systems under existing conditions, with effective and improved institutional arrangements.

The study addressed the following research questions explicitly:

1. What were the poverty situations across canal commands in the study areas?
2. Where were the poor people located along irrigation systems, and were there any geographic patterns of the poor within an irrigation system?
3. What were the poverty prevalence, depths, trends, main causes, and its relation with income/ asset distribution pattern, key issues, and strategies to reduce poverty (including those not related to irrigation)?
4. What were the benefits of surface irrigation for the poor and to what extent, including indirect benefits to small farmers and the landless?
5. What was the level of irrigation systems performance in the study area?
6. What were the major irrigation-related constraints on productivity?
7. What were the causes of unsatisfactory performance of the irrigation system?
8. To what extent was the poor irrigation system performance related to technical (farm water use, distribution pattern among canals or higher levels), institutional, economic/ financial and regulatory aspects of system management?

9. To what extent improved system performance benefited the poor and what were the opportunities to reduce poverty by improving performance of irrigation systems?

10. What were the impacts of irrigation-related institutions, laws, and policies on overall system performance, including impacts on productivity, and equity in access to irrigation water?

11. What were the various interventions and innovations, which had been adopted for improving irrigation systems performance and what was their effectiveness and implications for the poor?

12. Were there any measures to provide discretionary benefits to the poor while improving system performance?

13. What were the measures, which were undertaken to improve irrigation system performance while ensuring optimal benefits to the poor?

In part 2 various studies were reviewed relating to the estimation of poverty lines, inequality, absolute versus relative poverty, unemployment, different policies, social welfare programs, institutional reforms, gender, demographic factors, irrigation performance, irrigation management transfer, and their impact on poverty in Pakistan. The intention was to see the impact of various factors (reported in past studies) on poverty, both in rural as well as in the urban areas.

The study area and its characteristics were highlighted in part 3, section 2. It gave an account of methodology adopted for selecting the sample households along with the agricultural and socio-economic profile of the sample households across distributaries. Part 3, sections 3 and 4 provided the results regarding the spatial dimensions of poverty in selected irrigated areas and its determinants in the local setting.

The assessment of irrigation system performance was provided in part 3, section 5. This was completed to evaluate the impacts of irrigation systems performance on poverty in the sample areas. For this purpose; a number of different indicators were devised under the various criteria with respect to: (i) Productivity, equity and water supply (ii) sustainability (economic, environmental and infrastructure); and (iii) institutional and management. In order to find out the factors that affect the household expenditures and their relationships with the poverty, regression analyses were conducted. The determinants of poverty were statistically tested to critically separate the most important determinants. Logit modeling techniques were employed to test the null hypothesis that there was no significant differences in the incidence of poverty across head, middle and tail reach areas. From the estimated coefficients of the models, marginal effects of each independent variable were calculated. Various performance indicators have been built and used for the assessment of the efficiency of irrigation systems in the project areas. As performance is influenced by a number of factors, several performance indicators were employed to assess the absolute and relative performance of irrigation systems based on the productivity of the irrigation system, amount of water supplied, environmental impacts, O&M of the irrigation infrastructure, and institutional dimensions to improve the irrigation management in the systems.

In order to determine the effect of irrigation system performance on poverty, Logit modeling was also employed. Furthermore, instead of normal regression analyses, recursive-modeling technique was used. The Gross Value Product per hectare in thousand rupees was used as performance indicator across distributaries.

In order to enhance the crop productivity, the various constraints faced by the farmers during crop production were analyzed in part 3, section 6. These constraints vary spatially making it difficult to address the situation by single solution. The constraints to crop productivity faced by the sample farm households in the respective study areas were subdivided into five sub-groups related to water, inputs, marketing, technical and credit constraints. In order to evaluate the impact of different factors affecting the wheat productivity, various regression models were estimated with linear, log-linear, and double log forms. Based on the R^2 and other econometric criteria, the best model was selected to explain the variation in dependent variable caused by the explanatory variables.

In part 3, section 7, both software and hardware interventions, which took place in the irrigated areas of Pakistan were discussed. The first part of the chapter described the past interventions under took by the Government followed by the recent institutional intercession in the irrigation sector. Various other technological interventions and innovations are also discussed in this chapter.

In all the canal commands of the study areas, Participatory Rural Appraisals (PRA) were conducted. This exercise helped to understand and prioritize the community strengths weaknesses, opportunities and the threats (SWOT) related to irrigated-agriculture. The results of the SWOT analysis are presented in the part 3, section 8. The results discussed in the report are the combination of the responses from all the sample households, who participated in the PRAs and from whom the data were collected individually.

Conclusions

- By using poverty line-I, overall comparison of poverty incidence across different reaches of the distributaries revealed that on an average the lowest number of poor households resided in the middle reach of the distributaries while the highest head count poverty estimates were computed for households living in head reach of the distributaries for reasons of large family size, high dependency ratio and less off-farm employment opportunities in the sample area.

- The overall incidence of poverty at distributary level was estimated as 55, 58.9 and 62.9 percent, respectively for middle, tail and head reach areas. Higher incidence of poverty in the head reaches was due to high dependency ratio as compared with the middle and tail reach areas.

- By employing PL-II, it was found that overall incidence of poverty was the lowest (39.6 percent) at the middle reach while it was computed as 45 percent for both head and tail reach areas.

- The poverty gap across different reaches of the distributaries by employing PL-I shows that depth of poverty was higher at tail reaches (44.1 percent) which could be due to the prevalence of shortage of canal water, greater proportion of non-farmers and less off-farm employment opportunities in the area, while the lowest was prevailing in the middle reach areas (38.9 percent). However, there was significant variation among different distributaries at head, middle and tail reaches as seen from their respective overall estimates as a whole.

- Estimates of squared poverty gap indicated that the severity of poverty was minimum at middle reaches and maximum at the tail reach areas. Comparison of poverty gap by using PL-II revealed that the depth of poverty was highest (35.8 percent) at the tail reach while the lowest (29 percent) was prevailing at the middle reach areas. At the head reach, poor households required about 34 percent of additional expenditures to fill the poverty gap.

- The average family size of poor households was significantly higher (8.85) than non-poor households (6.49) when PL-I was used for analysis. Higher family size of the poor households resulted in a greater number of dependents (4.55 family members) when compared with to the non-poor households (having 2.91 dependent members).

- Educational level of the household head reflected the probability of better management of household affairs. It was found that in poor households, the average number of completed schooling years of the household head was 3.37 years when compared with 5.48 years for non-poor households. The decomposition of above results showed that 54.65 percent of the poor household heads were illiterate when compared with 38.38 percent of the non-poor households. More interestingly, about 14.95 percent of non-poor household heads completed more than 10 years of schooling when compared with 4.93 percent of poor household heads.

- Significantly, a higher percentage of non-poor households (47.68 percent) had the flush toilets within the household boundary when compared with 29.15 percent for the poor households. Overall, 67 percent of the poor households did not have any toilet facility within household boundary when compared with 44.85 percent of the non-poor households.

- Overall, it was found that in poor households, more than three persons were sharing a room while for non-poor households the corresponding estimate was around two persons per room. Overall, 19.19 percent of non-poor households were enjoying the luxury of one room per person when compared with only 1.13 percent of the poor households. On the other extreme, 48.73 percent of poor households were forced to share one room by more than 3 persons when compared with only 11.52 percent of the non-poor households.

- Significant differences were found regarding average farm size between poor and non-poor households. Non-poor farm households were cultivating an average farm size of 5.68 ha while corresponding estimate for poor households was 3.86 ha. Further decomposition indicated that 57.86 percent of the non-poor households were cultivating more than 3 ha of agricultural land when compared with 43.06 percent for the poor households. It was also estimated that only 8.98 percent of the non-poor households were cultivating less than 1 ha of agricultural land when compared with 12.45 percent for the poor households.

- The GVP of all crops, taken together was estimated as Rs. 24485 per ha for non-poor households while corresponding estimate for poor household was Rs. 19802 per ha because the poor households had to sell their produce at a lower price to the village shopkeepers from whom they had taken the consumption loans earlier.

- Lower cost of production for all crops was computed as Rs 13591 per ha for poor households when compared with Rs. 15107 per ha for non-poor households. This was due to higher use of family labor on farms owned by the poor households when compared with non-poor households.

- Results indicated that 71.3 percent of the non-poor household heads were engaged primarily in agriculture. Significantly higher proportion (10.42 percent) of poor household heads were working as agricultural worker/laborer.

- Non-poor households incurred higher expenditure on food items (Rs. 26467) when compared with Rs. 20229 for poor households. The poor households spent higher proportion of their incomes on food items than non-poor households. The poor households spent 48 percent of their total expenditure on food items when compared with 31 percent in the case of non-poor households.

- It was estimated that non-poor households incurred annual expenditure of Rs. 100057 when compared with the significantly lower amount of Rs 44553 in the case of poor households.

- Per capita annual expenses for non-poor households were almost three times that of poor households. Similarly, per capita expenditure incurred on food items by non-poor households were more than double what was incurred by poor households.

- An income Gini-coefficient of 0.58 was estimated for all the selected households. However, the expenditure Gini-coefficient was fairly less than the income Gini-coefficient with a value of 0.39 for all the selected households in the study areas indicating relatively less inequality in terms of expenditures than in income. Similarly, the estimate of land Gini-coefficient was calculated around 0.49.

- The results showed that an increase in family size and dependency ratio increased the probability of households to be poor.

- An increase in the land holding and productivity per hectare reduced the probability of households to be poor. Households at the tail reach areas were more prone to the risk of being poor when compared with the households at the head reach of the irrigation system. Tail reach areas could be characterized as low productivity areas, usually receiving less irrigation water per hectare and tagged with high incidence of poverty.

- It was also concluded that households with well-educated heads were less prone to the risk of being poor. This led to a policy implication that more investment on education was needed to improve the livelihood of the rural population.

- It was also found that large farmers were the main beneficiaries of the irrigation water than marginal and small farmers and their probability to be poor was significantly less than that of the households with small landholdings. A new round of land reconsolidation is required if land distribution is not possible to address the issue of rural poverty in Pakistan.

- It was concluded that distributaries with lower irrigation intensity were facing a higher degree of surface water scarcity and they were also facing the problem of poor quality groundwater. The irrigation system with relatively higher surface water availability and good quality groundwater experienced higher cropping intensity, but the cost of groundwater extracting inversely affected the cropping intensity.

- It was also found that the irrigation systems (with the share of groundwater in total irrigation water was lower) was having higher productivity on per hectare basis.

- A higher head-tail equity ratio in output per hectare was experienced in irrigation systems where groundwater quality was very poor with higher inequities in surface water supplies. However, cropping pattern and management skills also played a critical role when other factors remained constant.

- The relative irrigation water supply with respect to diverted water was found higher where groundwater quality was good for irrigation purposes.

- The important constraints on productivity of crops were found to be water related, according to the 37.09 percent of the farmers. The main reason was the shortage of surface water supplies due to a variety of reasons.

- Next to water, inputs related constraints like non-availability, high cost, and adulteration were the important ones as it was reported by 36.68 percent of the farmers. Around 26.23 percent of the farmers indicated various technical, marketing, and credit related constraints that limit the farmer’s ability to tap the potential of high productivity.

- Land preparation, irrigation, fertilizers and weedicides showed positive relationship with yield. The proper and efficient use of these inputs would lead to rise in productivity. The results of regression analysis showed that increased size of landholding and improvement in the quality of management through increased education level would lead to rise in crop productivity. Improved access to surface water irrigation and better quality groundwater would help in increasing the crop productivity. The use of fertilizer needs to be improved as required, keeping land fertility in view. This could help in boosting crop productivity in all areas.

- In the past, both hardware and software interventions took place in the irrigated areas of Pakistan. These interventions were having varying degrees of impact on the farmers.

- The SCARPs programs were thought to be beneficial in eliminating water logging, controlling salinity and for providing additional irrigation water to increase cropping intensities and yield. The program was found neutral to scale in nature. In the future, if any intervention is required it should be either neutral to scale or pro-poor.

- The FAO, under its food security program, provided a package of inputs, credit, machinery and extension services in LJC command area. The results showed that the productivity of wheat increased significantly on those farms, which benefited from the program when compared with those farms that were away from the project area.

- The policies, issues emerged from the SWOT analysis involved small and fragmented land holdings, soil fertility, drainage, waterlogging, salinity and rainfall. The possible solution for these issues were reported to be the enactment of law, prohibiting the subdivision of land beyond a certain economic threshold level, better O&M of the irrigation systems, construction of drainage system in poorly drained soils and water harvesting during the monsoon season.

- With respect to the agricultural inputs and cultural practices, the main issues were reported to be the use of impure seeds, non-availability of fertilizers at the proper time, improper pest management, labour shortages, non-use of various resource conservation technologies non-availability of credit, poor infrastructure, problems of output marketing and low productivity of crops. The possible solution to these issues could be the availability of certified seed to farmers, introduction of pest scouting and quality control standards for pesticides and fertilizers, promotion of local farm machinery which suits local environment, use of various resource conservation technologies like laser leveling, zero tillage, bed and furrow methods of sowing, and direct sowing of rice, provision of agricultural inputs on credit and the establishment of machinery pools for the farmers under one roof through the provision of Integrated Services Provision (ISP).

- There were two major issues related to livestock sector i.e. animal health and theft of livestock. By providing the veterinary health facilities to livestock at union council level and improving the law and order situation in the irrigated areas, these problems could be solved.

- The issues mainly concerned with irrigation included, improper O&M unscheduled closures of distributaries, poor methods of irrigation application, non-availability of water at tail reaches of the system and over-exploitation of underground water. All these issues called for the better O&M of the irrigation systems.

- The socio-economic issues reported were high illiteracy rate, unemployment, non-availability of human health care facilities, non-existence of vocational institutes and high incidence of poverty in the sample areas.

- High investment in education sector, establishment of human health care facilities and vocational institutes were recommended by the participants. They further asked to encourage the private sector for the establishment of industry and special targeted programs for the poor in irrigated areas, which could be helpful to reduce poverty in those areas.

Area of Future Research

Future research in the sample areas should address the following issues:

1. There is a need for conducting a comprehensive study to evaluate the potential pro-poor interventions that could be helpful in increasing the agricultural productivity in other low productivity irrigated areas.

2. The Integrated Services Provision (ISP) approach needs to be evaluated in detail. A comprehensive research needs to be undertaken on pilot basis in selected irrigated areas.

3. In the case of institutional reforms for Irrigation Management Transfer, a model could be tested having major participation from small and medium landholders from the middle and tail reaches of the system with strong statuary backup from the government.

4. The adoption of Resource Conservation Technologies (RCTs) could be expanded as a tool for alleviating poverty and needs to be evaluated in various agro-ecological zones of irrigated areas.

5. The relationship between diversification and poverty reduction needs to be studied carefully in various agro-ecological regions.

6. Studies need to be started in order to evaluate the impact of poor quality ground water on agriculture after its treatment in brackish water zones.

7. Studies need to be conducted on the socio-economic and environmental impacts of re-using municipal wastewater in peri-urban agriculture.

8. Studies need to be undertaken on water rights related to the post IMT issues with special reference to the poor.

9. The factors governing the informal water markets in irrigated areas need to be studied and its impact on poverty needs to be evaluated.

REPORT ON NATIONAL WORKSHOP

Pro-Poor Intervention Strategies in Irrigated Agriculture in Pakistan
(23-24 April, 2003, Islamabad)

The final national workshop of the ADB project entitled “Pro-poor intervention strategies in irrigated agriculture” was held in Holiday Inn hotel Islamabad, on 23-24 April 2003. The objectives of the workshop were to share the findings of the study with the stakeholders, policy makers and researchers currently working in the poverty area in Pakistan. There were four 4 technical sessions along with the inaugural session held during the workshop. In total, 12 papers and 4 keynotes were presented in the 4 technical sessions. This brief report sheds light on the deliberations and recommendations of the workshop.

In the inaugural session Dr. Asad Sarwar Qureshi, Acting Regional Director, IWMI-Pakistan, welcomed the participants. In his welcome address he said that the major aim of the two-day workshop was to share the results of the pro-poor project that IWMI had conducted in six Asian countries over the last two years. He added that the presentations would focus on different aspects of irrigated agriculture and their role in securing food for the rural poor living in these countries. He said that the findings of studies under this project are very timely and of extreme value because many countries in this region are developing plans, frameworks of actions and policies for alleviating poverty and improving livelihoods of the poor. He thanked the delegates for sparing their valuable time to participate in the workshop, despite of their heavy official engagements.

After the welcome address, Dr. Intizar Hussain, Senior Economist, IWMI, introduced the Pro-poor project. He said that the overall goal of the project was to promote and catalyze equitable economic growth in rural areas through pro-poor interventions in irrigated agriculture in participating developing countries. He mentioned that the specific objectives of the project were to determine realistic options to improve the returns to poor farmers in the low productivity irrigated areas within the context of improving the overall performance and sustainability of the established irrigation systems. He elaborated the project details and presented the project components, data collection procedures adopted and project hypotheses that were tested in the study. He explained that the current research project was different from the other previous similar projects. He said that in the current project the research was largely based on primary data, which were collected through in-depth fieldwork and that they revealed the ‘ground realities’. Also, he added that the implementation of the current project took place through a strong collaboration among national and international researchers in IWMI and development organizations in six countries. And most importantly, he said, “The output is timely and useful for new water policies and reform agendas in developing countries”.

Later on the Country Director, Asian Development Bank (ADB), Mr. Marshuk Ali Shah addressed the participants. In his address, he highlighted the role of ADB in the development of various sectors of economy, especially in the development of agricultural sector in Pakistan. He mentioned that during 1990s, ADB increased its lending in agricultural sector to supplement agricultural productivity, promoting market-oriented policy reforms, strengthening the institutional framework, and developing resource scarce areas of Pakistan. He added that in December 2001, under “Agriculture Sector Program Loan II”, ADB extended an amount of $350 million to Pakistan in order to focus on promoting efficient markets for main commodities for providing market based incentives to farmers, liberalizing markets for seed and fertilizer, and strengthening of small farmers support services with an underlying emphasis on targeting the welfare of the poor strata of society. Additionally he said that the Swabi Salinity Control and Reclamation Project (SCARP) and Pehur High Level Canal (PHLC) also helped the country in improving irrigation infrastructure to provide additional water and drainage with ADB's assistance. He further added that ADB took rural finance initiative to set up an accessible, affordable, and sustainable system focusing on the poor who would be benefiting from augmented economic opportunities for increasing income and employment.

The Chief Guest, Mr. Sikandar Hayat Bosan (State Minister for Agriculture, Government of Pakistan), in his inaugural address stressed the need to improve agricultural growth for meeting the food and fiber requirements of the growing population. He highlighted the importance of water in agriculture, which is becoming increasingly scarce with escalating competition across various sectors of economy. He emphasized the need for the vertical growth of the agriculture sector. According to official statistics, he said, about 28 percent of the country's population is currently living below poverty line with high proportion of rural population (32 percent) lying in poverty trap. He pointed out that poverty is a complex and multi-dimension phenomenon, which not only inhibits access of the poor to valuable resources of production but also restricts possible opportunities to improve the social, economic and political opportunities as well. He expressed his concern on volatility of agriculture, which left little room for the poor to get rid of this problem. He also congratulated IWMI for taking lead in such an important issue as how productivity enhancement through irrigation could be used for alleviating poverty. He further added that experiences of other nations in this regard would be useful in devising solutions for meeting the objective of poverty reduction. He hoped that the participants of the workshop would come up with solid pro-poor recommendations, which would help in reducing poverty and improving the lives of the forgotten and miserable segment of society by showing a new dawn of life, relief and satisfaction.

Finally in the inaugural session Dr. Waqar Jehangir (Senior Agricultural Economist-IWMI) thanked the honorable Minister, ADB's representative, researcher, policy makers, and delegates from different organizations for making the workshop valuable with their presence. He accentuated the need to focus on poverty in rural areas, as two-thirds of Pakistan's population is concentrated in rural areas of the country. He said that improving the living standards of rural population simply means a significant contribution towards uplifting of country's overall welfare level. He expected that the workshop would lead to evolve recommendations for policy makers as well as for researchers for future endeavors and would also provide useful insights to donors for refocusing their efforts to address the poverty problem at grassroots level that would have significant bearing on the overall poverty situation especially in rural areas, and more generally, in the country as a whole. He also thanked the Ministry of Food, Agriculture and Livestock, Pakistan Agriculture Research Council, and the Ministry of Planning for taking active part in the workshop.

TECHNICAL SESSION I: IRRIGATION AND POVERTY LINKAGES

Dr. Zafar Altaf was the Keynote Speaker for the first technical session. He said that the current policies regarding poverty and poverty alleviation are contradictory. In Pakistan, he said, 68 million people are in absolute poverty. He called upon to initiate the policies for the future so that the poor may get some relief. He suggested that the researchers and stakeholders should design interventions for the target poor population and asked to look for policies and programs for the many rather than the few. He said that change would not take place without discipline and wisdom in our research activities at national level. He also called upon to provide 'Free Market' to farmers. Elaborating at this point he said that Mafia has perverted this concept to its own monetary gains. Also, there is need to explore the competitive markets and comparative advantages where the poor farmers can be benefited. He said that development might not be possible in a neutral environment, policies need to be pro-poor to help the poor. Finally he asserted that care for the poor and the disadvantaged needs to be built into the policies.

Dr. Intizar Hussain took the floor and spoke on the linkages between agricultural water, food security and poverty and the lessons learnt so far in this regard. He put forward that at global level, there is an abundance of food, even at the national level food availability is no longer a major problem in most developing countries. He said that the real challenge on the front of food security is how to improve access and equity in food distribution so that the poor be benefited. He pointed out that majority of the poor earning/consuming less than 1 US$ a day live in South Asian and Sub-Saharan African countries. He synthesized the study results that poverty is higher in rural areas, particularly in those households that are resource poor. Also, non-farm households are experiencing high poverty than farm households. Additionally, high inequity in land and water distribution, poor education level of the members of households that offer much of unskilled labor, more dependents and few earners contribute towards the household's poverty. He said that though poverty varied spatially and temporally, in rural settings, irrigation water is the single powerful element that plays a very important role in ascertaining and lowering the incidence and severity of poverty.

Dr. Hussain further said that agricultural water sector investments are not always pro-poor. The direct impact of these investments depends on equity in land distribution, infrastructure condition/management, water allocation/distribution policies, procedures and practices, production technology, cropping patterns, crop diversification, and support measures (input output marketing, information, etc). Enhancing productivity of irrigated areas was shown as one of the key factors that would reduce poverty in rural areas of Pakistan. In order to enhance productivity, he pointed out various constraints such as poor access to machinery, new technology, poor quality seeds, adulterated inputs, high input prices, and low output prices, faced by the farmers be done away with. He proposed the pro-poor idea of Integrated Services Provision (ISP) that would ensure not only the availability of inputs including farm machinery but also the maintenance of high standards of quality and timely availability of inputs with an emphasis on poor households. Coupled with the availability of inputs, ISP would also be providing and disseminating the latest research based information and credit to poor households under a single roof. Additionally, it would also help farmers in marketing their excess output in the market at highly competitive prices localy, and later, in world markets. He said that the crux of ISP is that it would be run by private enterprises and strongly backed up by governmental regulations. He emphasized that this would prove the one last hit for breaking the cocoon of low agricultural productivity trap and would certainly improve the productivity and poverty situation even in the short run.

Dr. Waqar Jehangir presented the pro-poor study results focusing on spatial dimensions of poverty across canal commands in Punjab, Pakistan. His analysis was based upon the FGT measures of poverty. By comparing four different irrigation systems in Punjab, it has been found that poverty prevails in the entire province. The incidence of poverty increased from upper Indus basin to lower Indus basin. It was also found that incidence of poverty was higher in the tail reach areas of the irrigation systems whereas the difference between head and middle reaches was not found significant. He concluded that indicative patterns in poverty across different reaches of the irrigation systems do exist. One of the interesting findings of the study was that larger the irrigation system, clearer was the patterns regarding the incidence of poverty in the tail reach area. It clearly implied that size of the irrigation system does matter when comparing various irrigation systems for poverty. He shared another important finding that the incidence of poverty was higher in areas where surface water supplies were short and groundwater quality was poorer. His analysis indicated that estimates of poverty were quite sensitive to the selection of poverty line used for poverty analysis.

The analysis was further extended in the presentation of Dr. Muhammad Ashfaq who focused on "Determinants of poverty in canal commands of Punjab, Pakistan". In explaining the determinants of poverty he elucidated that poor households in the project sample areas could be characterized as households with small agricultural landholdings, less productivity, larger family size, high dependency ratio, and low education level. Poor households also indicated availability of less room space per person and relatively low level of sanitation facilities when compared with non-poor households. He said that poor households had significantly low crop and non-farm income. According to his analysis, non-poor households exhibited strong linkages with family members abroad, which was duly reflected as higher remittances received by them when compared with poor households. He mentioned that wide inequity in land distribution was prevailing in the study area. Around 75 percent of the population was operating only 40 percent of the agricultural landholding while 80 percent of the rural households owned only 40 percent of the agricultural land. Dr. Ashfaq revealed that the coefficient of inequality (Gini) for income distribution in the sample areas showed even more inequity in income distribution (0.58) when compared with land distribution (0.49). He showed that probability of households to be poor depends upon the size of operational landholding, dependency ratio, family size, education level of the head of a household, and agricultural performance/productivity (GVP per hectare). He also said that incidence of poverty was found higher; in tail reach areas, among households with small landholdings and in areas where groundwater quality was poorer.

TECHNICAL SESSION II: IRRIGATION SYSTEM PERFORMANCE AND POVERTY

In his keynote speech, Mr. Mushtaq A. Gill (Director General, Agriculture-Water Management, Punjab) expressed the need for making improvements in farm level water management for combating poverty. He showed concerns on slow growth in agricultural productivity in rice-wheat systems that might have resulted from the degradation of the resource base. Due to increasing canal water scarcity and increasing demand, it would become very difficult to sustain the current water usage in agriculture on a sustainable basis. Historically, the per capita cultivated land and canal water availability has decreased significantly in Pakistan. He proposed resource conservation agriculture as an option for poverty alleviation but this required further development of resource conservation technologies (RCT). He stressed the need to spread RCTs effectively so that the poor may also be benefited to the maximum extent. He proposed a package for this purpose, which includes watercourse improvement, use of laser land leveling technique, and zero tillage technology for increasing productivity and efficiency of the country's agriculture. He also pointed out that various socio-economic and environmental issues are required to be carefully analyzed and a rapid and effective development of various cost effective alternatives for increasing the efficacy of resource conservation technologies is needed. In fact, he proposed the route to poverty alleviation through efficient and highly productive agriculture.

Dr. Muhammad Ashfaq in this session presented the linkages between the performance of irrigation systems and its impact on poverty. He analyzed and compared various selected irrigation systems on the basis of hydrological, agricultural, social, financial, and economic parameters. On the basis of these, he stated that performance varied considerably across various canal commands. It was also found that increased canal water availability had direct linkage with the increase in cropping intensity in addition to good quality groundwater. According to him, wide variations in productivity across various irrigation systems indicate much of untapped potential for increasing the vertical growth of agriculture. He also articulated that the system under the Irrigation Management Transfer (IMT) showed less head-tail inequity in canal water availability and agricultural productivity. Moreover, high inequity in productivity and agricultural income was experienced in areas with relatively low canal water availability and poorer quality of groundwater. He favored Irrigation Management Transfer (IMT)/ Participatory Irrigation Management (PIM) as an option for better financial management of the irrigation systems.

The IMT/PIM (case study of Hakra 4-R Distributary) option for improving management and performance of the irrigation system was explained by the next presenter, Mr. Muhammad Mudasser. He pointed out that the problems of inequity and unreliability of canal water availability, financial burden on government exchequer, and poor performance of the Irrigation Department were the prime reasons for involving communities under PIM/IMT. In order to evaluate the impact of IMT, performance was assessed with respect to canal water availability, equity and reliability, along with financial performance and dispute resolutions. Mr. Mudasser said that the majority of farmers had expressed their satisfaction on FO working at Hakra 4-R Distributary. He elaborated that the discharge data at the distributary head supported the finding that after IMT, water supply was more reliable and equitable. Moreover, the events of water theft had greatly reduced. FO also benefited farmers with dispute resolution in minimum time. The overall abiana assessment and collection was increased and O&M financing gap was bridged successfully after IMT. He concluded that IMT/PIM could be much more beneficial if it continues with the pro-poor motive.

Dr. Asrar-ul-Haq Additional Secretary (technical) PID presented his paper on "Pro-poor irrigation management and interventions in Punjab - issues and options". He said that research has shown that water would be scarce by 2025 and population in arid and semi-arid regions would face major problems. He said that health and quality of life would face major challenges in coming years and the majority of the poor were expected to be vulnerable due to its scarcity, pollution and drought. According to him, high inequity in water distribution was the main reason for low productivity, and ultimately, that was the reason for high incidence of poverty. He enumerated the major factors contributing to water crisis as poor understanding of requirements for sustainable water management, failure to put in place the enabling framework and institutions, and scientific, educational, institutional, managerial, and socio-political gaps in local capacities. He stressed that the investments and effective institutional development at all levels of water management is a key initiative for the distribution of irrigation related benefits to the poor. He mentioned various strategic interventions/policies that are needed in various phases of implementation for sustainable water management in Punjab province such as institutional reforms, canal water operation planning for equitable distribution, etc. aiming to benefit all the stakeholders, especially the poor segment of the population.

TECHNICAL SESSION III: APPROACHES TO POVERTY ALLEVIATION

In his keynote address, Dr. Khalid Mahmood, Vice Chancellor, Arid Agriculture University, Rawalpindi, made a presentation on various determinants of poverty. He said that poverty is a complex phenomenon and its main causes are inequity in distribution of resources, social/ geographical isolation, lack of access to services, inadequate access to health, education, sanitation, drinking water, and poor governance. He indicated many general and specific characteristics of poverty such as demographic, economic, and social. He stressed that in order to get rid of poverty trap, faster growth of capital than labor, efficient use of capital, free trade, and increased equity in income distribution are the necessary conditions. Also, he mentioned that the increased agricultural productivity is of prime concern, but for poverty alleviation, policies and reforms targeting farm size, incentives for farm and non-farm enterprises, better marketing opportunities, improved information and extension services, and increase in credit facilities are pre-requisites under current agricultural settings. These policies must also be strengthened through better distribution of income to all and enhancing the mainstream gender inequality.

Dr. Mushtaq Khan, Chief, Center for Research on Poverty Reduction and Income Distribution (CPRID) was the next speaker and he highlighted the poverty trends in 1990s as well as the poverty reduction strategy for Pakistan, which is currently being followed by the Government of Pakistan. He said that South Asia comprises about 23 percent of the world population and around 44 percent of the world's poor reside in this region. According to him the incidence of poverty has increased in South Asia from 39 percent in 1990 to around 44 percent in 1998. He highlighted that on the basis of food-poverty approach, it has been found that in the last 15 years, incidence of poverty showed an increasing trend in rural areas of Punjab. Additionally, the rural poor and the female section of the population was characterized with the lowest literacy rate in Pakistan. He presented Poverty Reduction Strategy (PRS) of the Government of Pakistan, which clearly identifies poverty as the lack of essential physical and social assets and stresses that the poor need to be either provided or enabled to acquire such assets for livelihoods under this strategy. He further said that PRS is composed of economic reforms, physical and social asset creation for the poor, social safety nets and governance components. He said that the main emphasis of the strategy is on equitable income growth and complementary social development. According to him, the PRS seeks reduction in income poverty and inequality, improvement in education levels and provision of better health services for the poor, elimination of social exclusion and gender discrimination, involvement of marginalized groups in decision-making process, and provision of good governance.

Mr. Moiz Ali, Senior Management Executive, Pakistan Poverty Alleviation fund (PPAF) presented the paper of Mr. Kamal Hayat Chief Executive Officer, PPAF. In his presentation "Knowledge, Approaches and Practices in Poverty Alleviation" he expressed that communities are very well aware of the circumstances and conditions that entrap them in the poverty net and they are eager to find means and methods to break it. He expressed that it has been found that common perception was not limited to income and consumption poverty but communities considered other social, economic and environmental problems as a part of poverty. According to him, there seems to be no significant difference between the community and organization's perception of poverty. It was learnt that poverty targeting depended on the perception of poverty in the local context, methodology adopted to define poverty and to identify the poor, choices between organizational sustainability and poverty targeting, and the intervention modus operandi and the terms and conditions of participation and participation cost. It was also mentioned that greater coordination and synergy among the organizational elements would help to enhance performance and reduce cost of operations which might in turn lead towards sustainability within a reasonable period of time.

Mr. Munawar Hussain, Water Management Specialist, On Farm Water Management Department, was the next speaker who focused on “Poverty among farming communities in marginal areas of Punjab”. He showed that he estimated a 76.50 percent incidence of poverty on the basis of income in marginal areas of Punjab, Pakistan, which constitutes around 10.82 million hectares of area. He had also observed that poverty was sensitive to change in poverty line. It was found that family size, dependency ratio, education of household head, net landholding, and non-crop income were the main determinants of rural poverty in marginal areas of Punjab, Pakistan.

Dr. Abid Suleri, Researcher from Sustainable Development Policy Institute (SDPI) highlighted the other aspect of poverty alleviation in his presentation “Forest Policies for Sustainable Development and Poverty Alleviation in Pakistan: Issues and Options” with special reference to northern province, NWFP, of Pakistan. He recognized social, economic, environmental, and institutional stability as the four pillars of sustainable development. He stated that policies and institutions taken together determine people’s access and distribution of various productive assets, environment for private sector investment, involvement in decision-making processes, and rights of individuals and civil society. He stated that forest resources directly contribute to 90 percent of the poor living in extreme poverty for their livelihoods and indirectly for maintaining the healthy environment. According to him, NWFP contains around 40 percent of the natural forest of Pakistan with overall incidence of poverty about 44.3 percent. He said that various forest policies implemented had actually proved detrimental to forestry and poor population. This has resulted in the adoption of short-term survival strategies and unsustainable natural resource management for earning livelihoods by the poor segment of society. He concluded that people without any hope for the future have little incentives to mange natural resources well on sustainable basis. He stressed the need to focus on complementarities between conservation and development for the sustainable and securable livelihoods for the poor. His main message was that *Good laws and policies are useless without political and administrative will to change*. He said that otherwise the poor would remain mired in poverty which would push them into a spiral of over exploitation in the wake of all policy failures”.

TECHNICAL SESSION IV: PRO-POOR INTERVENTIONS IN IRRIGATED AGRICULTURE

The Keynote Speaker of the fourth and the last technical session was Dr. Zakir Hussain, Chairman, Department of Agricultural Economics, University of Agriculture, Faisalabad (UAF). He spoke on the issue of poverty and food security. He was of the view that poverty is the principal cause of food insecurity, though other factors also affect it. His analysis revealed that land and water productivity and head-tail inequity in irrigation water availability in Indus basin increased from head to tail reach areas. Soil salinity was also found increasing from head to tail reach areas. He stressed that poverty reduction strategy (PRS) needs to be focused and must address three main issues namely water, credit, and roads. Though priority varies across different provinces of Pakistan, however, he said, except Balochistan where lack of access to road is the main problem, water issues are at the top of the list. He said that it was the need of the time to respond to the needs of growing population for food, health and energy by adopting new water cultures based on caring, sparing and sharing basis. Additionally, he mentioned that setting up real sense of eco-citizenship by fostering thrift and public spiritedness is indispensable. He mentioned irrigation system's supply based nature, high inequities in water distribution, poor operation and maintenance, high system losses, slow development process, and lack of water conservation and application techniques as major obstacles that needed to be addressed. In the end, he proposed strategies and actions that are immediately needed to improve the current imbalances.

Dr. Muhammad Aslam Khan, Chief, Planning Commission, Government of Pakistan, was the next speaker who threw light on rural development and poverty nexus. He said that in the recent years, a rise in the incidence of poverty is observed in Pakistan, which according to him is mounting in rural areas. He presented a ladder for poverty reduction that accounts for assets, employment, income transfer, education, and family support in order of priority, which would lead the household out of the perpetual circle of poverty. He also drew attention towards the decreasing trend of development expenditures when compared with non-development expenditures in Pakistan, which need to be altered. He also highlighted the current land distribution in rural settings, which showed a high level of inequity. He explained the rural development strategy of the Government of Pakistan and mentioned various programs that were started with pro-poor emphasis. He concluded that intensification of crop production, crop diversification, development of non-crop agriculture, proper evaluation and monitoring system, availability of inputs and credit, empowerment of the target groups (for decision making), and partnership with public/private civil society/donors as necessary ingredients for the development of the poor stratum of society.

Dr. Mahboob Elahi, Joint Chief Economist, Planning and Development (P&D) Department, Government of Punjab, gave a presentation on poverty issues and policies for its alleviation. He focused mainly on the temporal impact of international prices on the domestic prices. He mentioned that despite Government's sectoral support and growth-oriented policies, poverty in rural areas has aggravated. He said the quantum of production in agricultural and non-agricultural sectors needs adjustment to ensure a rise in real factor income to improve general welfare. Due to heavy reliance on the export of traditional commodities, real prices/wages have declined and led to increase in poverty. A shift over to the production of fruits, vegetables, beef, mutton, etc (non-traditional commodities) would help in raising labor wages and smootheing the seasonal nature of employment in the rural areas. Additionally, he mentioned that migration of rural population would be checked for freeing the urban markets that would help in raising the level of urban wages.

Dr. Asad Qureshi, Acting Regional Director, IWMI Pakistan, focused on four problems i.e. differentiation between poverty and well being, estimating poverty line, ensuring food security, and the role of irrigated agriculture in ensuring food security in his presentation on "Targeting Food Security-Reducing Poverty through Irrigated Agriculture". He expressed the worst kind of poverty is when people do not have access to food and water to fulfill their basic physical needs. He defined wellbeing as peace of mind, good health, safety, freedom of choice and action, dependable livelihood and a steady source of income and above all - enough food. He also drew attention towards various poverty lines used by different researchers that has led to different estimates, which was confounding. He described that irrigated agriculture brought a range of potential benefits at national and regional level that helped in saving foreign exchange through reducing imports, and decreasing food prices through increased production. This ultimately helped in increasing household income and generating additional employment. However, still the productivity is low in Pakistan mainly due to different versions of water constraints. He proposed that by using water conservation and water-efficient technologies, productivity could be enhanced. Moreover, overcoming the problem of soil salinity, maintaining salt balance through better water management by improving equity and reliability of irrigation systems, and by cost effective and wise use of conjunctive water sustainable, productive, and pro-poor agriculture can be founded. More emphasis was suggested on food distribution for increasing access to the poor.

Miss Virginia Apple was the next speaker. She described Karez system in the Balochistan Province as Pro-poor water harvesting system in drought prone areas. She stated that in 1996-97, Karez irrigation was around 9 percent of the all irrigated land in Balouchistan, which is an economically low and socially underdeveloped area. Enough water in Karez ensured that communities would be able to get enough food and good health. Otherwise, hunger, loss of livelihoods and animal herds, sickness, and death become the fate of the poor. She said that the sustainability of Karez system is indispensable for the communities but unfortunately, drought and heavy pumping of ground water significantly brought down the groundwater level threatening the existence of this system. She explained that drought had significant economic and social impact on the poor adding up more in the pile of their miseries. Keeping in view of the current drought experiences she mentioned that skilful integration of social, scientific and technological research and action; effective liaison between civil society and the government; and 'Political will', the commitment of economic and managerial resources, and good governance, must be very much integrated for effective response to any future drought period.

The session IV ended with group formation and explanation of TOR by Dr. Intizar Hussain. Two groups were formed and each group selected a chairperson and a rapporteur from among themselves. The groups were asked to identify during the discussions any messages that have been left. Also, they were requested to point out and elaborate on other interventions and actions that they would like to propose. In the end of the discussion, the members would prioritize the proposed actions. The discussion groups were given one hour for discussions and the recommendations of the discussions were presented in the closing session of the workshop.

CLOSING SESSION

The closing session of the workshop was chaired by Dr. Badruddin Soomro, Chairman, PARC. The workshop ended with specific policy recommendations forwarded to the government to take decisions for creating enabling environment for the promotion of these strategies for the general welfare of our farming community.

The rapporteurs of the two discussion groups presented the recommendations upon which the Pro-poor workshop delegates agreed. Following is the summary of the recommendations:

- Poverty is a very complex and multidimensional phenomenon, which needs interventions on many fronts including physical assets, social and economic assets, safety nets and governance.

- There is a need to create conditions in which the poor are either given or enabled to acquire the assets while allowing the environment to get returns from these assets.

- A significant gap between actual and potential productivity levels prevails, which calls for enhancing land and water productivity because enormous potential exists to increase agricultural productivity in Pakistan.

- The key to enhance productivity is to improve access to production inputs (water and other inputs), marketing system, and delivery of services. This could be achieved by creating effective institutions/ institutional mechanisms.

- Crop forecasting mechanisms should be developed in a way that the latest information would be available to the farmers and other stakeholders on regular basis.

- Integrated land and water resources management (ILWRM) could be done through community participation with the public sector playing an important role as enabler, facilitator and regulator.

- Institutional reforms with pro-poor strategies are needed in the irrigation water sector.

- Integrated services provision (ISP) by the private sector with public sector playing an important role as enabler, facilitator and regulator is required.

- New innovations and targeted pro-poor investments in the irrigation water sector shall be tried.

- Develop clear water policy and incorporate poverty concerns. Policy guidelines need to be based on research-based knowledge.

- Replicate IMT experience in other canal commands with strong regulatory backup.

- The irrigation sector financing should be based on full O&M cost recovery with pro-poor water charging strategy (i.e. according to location and farm size).

- Integrated management of surface and groundwater should be made through canal water reallocation and conjunctive use of water.

- Implementation of groundwater regulatory framework should be implemented in its true spirit. Specific cropping patterns and agricultural technologies based on scientific knowledge of the canal command areas should be recommended.

- The recommendations to change cropping patterns should be based on crop diversification, high value crops (including non-conventional crops) and resource conservation practices.

- Targeted investments in irrigation infrastructure are recommended for the development, improvement and rehabilitation of surface water supplies and groundwater development.

After the recommendations were given, the Chairman of the session said in his concluding remarks that the government is trying a lot of policies and interventions but due to one reason or the other they have not been implemented on sustainable basis. He said that the politicians should be pressed for the sustainability of the policies on poverty alleviation. There should be emphasis on the macro-level instead of the micro-level. He congratulated IWMI for holding a successful workshop on a very important subject in which sensitive issues such as pro-poor policies and linkages between the irrigated agriculture and poverty were highlighted and given due consideration by the participants. He hoped that the recommendations would be translated into action by the government for poverty alleviation. He further said that Pakistan is a poor country with irrigated agriculture, and finances would have to come from other resources including donors, to help the farming community. He stressed that it should be clear that 'who is going to do what' for poverty alleviation. He proposed Phase I to be Action Plan. The priorities or interventions that have been the outcome of the ongoing workshop should be short-listed. And then, they should be put forward to the government for poverty alleviation. The mission should continue and we all should be optimistic.

Dr. Asad Qureshi gave the vote of thanks and on behalf of IWMI, he assured the participants and distinguished guests that the efforts for poverty alleviation would continue. He stressed that for sustainable development there should be enough resources, efficient infrastructure and right information at right time. He suggested that researchers should involve anthropologists; psychologists and sociologists in their studies to better understand the human behavior, which might help in wider acceptability of research results by different sectors of society including policy makers. He declared the workshop a great success as all the objectives set forth for this workshop has been achieved. He thanked all those who made commitments to join hands with IWMI in the fight against poverty. He also thanked IWMI staff for their support in organizing the workshop. He acknowledged the services of Dr. Intizar and his team for providing a platform to the galaxy of researchers and other stakeholders to discuss the irrigation and poverty issues in detail.

References

ACE-Associate Consultant Engineers (Pvt) Ltd. 1985. *SCARP transition Pilot Project, Khanka Dogran Unit of SCARP-1*, PC-I, Performa, Government of Pakistan.

ACE-NESPAK-NDC. 1997. *Hydrogeological Studies*. Final Report, Second SCARP Transition Project, Irrigation and Power Department, Government of Punjab, Lahore

Action-Aid Pakistan. 1997. *Gender and poverty in Pakistan: A background paper*. Action Aid Pakistan.

Adams, J.J.; and R.H. He. 1995. *Sources of income inequality and poverty in rural Pakistan*. http://www.ifpri.cgiar.org/pubs/obstract/abstr/oz/htm.

Ahmad, E.; and C. Allison. 1990. *Poverty, growth and public policy in Pakistan*. Draft Paper.

Ahmad, E.; and S. Ludlow. 1989. Poverty inequality and growth in Pakistan. *The Pakistan Development Review*, 28(4): Pp. 831-850.

Ahmad, N. 1998. Poverty in Pakistan. *Pakistan Journal of Applied Economics, Vol. 14 (1 &2),* 1-26.

Akhtar, S. 1988. *Poverty in Pakistan*. Draft Mimeo. World Bank: Islamabad, Pakistan.

Alderman, H.; and M. Garcia. 1993. *Poverty, household food security and nutrition in rural Pakistan*. Research Report 96. IFPRI: Washington, D.C.

Alexandridis, T.; S. Asif; and S. Ali. 1999. *Water performance indicators using satellite imagery for the Fordwah Eastern Sadiqia (South) Irrigation and Drainage Project*. IIMI-Pakistan Research Report No.R-87. Lahore, Pakistan: International Irrigation Management Institute.

Ali, S. M. 2001. *Poverty and child mortality in Pakistan*. MIMAP Technical Paper Series 6. PIDE: Islamabad, Pakistan.

Ali, S.S.; and S. Tahir. 1999. *Dynamics of growth, poverty and inequality in Pakistan*.

Anwar, T. 1996. Structural adjustment and poverty: The case of Pakistan. *The Pakistan Development Review*, 35 (4): Pp9ll-926.

Anwar, T. 1997. Incidence of relative poverty in Pakistan: Evidence from household survey. *Journal of Rural Development & Administration, Vol. XXIX*: Peshawar, Pakistan.

Arif, G.M.; H. Nazliand; and R. Haq.2001. *Rural non-agriculture employment and poverty in Pakistan*. Islamabad, Pakistan: Pakistan Institute of Development Economics.

Arif, G.M. 2000, Recent rise in poverty and its implication for poor households in Pakistan, *The Pakistan Development Review*, 39 (4), 1153-1170.

Bastiaanssen, W.G.M.; D.J. Molden; S. Thiruvengadachari; A.A.M.F.R. Smit; L. Mutuwatte; and G. Jayasinghe. 1999. *Remote sensing and hydrologic models for performance assessment in Sirsa Irrigation Circle, India*. Research Report No. 27. Colombo, Sri Lanka: International Water Management Institute.

Baulch, B.; and N. McCulloch. 1998. *Being poor and becoming poor: Poverty status and poverty transition in rural Pakistan*. Working Paper No. 79. Institute of Development Studies, University of Surrex, UK.

Bhatti, M.A.; R. Haq; and T. Javed. 1999. A sectoral analysis of poverty in Pakistan. *The Pakistan Development Review* 38(4): Pp. 859-872.

Chambers, R. 1992. *Rural Appraisal: Rapid, Relaxed, and Participatory*. Institute of Development Studies. Discussion Paper 311: Sussex: HELP.

Cheema, M. A.; Z. I. Mirza; M. Hassan; and D. J. Bandaragoda. 1997. *Socio-economic baseline survey for a pilot project on water users organization in Hakra-4-R distributary command area, Punjab*. IIMI-Pakistan Report No. 37.

Deb, U. K.; G. D. Nageswara Rao; Y. Mohan Rao; and R. Slater. 2002. *Diversification and Livelihood Options: A Study of Two Villages of Andhra Pradesh, India: 1975-2001*. ODI, London, UK.

Edwards, R. 1995. *PRA and raised Expectations: Potential and Pitfall*, PLA Notes (1995),Issue 22, pp 17-19, IIED, London, UK.

Ercelawn, A. 1984. Income inequality in rural Pakistan: A study of sample villages. *Pakistan Journal of Applied Economics, Vol. III (I),* 1-26.

Ercelawn, A. 1988. *Tables presented at World Bank Seminar*. Islamabad.

Ercelawn, A. 1989. *Poverty in Pakistan: Choice of poverty criteria*. Draft Paper.

Fuss, M.; D. McFadden; and Y. Mundlak. 1978. *Production Economics: A Dual Approach to Theory and Applications*. eds. M. Fuss and D. McFadden. North Holland Publishing company. pp 224-225.

Gazdar, H, S.; S. Howes; and S. Zaidi. 1994. *Poverty in Pakistan: Measurement trends and patterns.* STICRD, ISE, London, UK.

Gill, M. A.; B. A.. Solehria; N. H. Bukahri; and M. Ahmad. 2002. *Use of poor quality groundwater through Conjunctive Water Management*. Proceedings of International Workshop on Conjunctive Water Management for Sustainable Irrigated Agriculture in South Asia, IWMI, Pakistan.

Goheer, N.A. 1999. Poverty in Pakistan: Increasing incidence, chronic gender preponderance and the plausibility of Grameen-type intermediation. *The Pakistan Development Review*, 38 (4): Pp. 373-894.

Government of Pakistan. 2001. *Agricultural Statistics of Pakistan 2001.* Economic Adviser's Wing, Ministry of Food Agriculture and Livestock, Islamabad, Pakistan.

Government of Pakistan. 2002. *Pakistan Economic Survey 2001-2002.* Finance Division, Economic Adviser's Wing, Islamabad, Pakistan.

Government of Pakistan. 2001. *Three year poverty reduction program 2001-04*. Islamabad, Pakistan: Planning Commission.

Grimard, F. 1996. Does the poor's consumption of calories respond to changes in income? Evidence from Pakistan. *The Pakistan Development Review*, 35(3): Pp. 257-283.

Harris, G.; S. Howes; and S. Zaidi. 1994. *A profile of poverty: Some insights from the Pakistan Integrated Household Survey 1991*. London School of Economics, 51994.

Havinga, I.C.; F.W. Haanappel; A. S. Louter; and W.A. Andel. 1989. Poverty in Pakistan 1984-1985. *The Pakistan Development Review*, 28 (4): Pp. 851-869.

Hussain, A. 1997. *Overcoming poverty*. A Report published by The Task Force on Poverty Eradication, Overcoming Poverty, Government of Pakistan. Islamabad, Pakistan: pp. 69.

Irfan, M.; and R. Amjad. 1984. Poverty in rural Pakistan. In *Poverty in Rural Asia*. eds. A.R. Khan and E. Lee. ILO/ARIEP.

Jafri, S.M.Y.; and A. Khattak. 1995. Income inequality and poverty in Pakistan. *Pakistan Economic and Social Review, Vol. XXXIII*. Lahore, Pakistan.

Jehangir W. A.; and M. Mudasser. 1998. *Irrigation management and its Viability: A Case Study of Hakra 4-R Distributary, Punjab, Pakistan.* Publication No. 188. Westwood Colony, Lahore, Pakistan: International Water Logging and Salinity Research Institute.

Kalwij, I.; Z. I. Mirza; A. Ami; and A. Hameed. 1999. *Disseminating the Bed and furrow Irrigation Methods for Cotton Cultivation in Hakra-4-R distributary with the water User Federation.* Report No. R-83. Lahore, Pakistan: International Water Management Institute.

Kemal, A.R. 1994. Structural adjustment, employment, income distribution and poverty. *The Pakistan Development Review*, 33(4). Pp: 901-914.

Kruijk, H. D.; and M.V. Leeuwen. 1985. Changes in poverty and income inequality in Pakistan during the 1970s. *The Pakistan Development Review, XXIV Q & 4.*

Madala, G. S. 2002. *Introduction to Econometrics,* 3rd edition. London: Macmillan.

Mahbub-ul-Haq Centre for Human Development and UNDP. 1999. *A profile of poverty in Pakistan*. Islamabad, Pakistan.

Mahmood, S.; H.S. Khalid; and T. Malunood. 1989. The food poverty and its causes in Pakistan. *The Pakistan Development Review, Vol. XXX*. Islamabad, Pakistan.

Malik, M.H. 1988. Some new evidence on the incidence of poverty in Pakistan. *The Pakistan Development Review*, 27 (4), winter.

Malik, S. 1996. Determinants of rural poverty in Pakistan: A micro study. *The Pakistan Development Review*, 3 5(2): Pp. 171-187.

Malik, S. J. 1991. Poverty in Pakistan 1984/85 and 1987/88. In *Including the Poor*. eds. M. Lipton, and J. Van Gaag. The World Bank. Washington, D.C.

Malik, S. J. and H. Nazli. 1999. *Rural poverty credit use: Evidence from Pakistan*. Paper presented in 15th AGM of Pakistan Society of Development Economics. 5-8 November. Islamabad, Pakistan.

Malik, S. J. M. Hussain; and N.S. Sherazi. 1994. Role of infaq in poverty alleviation in Pakistan. *The Pakistan Development Review*, 33(4): Pp. 935-952.

Malmberg, G. T. 1968. *Reclamation by Tubewell Drainage in Rechna Doab and adjacent Areas, Punjab Region, Pakistan*. USGS water supply paper 1608.

McCracken, J. A.; J. N. Pretty; and G. R. Conway. 1988. *An Introduction to Rapid Rural Appraisal for Agricultural Development*. London, U.K.: International Institute for Environment and Development.

Memon, M.; and P. Arif. 1993. *Factors Associated with the Deterioration of the SCARP Tubewells.* ISMR Symposium Proceedings, Vol. VI, Lahore.

Molden, D.; R. Sakthivadival; C.J. Perry; C. Fraiture; and W.H. Kloezen. 1998. *Indicators for comparing performance of irrigated agricultural systems*. IWMI Research Report No. 20. Colombo, Sri Lanka: International Water Management Institute.

Mujahid, G.B.S. 1978. A note of measurement of poverty and income inequalities in Pakistan: Some observations on methodology. *The Pakistan Development Review*, Vol. XVII, No. 3. Autumn.

Mundorff, M. J.; P. H. Carrigan Jr.; T. D. Steel; and A. D. Randall. 1976. *Hydrologic Evaluation of Salinity Control and Reclamation Projects in the Indus Plain, Pakistan-A Summay*. US Geological Survey Water-Supply Paper 1608-Q.

Mustafa, K.; Z.A. Gill; and T. Azid. 2001. *NGO's micro finance and poverty alleviation*: *Experience of the rural poor in Pakistan*. Proceedings of the 16th Annual General Meeting 2001.Islamabad, Pakistan; The Pakistan Institute of Development Economics.

Naseem, S.M. 1977. *Rural poverty and landlessness in Pakistan*. ILO Report on Poverty and Landlessness in Asia. ILO, Geneva.

Nasir, Z.M. 2001. *Poverty and labor market linkages in Pakistan*. MIMAP Technical Paper Series.7, PIDE. Islamabad, Pakistan.

PPSGDP. 1998. *Canal seepage analysis for calculation of recharge to groundwater*. Technical paper No. 14, Punjab Private Groundwater Sector Development Project (PPSGDP), Planning and Development Department, Government of Punjab.

Pieri , C.; J. Dumanski; A. Hamblin; and A. Young. 1995. *Land Quality Indicators.*World Bank, Discussion Paper No. 315. Washington. DC.

Qureshi, S.K. 2001. *An overview of Government's poverty alleviation policies and programs*. MIMAP Technical Paper Series No. 12, PIDE. Islamabad, Pakistan.

Rehman, G.; W. A. Jehangir; A. Rehman; M. Aslam; and G. V. Skogerboe. 1997. *Principal Findings and Implications for Sustainable Irrigated Agriculture:Salinity Management Alternatives for the Rechna Doab, Punjab, Pakistan. Volume I.* Research Report Number R-21.1, Pakistan National Program, Lahore: International Irrigation Management Institute.

Sattar, A.; A. R. Tahir; and F. H. Khan. 2001. *Impact of Precision Land Leveling on Water Saving and Drainage Requirements*. Proceedings of the Second National Semina on Drainage in Palistan held in University of Agriculture, Faisalabad on April 18-19. 2001.

Theis, J.; and H. Grady. 1991. *Participatory Rapid Appraisal for Community Development*. London, U.K.: Save the Children Fund.

Wasey, A. 1977. Urban poverty line estimates. *The Pakistan Development Review, Vol. XVI,* Islamabad, Pakistan.

WSIP. 1990. *Water Sector Investment Plan*. Lahore, Pakistan; National Engineering Services.

Zaidi, M.A.; and K. De Vos. 1994. Trend analysis of relative poverty in Pakistan (1984-85-1987-88). *The Pakistan Development Review,* 33 (4): Pp: 915-934.

Zaman, W. 1998. *Impact of farmers' participation for water resources management in the Punjab province, Pakistan*. Lahore, Pakistan: International Water Management Institute.

Appendix-I

APPROACH AND METHODOLOGICAL FRAMEWORK

A basic problem in carrying out any work on poverty is how to define the poor and how to measure poverty. Traditional approaches to measure poverty have centered on the concepts of income and consumption levels. Poverty is generally perceived in two distinct ways i.e. absolute poverty and relative poverty. Absolute poverty is defined in terms of minimum consumption needs without reference to income or consumption levels of the general population. A relative poverty situation, on the other hand, is generally defined in relation to the mean income or consumption of the population. A person is considered poor, in absolute terms, if his/her income or consumption level falls below some minimum level necessary to meet basic needs – this minimum level is called the poverty line. However, it has been argued that income is a narrow concept and is not an adequate measure of poverty and well being of the households. In recent years, it has been increasingly recognized by the researchers that poverty is a multidimensional concept, extending from low levels of income and consumption to lack of education and poor health, and other social dimensions including powerlessness, insecurity, vulnerability, isolation, social exclusion and gender disparities. Similarly, the concepts of livelihood, basic capabilities and entitlements have broadened the concepts of poverty. While looking at poverty from both economic and non-economic dimensions, it provides a comprehensive and holistic approach for understanding poverty. Much of the empirical work in poverty relies on traditional income and consumption measures i.e. estimating poverty lines using basic needs approach. As basic needs vary across time and space, poverty lines also vary over time and across societies, depending upon the level of socio-economic development, social norms, and values within regions in a country or across countries.

Since water and land are important rural resources, the concept of resource poverty is relevant here. The resource poor are defined as those having relatively little or no access to resources, where resources are defined as means of production (which include land, water and other assets including farm machinery). Land being the fundamental rural resource, the resource poor may be further classified into two categories: 1) the land poor who own or operate land, but their land holdings are generally small (mostly small-scale and marginal farmers); and 2) landless people who own or operate no land and whose major source of income is wage employment. Given the nature of links between irrigation water and land, irrigation has the potential to have direct impacts only on those having access to land (land poor and resourceful farmers). Benefits of irrigation extend to the landless, mainly, indirectly through increased employment opportunities from the introduction of irrigation or improvements in irrigation management. For the purpose of this study, poverty was measured in terms of the following two dimensions:

Income/expenditure Poverty where poverty line was defined as minimum income/expenditure needed for basic needs to survive.

Non-income Poverty including asset or resource poverty and vulnerability, and social poverty such as a lack of participation or involvement in social activities.

MEASURING INCOME/EXPENDITURE POVERTY

The measurement of income poverty involves: 1) specification of indicators of well-being such as income or expenditure; 2) specification of a poverty line in terms of an income level or threshold below which a person or household is considered poor; and 3) construction of poverty measures. The Foster-Greer-Thorbecke (FGT) class of measures is the most commonly used measures of poverty, which capture three aspects of poverty: incidence, depth/intensity, and severity of poverty. These measures are: Headcount Index, the Poverty Gap Index, and the Squared Poverty Gap Index.

The Headcount Index is defined as the share or proportion of the population, which is poor or whose income is below the specified poverty line. This is a measure of incidence of poverty. If in a population of size n, there are q number of poor people whose income y is less than the poverty line z, then head count index is defined as:

Head Count Index ***HC = q/n***

The Poverty Gap Index is defined as the mean distance separating the population from the poverty line. This can be interpreted as a measure of depth of poverty. Those, not poor, are given a distance of zero. This measure can be mathematically represented as:

Poverty Gap $$PG = \frac{1}{n}\sum_{i=1}^{n}\frac{z - y_i}{z}$$

Where, y_i is the income of the individual i or household i, and the sum is taken only on those individuals who are poor (below poverty line).

The poverty gap can also be defined as the product of the Head Count Index ratio and the income gap ratio, represented as:

PG = I*H, where I is the income gap ratio

Where: $I = \frac{z - y_q}{z}$, and,

$$y_q = \frac{1}{q}\sum_{i=1}^{q} y_i$$ is the average income of the poor.

The Squared Poverty Gap Index is a measure of the severity of poverty. The poverty gap takes into account the distance separating the poor from the poverty line, while the squared poverty gap $[PG]^2$ takes into account the square of the distance. The squared poverty gap index gives more weight to the poor, by taking into account the inequality among the poor. Greater weights are given to larger gaps and the weights are the poverty gaps. It is represented as following:-

Squared Poverty Gap $(PG)^2 = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{z-y_1}{z}\right)^2$

Both the Poverty Gap and the Squared Poverty Gap Index put more emphasis on those who are further away from the poverty line. The general formula for all the three measures is given below, which depends on parameter α, which takes the value of zero for the Head Count, one for the Poverty Gap and two for the Squared Poverty Gap Index.

$$P(\alpha) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_1}{z}\right)^{\alpha}$$

The above measures can be analyzed by various socio-economic parameters and by geographic locations within irrigation systems.

Poverty Line

As mentioned above, specification of poverty line is an important step in estimating the above measures. There are three commonly used approaches applied for estimating the poverty line: a) based on caloric intake, b) income /expenditure needed for required food energy intake (food only), and c) cost of basic needs (food and nonfood). For the purpose of this study, we will use secondary estimates of national/regional poverty lines available from the national statistical agencies for that country/region.

Definition of Income

The concept of rural income, as used in the discussion above, is defined as the total income received in both cash and kind in a given year. Income received in kind was computed in monetary value using the prevailing prices. The total income comprised the sum of crop income, non-crop income, income from selling of animals and income from renting of agricultural machinery and implements. The Net crop income includes the sum of incomes from all crops, the difference of land rent received/ paid and difference of income from share in/out land. The non-crop income was the sum of incomes from artisan/ repair work, other enterprises, interest earned on household savings, pensions, remittances from in/out side the country, gifts/transfer payments, animal/poultry products, handicrafts, salaries and other non crop items. Income from agricultural wages – includes income from working in agricultural activities on others' farms. Income from trade, services and other nonagricultural sources – includes income from shop-keeping, petty trade, business and market intermediaries, self-employment, salaried services, earnings from manual labor employed in rural processing and industrial activities, transport operations, housing and road construction and other similar activities.

Definition of Expenditures

The total expenditure by the households comprises expenses incurred on items (in following 4 categories), which were purchased from the market or purchased from village shopkeeper on loan basis. The items included in each category are given below:

Category I. The items included in this category were wheat, flour, rice, pulses, maize flour, potato, vegetables, mutton, beef, chicken, fish, eggs, milk, yogurt, fruit and bread.

Category II. The items included in this category were tea, soft drinks, squashes, syrups, cooking oil, ghee, sugar, salt, spices, gur, jawar flour and suji.

Category III. The items included in this category were tobacco for huqqa, cigarette, soap, shampoo, electric charges, telephone charges, cow dung, wood, gas, illumination fuel and water.

Category IV. The items included in this category were clothing, shoes, medical care, treatment for sickness, education, recreation, expenses for ceremonial occasions, transportation and communication, remittance to family members or relatives, house rent, loan payment, tax, usher, deposit to banks, charities, funerals, legal disputes, rent for shop, election expenditure, and house servants.

Non-Income Dimensions of Poverty

In addition to income poverty, the non-income dimensions of poverty were also studied including family size of the household, dependency ratio, education and employment status, access to public amenities, assets/resource poverty, etc.

METHODOLOGICAL FRAMEWORK FOR ASSESSING IRRIGATION SYSTEM PERFORMANCE

In this study, the irrigation system performance was assessed in order to evaluate its impacts on poverty in the sample areas. For this purpose, a number of different indicators were devised under the various criteria i.e. (a) Productivity, equity and water supply, (b) Sustainability (economic, environmental and infrastructure) and (c) Institutional/organizational/management effectiveness as explained in Table 1.1.

Table 1.1. Indicators for assessing performance of irrigation systems.

Broad Criteria	Sub-criteria	Indicators
Productivity, equity and water supply	Productivity	Irrigation intensity Cropping intensity Output per unit command area Total production Output per unit of diverted water Output per unit of consumed water Output per unit of labor Head-tail equity in output
	Water supply	Relative water supply (RWS) Relative irrigation supply (RIS) Water delivery capacity Water delivery performance Overall system efficiency Head-tail equity
Sustainability	Economic	Gross value of farm production per unit area Net value of farm production per unit area Net value of farm production as percent of total household income Irrigation benefit per unit area/water (farm level) System Level profitability Water charge collection performance Systems financial self-sufficiency O& M financing gap
	Environmental	Percent of command affected by waterlogging and salinity and percent change Groundwater depth and percent change
	Infrastructure	Number of infrastructure at primary, secondary and tertiary levels (canals, distributaries, watercourses) 26. Number of control structures per 1000 ha
Institutional /management	Formal irrigation agency and community	Number of irrigation agency employees per 1000 ha at system management level Number of irrigation agency employees per 1000 ha for maintenance and operations at system level Users' participation/involvement in irrigation management (at primary, secondary and tertiary levels) Gender performance indicators

Definitions and computation procedures for key performance assessment indicators

A. Productivity, Equity and Water Supply

(i) Irrigation Intensity

Irrigation intensity (II) is defined by the ratio of net irrigated area (NIA) and the design command area (DCA): II = (NIA/DCA).

(ii) Cropping Intensity

Cropping intensity (CI) is defined by the ratio of gross cultivated area (GCA) to design command area (DCA): CI = (GCA/DCA).

(iii) Output per Unit Command Area

Output per unit command area (OCOA) is defined as the ratio of total production (TP) and command area (COA): OCOA= (TP/COA).

(iv) Total Production in Command Area

The command area is the nominal or deign area to be irrigated (for example, consider an irrigated area that nominally is to serve 1000 ha. During the rainy and dry seasons 800 ha and 400 ha are irrigated respectively. In this case, the irrigated-cropped area is 1200 ha. The command area is 1000 ha). Production, here, is the output of command area in terms of gross or net value of production (see GVP or NVP below).

(v) Output per Unit of Diverted Irrigation Water

Output per unit of diverted irrigation water (ODW) is defined as the ratio of actual total production (ATP) to diverted irrigation water (DIW): ODW=(ATP/DIW). DIW is the volume of surface irrigation water diverted to the command area, plus net removals from groundwater.

(vi) Output per Unit of Consumed Water

Output per unit water consumed (OCW) is defined as the ratio of actual total production (ATP) to volume of water consumed by ET (WET): OCW=(ATP/WET). WET is the actual evapotranspiration of crops.

(vii) Output per Unit of Labor

Output per unit of labor (OL) is defined as the ratio of actual total production (ATP) to total number of person days of labor (PDL): OL=(ATP/PDL).

(viii) Head-Tail Equity Ratio in Output

Head-tail equity ratio in output (HTERO) is computed as the ratio of average output per unit area of the upper 25 percent of the system – head- (OUAH) to average output per unit areas of the tail 25 percent of the system (OUAT): HTERO = (OUAH/OUAT). Output may be defined in terms of GVP.

(ix) Relative Water Supply (RWS)

Relative Water Supply (RWS) is defined as the ratio of total water supply (TWS- which is equal to surface diversions plus net groundwater draft plus rainfall) and crop demand (CD is equal to potential crop Et or Et under well watered conditions- in the case of rice, deep percolation and seepage losses are added to the crop demand): RWS = (TWS/CD). This is an indicator of adequacy or shortage of supplies -- matching supplies with demand.

(x) Relative Irrigation Supply (RIS)

Relative Irrigation Supply (RIS) is defined as the ratio of total irrigation supply (TIS- which is equal to only surface diversions and net groundwater draft and does NOT include rainfall) and irrigation demand (ID is equal to the crop ET less effective rainfall): RIS = (TIS/ID). This is also an indicator of adequacy or shortage of water supplies.

(xi) Water Delivery Capacity

Water delivery capacity (WDC) is defined as the ratio of canal capacity to deliver water at system head (CCD- the present discharge capacity of the canal at the system head) and peak consumptive demand (PCD-the peak crop irrigation requirements for a monthly period expressed as a flow rate at the head of the irrigation system): WDC=CCD/PCD).

(xii) Water Delivery Performance

Water delivery performance (WDP) is defined as the ratio of actual (AD) to target (TD) volume of water delivered: WDP= (AD/TD).

(xiii) Overall System Efficiency

Overall system efficiency (OSE) is defined as ratio of crop water requirements (CWR) and total inflow into canal system (TI): OPE= (CWR/TIC).

(xiv) Head-Tail Equity

Head-tail equity ratio (HTERW) is defined as the ratio of average delivery performance ratio (DPR - which is the ratio of actual discharge to target discharge) of upper 25 percent of the system (DPRH) to average DPR of tail 25 percent of the system (DPRT): HTERW = (DPRU/DPRT).

B. Economic/Financial, Environmental and Infrastructure Sustainability

(i) Gross Value of Farm Production (GVP) per Unit Area

Gross value of farm production (GVP) per unit is defined as output per unit area measured at local or world prices. Standardized gross value of production (SGVP) is a better indicator than GVP as it accounts for differences in local prices, and also accounts for crops not traded in the international markets. It is useful for cross system comparison purposes (Molden et al. 1998).

(ii) Net Value of Production (NVP) per Unit Area

Net value of farm production per unit area is defined as GVP per unit area minus cash costs of production.

(iii) Net Value of Farm Production as Percent of Total Household Income

(iv) Irrigation Benefit per Unit Area/ Water (Farm Level)

Irrigation benefit per unit area (IB) is defined as the net value of farm production per unit area (NVP) from irrigated area minus net value of farm production per unit area from rain-fed (irrigation benefit per unit of water diverted can be calculated simply by dividing the difference in NVPs by the total amount of water diverted).

(v) System Level Profitability

System level profitability (SP) is defined as the ratio of irrigation benefit (IB) per unit area to total irrigation expenses per unit area (water based system profitability can be calculated by dividing irrigation benefit per unit water by total irrigation expenses per unit of water).

(vi) Water Charge Collection Performance

Water charge collection performance (WCCP) is defined as the ratio of actual total annual income from irrigation water charges (TIWC) collected to maximum collectable, assessed, or due (MCWC).

(vii) System Financial Self-sufficiency

System financial self-sufficiency (SFS) is defined as the ratio of actual total annual income from water charges (TIWC) to actual total annual O & M expenditure (AOME).

(viii) O&M Financing Gap

O & M financing gap (OMFG) is defined as the ratio of actual total annual O&M expenditure (AOME) to the required or optimum O&M expenditure (ROME).

(ix) Percent of command affected by waterlogging and salinity and percent change (seasonal or annual) in command area affected

(x) Groundwater Depth and Percent Change (seasonal or annual) in Depth

(xi) Number of Infrastructures at Primary, Secondary and Tertiary Levels (Canals, Distributaries, Watercourses)

(xii) Number of Control Structures per 1000 ha in command area

C. Institutional/Organizational/Management Effectiveness

i. Number of Irrigation Agency Employees per 1000 ha at System Management Level

ii. Number of Irrigation Agency Employees per 1000 ha for Operations and Maintenance at System Level

iii. Users Participation/Involvement in Irrigation Management (at Primary, Secondary and Tertiary Levels)

Econometric Analysis and Functional Forms

To estimate the empirical relationship between the dependent and different explanatory variables, the econometric criteria suggested by Fuss, McFadden and Mundlak (1978) and Madala (2002) were used. Economic theory rarely provides us with precise mathematical forms of economic relationships. This study analyzed various functional relationships. The generic functional form is given as follows (the specific functional forms are given in the respective parts of the report).

$$Y_i = a + \sum_{j}^{n} B_j X_{ij} + e$$

i = 1, 2, ...n farm households.
j = 1, 2, ...n determinant variables.

Where:

Y_i	=	Dependent variable
$X_1 \ldots X_n$	=	Set of independent variables including dummy variables
a	=	Constant
e	=	Random error term.

PRA Methodological Framework

For better understanding of the participatory rural appraisal (PRA) framework, various definitions of PRA are given as under:

PRA is a combination of approaches and methods designed to ensure the development of analytical skills and the mutual sharing of knowledge and aspirations so that communities are actively involved with outsiders in guiding the development process. However, during this process conflicts invariably arise. PRA Methods may be insufficient for analyzing and resolving conflicts.

"PRA is an empowering process of appraisal, analysis, planning, action, monitoring and evaluation". (Chambers 1992)

"...PRA is an attitude of mind governing how we interact with others throughout the process of development". (Edwards 1995)

Components of PRA

Following are the important components of PRA, which are commonly employed in the field for collecting the information.

- Participation
- Teamwork
- Flexibility
- Optimal ignorance
- Triangulation

Local participants' input in PRA activities constitutes an essential part of its value as a research tool and planning method and as a means for diffusing the participatory approach to development. PRA needs informal interaction and brainstorming among those involved in the process. In order to conduct PRA effectively, a team should include local people with perspective and knowledge of the area's conditions, traditions and socio-economic structure. A well-balanced team would represent the diversity of socio-economic, cultural, gender and generational perspectives. PRA provides a flexible framework for its participants. The combination of techniques that is appropriate in a particular context would be determined by such variables as the size and skill mix of the PRA team, time and resources available and the topic and location of the study. To be efficient in terms of both time and money, PRA work intends to gather just enough information to make the necessary recommendations and decisions. PRA techniques were used for the collection of qualitative data. To ensure the validity and reliability of the information, PRA teams needs to follow the rule of thumb that at least three sources must be consulted or techniques must be used to verify the information collected for the same topics.

PRA Tools

PRA is considered as an exercise for communicating and transferring of knowledge. Regardless of whether it is carried out as part of project identification or appraisal or as part of country economic and socio-development work, the learning by doing and teamwork spirit of PRA requires transparent procedures (McCracken *et al* 1988; Theis and Grady 1991 and Chambers 1992). The other commonly used tools in PRA are enlisted as following:

Semi-structured interviewing
Focused group discussions
Priority-setting (matrix ranking)
Mapping and modeling
Seasonal and historical diagramming
Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis, etc.

References

Chambers, R. 1992. *Rural Appraisal: Rapid, Relaxed, and Participatory*. Institute of Development Studies. Discussion Paper 311: Sussex: HELP.

Edwards, R. 1995.*PRA and Raised Expectations: Potential and Pitfall*. PLA Notes (1995), Issue 22, pp 17-19, IIED, London, UK.

Fuss, M.; D. McFadden; and Y. Mundlak. 1978. *Production Economics: A Dual Approach to Theory and Applications*. eds. M. Fuss and D. McFadden. North Holland Publishing company, 1978. pp. 224-225

Madala, G. S. 2002. *Introduction to Econometrics*, 3rd edition, London:Macmillan.

McCracken, J. A.; J. N. Pretty; and G. R. Conway. 1988. *An Introduction to Rapid Rural Appraisal for Agricultural Development*. London, U.K.: International Institute for Environment and Development.

Theis, J.; and H. Grady. 1991. *Participatory Rapid Appraisal for Community Development.* London, U.K.: Save the Children Fund.

Appendix – II

RESULTS OF SWOT ANALYSIS BY SYSTEM

Table 10.1 presents the SWOT analysis based on the information collected in the sample areas of the Upper Jehlum Canal (UJC) irrigation system. The households revealed their strengths. The participants in UJC responded that they have been endowed with fertile and productive soils that enabled them to grow more crops in a year. Due to well-drained soils, relatively high rainfall, existence of surface irrigation system and good quality groundwater, the farmers were able to cultivate almost all areas of their landholding. The farmers said that most of the cultivated area was under the improved varieties and farmers used fertilizer. Almost seventy percent of the farm households were practicing the use of weedicides and insecticides for controlling the weeds and insects in the crops, respectively. The labor was available for performing day-to-day functions in the field. In the areas of UJC irrigation system, farmers were getting good crop yields. The respondents while accounting their strengths further added that there was no serious problem of waterlogging and salinity; law and order situation was comparatively better and incidences of animal theft were almost non-existing. There existed employment opportunities in the off-farm sector like fan and footwear industries. The farm households of the area held that good quality soils and fresh groundwater were important factors towards uplifting the economic condition of the area. Moreover, influx of foreign remittances, reasonable amount of rainfall and its distribution, and the prevalence of lined watercourses add up to their resource base in UJC. All these factors were reported to be favorable for smooth running of the agricultural economies in the area.

The factors mentioned in the column of Strengths in Table 10.1 were found favorable for smooth running of the agricultural economy of the area but the respondents also reported few weaknesses, which were hindering their agricultural productivity and also economic development of the study area.

High illiteracy rate resulted in less awareness about the use of modern techniques of farming (like proper and timely use of weedicides, insecticides and sowing methods, etc.) and depriving others from their water rights through water theft at the head areas. The sample households reported the opportunities for the introduction and adoption of modern resource conservation technologies, which might lead farmers towards risk aversion, but the major weakness was the small size of landholdings, which prevented them from using improved technologies. The farmers were sowing crops with traditional methods. The farmers also faced the problem of adulteration in fertilizers and insecticides. Difficulty faced by farmers due to non-availability of agricultural machinery and overcharging of water rates by Patwaries were the other weakness which should be corrected through establishing machinery pools and implementation of rules for making the water charge collection procedure more transparent. In few areas, poorly drained soils were causing the problems of waterlogging. Even if, sometimes, due to good weather conditions, farmers would get bumper crops the marketing problem did not allow them to reap the benefits. Late payment by sugar mills for sugarcane crop, refusal for the procurement of wheat and poor road infrastructure were reported other weaknesses of rural economics of the area. Poor access to institutional credit due to cumbersome procedure and rent seeking by the institutional lending sources and revenue patwaries for documentation were also reported as the weaknesses affecting the households in the area. The participants also reported poor availability of health facilities for human beings and animals.

As for the opportunities that could be made available for the betterment of the area, the sample households were of the view that improvement of the irrigation infrastructure and provision of a comprehensive input package would lead towards reducing water losses and improving yields. They also added that with the better availability of agricultural machinery, the crop productivity could be increased. Since a greater demand for skilled labor in the off-farm sector exists, especially in shoe making and fan manufacturing industry, there were more opportunities for the establishment of the new industries to absorb additional labor force, which was entering the labour market. Reclamation of saline soils in the head and middle of 9-R Khoja distributary, could also provide opportunity for enhancing production and economic condition of the people of the UJC area.

Table 2.1. Results of the SWOT analysis for agriculture sector (System –1) UJC.

Items	Strengths	Weaknesses	Opportunities	Threats
Land use (cropping intensity)	Relatively high cropping intensity (163%)	Heavy dependence on groundwater sources	Cropping Intensities could further be increased through better management of the canal water	Unchecked use of groundwater could lead to depletion of this valuable resource
Landhold-ings	Relatively less fallow land	Small and fragmented landholdings	Consolidation of land	Due to law of inheritance, landholdings would become further smaller/ uneconomical
Soil	In most areas, soils were fertile and productive	In some areas, soil were deficient in micro-nutrients	New technologies could play a vital role in conserving the agri. resources	Continuous use of marginally poor groundwater in some areas (e.g. Kakowal tail, 9-R head) might be deteriorating soil quality
Rainfall	Relatively higher rainfall	This was also aggravating the problem of waterlogging in certain areas (e.g. Head and middle of 9-R Khoja Distributary)	During monsoon, there is a scope for water harvesting	Rainfall during wheat growing season, may severely damage the crop in the head and middle areas of 9-R distributary
Drainage	Most areas have relatively well-drained soils	Poorly drained soils in some areas (e.g. 9-R Khoja Distributary)	Scope for planting of wheat crop on beds	Waterlogging could increase in the absence of proper measures
Ploughing equipment	Locally manufactured equipment were available	Could not purchase modern agri. machinery due to its high cost	Timely completion of agri. operations if modern machinery could be available on rental basis	-
Improved seed	Majority of farms were under improved varieties	The yield potential of improved varieties could not be achieved due to improper use of	Proper and timely use of improved seed could increase the yield of seeds	Susceptibility of seeds to insect, pest or diseases

Items	Strengths	Weaknesses	Opportunities	Threats
		inputs		
Methods of sowing	-	Traditional methods of sowing	Introduction of new methods for crop sowing (dry sowing of rice and line sowing of wheat)	Due to illiteracy, innovation and adoption could be very slow
Use/availabi-lity of fertilizer	Majority of the farmers are using fertilizers	Quality constraints and non-availability at required time	Quality check and timely provision of fertilizer could increase the crop production	Indebtedness may increase due to use of adulterated fertilizer
Irrigation related issues a) Surface water	Existence of canal irrigation system	Poor O & M of existing irrigation system Insufficient quantity of surface water	Better O&M of irrigation system could help to increase yield and reduce the poverty of the area	Further deterioration of the system could increase the poverty in the area.
b) Groundwater	Good quality groundwater	Non-availability of technicians for maintenance and boring of tubewells	Better management of groundwater Training program of technicians for tubewell maintenance	Over-exploitation of groundwater could deplete water resources quickly
Weed management	Farmers were using weedicides to control the weeds	Majority of farmers were unaware of proper timing for the use of weedicide	Extension Department could help create awareness about the selection of weedicide for particular type of weed and time of application of weedicides	Absence of improved weed management and weeds might lead to decrease in yield
Pest and disease management	Wheat is usually disease free	Low incidence of pest scouting for rice and sugarcane crops	With better pest scouting, productivity of rice and sugarcane crop could be increased	Use of adulterated pesticides were a threat to farmers
Labor issues	Adequate labor supply	Majority of the labour is unskilled Low wages in agriculture	With better training, productivity of labour could be increased Labor intensive technologies could be introduced	Low wage rate leading to transfer of labour from agricultural to industrial and service sectors
Harvesting	Availability of local labour for harvesting	Due to manual work, more harvesting losses Longer harvesting period	Labor intensive technologies such as harvesting with reaper could be beneficial	Rain at harvesting time could cause losses
Crop yields	Good crops yields	Low yield on farms with late wheat sowing due to late harvesting of rice Yield differences across farms	Yield gap could be reduced by providing input package to farmers	Pest attack, diseases, bad weather and adulterated inputs
Marketing problem of	Existence of rice shellers and sugar	Low output prices, delayed payments,	Better infrastructure and measures to stop	Could lead to decrease the area under sugarcane

Items	Strengths	Weaknesses	Opportunities	Threats
output	mills	poor infrastructure e.g. roads	delayed payments by sugar mills	cultivation
Veterinary healthcare facilities	-	Poor animal healthcare facilities	Need to Establish the veterinary hospitals/dispensaries at union council level	Non-availability of veterinary healthcare facilities may cause severe economic losses in case of epidemics, disease of animals/ poultry
Animal theft	Relatively low incidence of animal theft	-	Proper implementation of laws to control theft	Increase in animal theft could reduce animal rearing in the area
Access to credit	Using informal credit sources for consumption / production	Poor access to institutional credit	Soft term loans can be issued through banks	Difficulties in getting institutional credit would lead to the exploitation by non-institutional sources
Waterloggi-ng & Salinity	No serious problem of waterlogging in the sample area	In some areas problem of salinity is present	Land could be reclaimed through introduction of (physical, chemical and biological) reclamation methods	Deterioration of land quality due to salinity would lead to decrease in production
Other socio-economic issues	Existence of off-farm income opportunities High remittances	High illiteracy rate Poor healthcare facilities	Establishment of the education facilities in the area	Higher unemployment of youth might increase violence in the area

The results of SWOT analysis with the respondents in the Lower Jehlum Canal (LJC) command area are given in the Table 2.1. The analysis revealed thought provoking results regarding the strengths, weaknesses, opportunities and threats confronted by the community living in the command areas of LJC. While talking about their strengths the households in the LJC area pointed out that they had good quality lands capable of producing high value crops including vegetables, sugarcane, and fruits. They also reported the proportionally higher number of tubewells in the LJC area because of relatively good quality of underground water, particularly at head reaches of the system. Livestock rearing was also one of the strengths of this area. The sample households said that a major share of their income was through the selling of livestock and their by-products like milk, Ghee, etc. The farmers also pointed out the availability of labour for agricultural activities, which provided support in making agriculture more productive.

Responding to questions regarding the weaknesses of the area, the households reported that the prevalence of high illiteracy rate in the area due to less educational facilities available was a major weakness. They also reported the highly skewed land distribution (0.44 and 0.56) in the areas of Lalian and Khadir distributaries, respectively, that resulted in higher incidence of poverty. They also complained about shortage of surface water and poor extension services in the area. Deterioration of soils as a result of the application of poor quality of groundwater in the tail reaches, non-availability of modern farm machinery, non-availability of certified seed, quality fertilizers and pesticides, unemployment, livestock theft, difficulty in having institutional credit and less off-farm employment opportunities are other weaknesses of the farm households in the area.

While counting on the opportunities, the sample households in the LJC system emphasized on the establishment of processing industries from the view point of their agricultural outputs, particularly for citrus in the area, so that farmers could get higher GVP from their agricultural outputs and the landless people could find jobs in those industries. Sample households also stressed on the need to facilitate the livestock farming, which was also an income-enhancing factor and its promotion would lead to reduce the poverty in the area. About the role of the Extension Department, the households were of the view that the department could help to provide agricultural education to the farmers, which would help increase the output of the farms. Households also pointed out soil reclamation, establishment of agricultural machinery pools (to provide agricultural equipment/machinery on rental basis to poor farmers), equity in canal water distribution, quality control of inputs, provision of institutional credit and removal of bottlenecks in marketing would enhance the productivity of the area and reduce poverty among the households.

In the case of LJC system, the participants at Khadir distributary pointed out various other opportunities like land reform and introduction of bed planting for wheat crop in poorly drained soils of the area (Lalian tail) which could play their part to develop agriculture and might reduce poverty in the area. The farmers were of the view that introduction of improved varieties of crop along with modern sowing methods would also help to increase the yield in the whole area. Training of farmers regarding insect pest scouting, better management of weeds and groundwater could conserve resources and increase the yield on the farms in the area. Resolving marketing problems regarding farm output would provide incentive to farmers to work hard and produce more. Provision of soft loans and better health facilities for animals would encourage the farmers for investing in more livestock production.

In spite of all the above-mentioned strengths and opportunities, the farm households also reported some threats, which were adversely hampering the productivity of the resources. These were the spread of gastric disease due to poor quality of drinking water, increasing trend of waterlogging/salinity, water theft and further deterioration of irrigation infrastructure, high illiteracy rate and over-exploitation of groundwater at various levels. The participants also pointed out other threats to local economy as marketing of adulterated fertilizers and pesticides, spread of epidemics of animals and increased use of drugs among youth at the tail reach of Khadir distributary.

When households were asked to reveal the threats, they reported that the major threats to the household in the LJC area were animal and water theft, causing poverty in the area. Citrus orchards were considered as important source of income in LJC area and it was pointed out that due to use of brackish groundwater for irrigation citrus gardens were deteriorating in some of the areas. When households were inquired about the availability of irrigation water, they replied that due to shortage of surface water in the area, farm households were compelled to use poor quality groundwater to irrigate their field resulting in the deterioration of soils. Other threats to the regional agricultural economies were said to be the deterioration in canal irrigation system, sub-division of land in to smaller units, making units uneconomical, prevalence of drought condition, non-availability of farm machinery and fertilizer at the time needed and the increase of animal theft in the areas of agricultural economies. Table 2.2 carries the results of SWOT analysis conducted on the command area of LJC.

Table 2.2. SWOT analysis for agriculture sector (system –2) LJC.

Items	Strengths	Weaknesses	Opportunities	Threats
Land use (cropping intensity)	-	Relatively lower cropping intensity (131%) when compared with UJC	Cropping intensity could be increased by making conjunctive use of water	Continuous application of poor quality groundwater could deteriorate the quality of land
Landholding (size<5 ha)	Relatively more small farmers (83.19 %) leading to better use of land resources	Inequality in land distribution	Land reforms could be the solution of inequality in land distribution	Exploitation by large farmers would lead to increase in poverty
Soil	Good quality productive soils	Deterioration of soils due to application of poor quality groundwater in the tail areas	Soil reclamation methods could be introduced at the field levels	Continuous use of brackish groundwater at tail end would deteriorate soil resources
Rainfall	-	Relatively low rainfall	Rain water could be harvested during the rainy season by making field ponds	Depletion of groundwater resources due to absolute shortage of surface water at Khadir tail and improper management of rainfall water
Soil Drainage	Well drained soils in most areas	At the tail reach of Lalian distributary soil permeability has decreased due to brackish groundwater application	Furrow irrigation system could be introduced in order to combat the problem of soil permeability	Danger of agricultural land becoming barren at the tail of Lalian distributary
Ploughing equipment	Availability of agricultural machinery in FAO project area	Difficult access to modern ploughing equipment outside the FAO project area	Agricultural machinery pools could be established to provide services to farmers	Non availability of skilled machinery technicians could be a threat to modern machinery
Improved seed	Use of improved seed varieties in FAO project area	Difficulty in having access to improved seed in other areas	Yield potential of improved seeds could be obtained by the use of good quality improved seed	There could be a rapid decrease in the vigor of the improved seed varieties due to mixing of seeds of different varieties
Sowing methods	-	Traditional methods of sowing	Improved methods of sowing could lead to high yields in the area	Due to low literacy rate, adoption of new techniques would be slow
Fertilizer use/availability	Majority of farm households use fertilizer	Black marketing at the time of sowing leading to low use of fertilizers	Proper implementation of anti-hoarding laws could make the supply of fertilizers smooth	Non-availability / low use of fertilizers at required time could lead to severe shortfall in yield
Irrigation related issues a) Surface water	Existence of surface irrigation system in the area	Water theft at the head of Lalian and Khadir distributary deprived the tail end farmers of irrigation water at tail	Equity in water distribution could reduce the poverty in the tail end area	Water theft in head area could increase the poverty in the tail end areas

Items	Strengths	Weaknesses	Opportunities	Threats
		ends		
b) Groundwater	Good quality groundwater in the areas adjacent to the river Chenab especially the command area of Khadir distributary	Brackish groundwater in some areas like the tail of Lalian distributary	Conjunctive use of brackish water could reduce the harmful effects on crops	Continuous use of brackish groundwater could destroy the citrus orchards in the command area of Lalian distributary
Weed management	Use of weedicides by the farmers in the area	Improper time of weedicide application	Extension services could play important role to train farmers for the proper time of application	High infestation of weeds could reduce the yield substantially
Pest and disease management	Farm households use of Pesticides to control the insects pests	Incidence of adulteration in pesticides	Quality control on pesticides could save the citrus orchards and other crops	If no control on pesticide quality, then insect attack on citrus orchards and other crops might increase
Labor issues	Usually farm labor is available Scope for off farm employment opportunities	Non-availability of employment opportunities for labor throughout the year Majority of labor available is unskilled	Establishment of agro based industries to provide employment to the labor force	Introduction of capital intensive technologies might not be controlled, displacement of the agricultural labor
Harvesting	Manual harvesting provide employment opportunities to the local labor force	Labor shortage at the time of harvesting	Introduction of labor intensive technologies such as reaper harvesting could be introduced	Unfavorable weather conditions at the time of harvesting could lead to delay and losses
Crop yields	Good crop and orchard yields particularly where sufficient canal irrigation was available	Low yields in some areas, where canal irrigation was not available and groundwater quality was poor	Better crop management and provision of quality inputs at the time of need might lead to high crop yield	If farmers' due share of canal water were not provided and they were forced to use poor quality groundwater, yield would decrease with the passage of time
Marketing problem	-	1. Low price of output 2. Delayed payments 3. Poor farm-to-market road infrastructure and poor transportation facilities	Better infrastructure, transportation and marketing intelligence could reduce the problems of farmers	Existence of marketing problems could lead towards poor income from citrus and sugarcane crop
Veterinary healthcare facilities	Relatively better animal healthcare facilities in the form of hospitals than UJC	Staff at veterinary centers were not regular Medicines were not available	Timely vaccination by govt. hospitals against epidemic diseases could increase the production of meat and milk in the area	If there was no improvement in the livestock healthcare facilities, this would lead to economic losses to the farmers in the area
Animal theft	-	Relatively more theft of livestock was reported	Improvement in the law and order situation could control the problem of livestock theft	Increase in the incidence of animal theft would force the farmers to decrease the animal husbandry activities on their farms

Items	Strengths	Weaknesses	Opportunities	Threats
Credit availability	-	Difficulty to access the institutional credit due to cumbersome procedure and rent seeking by institutional lending agencies	Soft term loans could improve the financial conditions of the farmers and ultimately the output on their farms	If lending institutions would not support the poor farmers, then, their poverty could persist under the exploitation of professional money lenders
Waterlogging & Salinity	Most of the areas were free from waterlogging and salinity problems	Salinity (sodicity) problem in some areas especially at tail end of Lalian	Provision of due share of canal water could reduce the problem	Continuous deterioration of soil quality due to application of poor quality groundwater
Other socio-economic issues	-	High illiteracy rate Low on-farm and off-farm wages	Provision of the education & healthcare facilities Establishment of agro-based industry	Illiteracy and low income could deteriorate the law and order situation in the area of LJC

The results of SWOT analysis conducted in the sample households in the command area of Lower Chenab Canal system (LCC) are shown in Table 2.3. While counting on their strengths, the respondents said that they had good cropping pattern supported by good irrigation. They also reported that they had relatively high literacy level leading to good management practices that led to high yields of crops. Moreover, all the households in the area were quoted to be co-operative with each other. The respondents also considered well-drained fertile soil, use of HYVs, use of fertilizers and weedicides by the majority of farm households as their strength. Due to relatively better educational facilities and high literacy rate, there was more awareness among farmers about use of modern inputs and they were getting good yield from wheat crop. Relatively better road infrastructure and low incidence of animal theft were also considered the strengths of the area.

Side by side with the above strengths of the households in the LCC command area, also reported were certain weaknesses/shortcomings, pushing the households into the vicious circle of poverty. The farmers reported that due to poor quality groundwater, the farm households were totally dependent on surface water supplies for crop cultivation and even for drinking purpose. Absolute dependence on canal irrigation water would lead to low cropping intensity. Moreover, there were no good marketing facilities for the sale of their produce at reasonable prices, which was a discouraging and disappointing factor for the farming community. Some times sowing of wheat crop was said to be delayed due to the unavailability of surface water supplies at sowing time and late harvesting of the cotton crop. The households also reported that the existence of small landholdings, less and uneven distribution of rainfall, mixing of different varieties of seed, adulteration in DAP fertilizers, brackish groundwater, unscheduled closure of canals, shortage of labor at peak time, late payment of crops and week financial conditions of the farmers as their weaknesses.

While talking about the opportunities, the households were of the view that the introduction of salt tolerant varieties of wheat through the extension services could produce better results. There was a possibility of adoption of new technologies in this area because overall literacy rate was high. Land reclamation could also lead to increase the production and ultimately reduce poverty. Better O & M of irrigation system could lead to more supplies of irrigation water, which would help to increase the cropping intensities in the area. The increasing use of locally manufactured farm machinery would help the local industry to flourish and increase the employment opportunities. Extension department could play their role to train the farmers about the optimal use of inputs. Better procurement procedure/prices for the harvested crops would help the farmers to work hard and produce more. Provision of institutional credit would improve the financial conditions of farmers and ultimately would lead to increase the productivity reducing the poverty in the study area.

When the sample households were asked to reveal the threats to their agricultural practices, they replied that although their lands were productive, due to severe shortage of surface water supplies, they had to supplement irrigation supplies with the brackish groundwater, which was damaging the soil structure and texture. This ultimately was leading towards deterioration of the soil quality. Moreover, the use of brackish groundwater for drinking purposes was posing a serious threat to the health of the people and livestock ultimately leading to gastric trouble . Another possible threat the farm households reported was non-availability of modern agricultural machinery at the required time that caused late sowing, ultimately leading to decrease in production. The households also considered continuous deterioration of irrigation system as a threat too. They also reported that due to non-existence of better veterinary facilities, break out of epidemics could cause major economic loss to the area.

Table 2.3. SWOT analysis for agriculture sector (system –3) LCC.

Items	Strengths	Weaknesses	Opportunities	Threats
Land use (cropping intensity)	-	Low cropping intensity due to scarcity of canal water (137%) when compared with UJC	Better O & M of irrigation system	Deterioration of current irrigation infrastructure could decrease the cropping intensity and might lead to increased poverty
Landholding (size<5 ha)	-	Small landholdings (96.44% of farms) less than 5 ha.	Enactment of law that prohibit the subdivision of land to keep economic holding	Continuous sub-division of land had increased un-economical units and further subdivision would lead to inefficiencies and poverty
Soil	Fertile soils	Danger of deterioration of land quality due to use of brackish groundwater	Maintenance of the soil fertility with improved irrigation methods	Use of brackish groundwater could deteriorate soil quality rapidly
Drainage	-	Decreasing soil porosity due to increasing secondary salinization problem	Conjunctive water management	Yield potential of the soils could decrease due to soil permeability problems which would arise due to application of brackish groundwater
Ploughing equipment	Relatively more use	Difficult access to	Use of advanced	Non-availability of

Items	Strengths	Weaknesses	Opportunities	Threats
	of advanced farm machinery	farm machinery on rental basis	machines by progressive farmers would inspire the others to use improved farm machinery Opportunities for local manufacturing industry to flourish	farm machinery on rental basis could lead the late sowing of crops and decrease of yield
Improved seed	Use of improved seed verities by majority of farmers	Mixing of different seed varieties by farmers	Seed certification could lead towards the availability of pure seed varieties	Yield losses due to susceptibility of crop varieties to insect/pest and disease attack
Methods of sowing	Relatively higher awareness among progressive farmers about line sowing in wheat crop	Traditional sowing methods in most of the areas	Adoption of improved sowing methods could be demonstrated for farmers by the Extension Department	Traditional sowing methods might hamper the crop yield on the farms
Use/availability of fertilizers	Majority of the farmers are using fertilizers	High price of fertilizers, Adulteration of fertilizers especially in DAP	Fertilizer selling centers could be established at union council level Quality check on fertilizers could help farmers to get quality fertilizer which might increase the yield of crops	Adulteration of fertilizers especially DAP would decrease the yield of crops and could cause economic losses to farmers
Irrigation related issues a) Surface water	Less disputes on water related issues Existence of surface irrigation system	Unscheduled canal closure Water theft at head of LCC	Better O & M of the irrigation system	Deteriorating irrigation infrastructure would lead to decrease in production and increase in poverty
ii) Groundwater	-	Brackish groundwater	Conjunctive use of water in the LCC could lead towards the reduction of poverty in the area	Deterioration of soil quality due to continuous use of brackish groundwater
Weed management	Practicing weed management by using herbicides	Farm households were unaware of appropriate time for herbicide application, adulteration of weedicides	Extension services could play their role for training the farmers about optimal timing of the weedicide usage Quality control of marketed herbicides	Decrease in yields due to uncontrolled weeds
Pest and disease management	Relatively better management of pests and disease	Adulteration of insecticides / pesticide was reported	Proper quality control of pesticides could save the crops from insects	Impure chemicals could result in the severe economic losses to farmers
Labor issues	Relatively better off-farm employment opportunities	Shortage of labor at the time of sowing and harvesting	Introduction of labor intensive modern technologies could be promoted to	Shortage of labor at the time of sowing and harvesting could delay the activities

Items	Strengths	Weaknesses	Opportunities	Threats
			complete farm activities on time	resulting in yield losses
Harvesting	Absorption of labor for harvesting of crops due to manual operations	Shortage of labor at the time of harvesting	Harvesting by machines	Delay in the completion of farm activities, e.g. harvesting, could result in the yield losses
Crop yields	Relatively good crop yields	-	Yield could be further increased by better input management particularly by managing properly, canal irrigation water	Yield potential of various crops might decrease with increasing use of brackish water
Marketing problem	Relatively better farm-to- market road infrastructure	Low out put prices Delayed payment of sugarcane crop	Transparent procurement procedure for wheat crop would encourage the farmers to produce more Check on sugarmills for the timely payment to farmers	Intermediaries were reported a big threat because they exploited the farmers
Veterinary healthcare facilities	-	Lesser veterinary healthcare facilities	Establishment and maintenance of veterinary health care centers at union council level would encourage the farmers for animal rearing	Due to lack of veterinary health facilities, epidemics could cause enormous economic losses to farmers
Animal theft	In the lower LCC areas, lesser incidence of animal theft	There was existence of greater animal theft in the upper part of LCC areas	Improvement in law and order situation could control the problem of livestock theft	Animal theft in the upper LCC areas could increase poverty
Credit availability	-	Difficulties in getting access to institutional credit	Soft term loans could help farmers to come out of the vicious circle of poverty	Rent seeking and cumbersome procedure would prohibit poor farmers from obtaining loans & buying farm inputs
Waterlogging & Salinity	-	Salinity problems might increase due to the use of brackish groundwater	Land reclamation schemes could be introduced	Brackish groundwater application could deteriorate soil quality
Other socio-economic issues	High literacy rate Relatively better off-farm employment opportunities	In spite of better employment opportunities, unemployment rate was high	Further investment in education sector, particularly establishment of vocational institutes, could improve the poverty situation	Spreading of gambling, drug use and other social evils due to high illiteracy and unemployment

The households, which participated in the PRAs in Hakra area, were asked to narrate their strengths and weaknesses and also to report the opportunities and the threats, which they were facing in performing their agricultural practices. Their viewpoints are summarized and presented in Table 2.4. Counting on their strengths, the participants said that they had the existence of farmers' organization, because of which they were able to solve their irrigation problems to a larger extent. They knew the exact water charges (abiana), and were also aware of the collection and assessment procedure. About water losses at distributary level, the farmers believed that after the formation of FO, they had reduced and there was more equity in water distribution. They also said that the FO arranged training sessions for farmers about the use of advanced agricultural machinery. They pointed out that there existed a transparent abiana collection system. The farm households were of the view that water theft had reduced and better O & M was practiced in the area after the formation of FO. Other strengths were mentioned as availability of labor for farm operations and relatively better road infrastructure in the command areas of Hakra 4-R.

Responding to the questions regarding the weaknesses, the sample households were of the view that quality of groundwater was poor in the command areas of Hakra 4-R, which was one of the important reasons of low productivity in the area. They pointed out that landholdings in Hakra 4-R were small and fragmented side by side with big landlords. They also reported the less number of tubewells in the areas due to brackish groundwater. Another weakness was the lack of required skills and training of FO staff, which was hindering the performance of the irrigation system in Hakra 4-R. Also reported was the existence of low wage rate in the area, poor weed management, adulteration of inputs and poor marketing system posing problems to the households in Hakra 4-R.

Speaking of various opportunities, the respondents said that Farmer's Organization in Hakra 4-R command area could serve as a model for the farmers of the other canal commands in the Hakra system. They believed that there existed more chances of formation of such organizations through the involvement of local farmers. Moreover, community based development works might be implemented more successfully because people of the area were already socially active. Land reclamation effort could lead towards increase in productivity and improve economic condition of the people of the area. The households were of the view that improving the quality of inputs and removing the marketing problems could reduce poverty of the farmers in the Hakra 4-R.

In spite of the above mentioned opportunities and strengths, the sample households pointed out some threats, which were expected to affect the respondents of the Hakra 4-R if not managed in time. Among those were the deteriorating soil quality and sale of adulterated pesticides which was aggravating the weak economic condition of the community. Moreover, PIDA was reported to be non-cooperative with the farmers' organization and was creating problems against the better performance of the FO. Another threat to the area was reported to be continuous drought conditions that had decreased the yields. The sample households were of the view that if adulteration was not stopped, it would cause enormous economic loss to the farmers and would increase the poverty among farm households in Hakra 4-R. The increasing number of marketing intermediaries was also a threat since they were not creating any utility to the farm households. Instead they were taking away their shares. Another fear of the farmers was the increasing trend of unemployment in the Hakra 4-R.

Table 2.4. SWOT analysis for agriculture sector (system –4) Hakra 4-R.

Items	Strengths	Weaknesses	Opportunities	Threats
Land use (cropping intensity)	Relatively high cropping intensity due to better management of irrigation system (153 %)	Cropping intensity totally depended on canal irrigation	Introduction of improved water management practices (irrigation methods) can further increase cropping intensity	Cropping intensity could be reduced due to high rainfall leading to waterlogging and salinity
Soil	Moderately good soils of left bank of Hakra 4-R distributary	Deteriorating land quality due to use of brackish groundwater especially in tail reach of Hakra 4-R	Land reclamation could maintain the soil fertility	Use of brackish groundwater could deteriorate soil quality rapidly in certain areas
Landholding (size<5 ha)	-	Small landholdings (91.78 %)	Enactment of law which prohibits the subdivision of land beyond optimal economic unit	Continuous subdivision of land would lead to the inefficiencies of land poverty
Rainfall	-	Relatively less rain fall	Introduction of improved water management practices	Decrease in yield due to drought-like conditions
Drainage	-	Poorly drained soils in some areas such as Chak # 76 4-R	Groundwater treatment methods such as sulfurous acid generator could be introduced	Yield potential of the soils could decrease due to soil permeability problem
Ploughing equipment	Relatively more use of modern ploughing equipment	Difficult to access farm machinery on rental basis by small farmers	FO plate form could be used to provide farm implements to farmers on rental basis There are opportunities for local industries to flourish	Delay in the availability of farm machinery could lead to the late sowing/harvesting of crops and ultimately decrease in yield
Improved seed	Use of improved seed varieties by the farmers	Mixing of different seed varieties	Implementation of seed quality standards can ensure high crop yields	Yield and investment losses due to impure seeds
Methods of sowing	-	Traditional sowing methods in most of the areas	Introduction of bed planting for wheat could deal with the problem of waterlogging and salinity	Non-uniform seed placement through traditional methods could result in yield losses
Use/availability of fertilizer	Majority of the farmers were using fertilizers	Black marketing leading to higher price of fertilizers Adulteration of fertilizers	Distribution of fertilizers through farmers' organization could ensure the timely availability and quality of fertilizers	Adulteration of fertilizers could result in low yield and the waste of investment

Items	Strengths	Weaknesses	Opportunities	Threats
Irrigation related issues Surface water	Presence of Farmer's Organization Relatively high equity in water distribution Less water theft Few disputes on water related issues	Unscheduled canal closure by Irrigation Department	Improved water application methods could be introduced through FO for better irrigation application	Prolonged canal closure could delay sowing ultimately resulting in low yield of crops
Groundwater	-	Brackish groundwater	Water treatment by sulfurous acid generator for irrigation purposes	Deterioration of land quality due to brackish groundwater application
Weed management	-	Poor weed management	Extension Department could educate farmers about the weed management	High incidence of weeds could decrease crop yields
Pest and disease management	Use of pesticides by farm households for pest control	Adulteration of pesticides is a common phenomenon	Strict implementation of quality checks could control this evil	Use of adulterated pesticides could destroy crops, resulting in economic losses to farmers
Labor issues	Abundance of labor	Low wage rate in agriculture sector	Establishment of agro-based industry could absorb additional labor in the off season	Unavailability of employment throughout the year could lead towards increasing poverty
Harvesting	Absorption of more labor for crop harvesting due to manual operations	Shortage of labor at the time of harvesting	Labor intensive technologies could be introduced	Bad weather conditions could increase harvest losses
Crop yields	-	Relatively low crop yields mainly due to unscheduled canal closure by Irrigation Department	Crop yields could be increased by ensuring the quality of agricultural inputs and irrigation water supplies	Impure chemicals were a big threat to crop yields
Marketing problem	Relatively better farm-to- market road infrastructure	1.Low output prices 2.Can not afford storage due to poor economic conditions 3. Large number of intermediaries	Transparent procurement procedure of wheat and cotton would encourage farmers to produce more	Market intermediaries were a threat because they were exploiting the farmers
Veterinary healthcare facilities	-	Poor veterinary healthcare facilities in the Hakra 4-R area	Animal healthcare centers could be established at union council level to provide facilities	Diseases and break out of epidemics were a big threat to livestock health which could lead to economic losses to farmers
Animal theft	Relatively few cases of livestock theft were reported in Hakra 4-R	-	-	An increase in animal theft could cause economic loss to farmers
Credit availability	Informal sector i.e. commission agents	Difficult access to institutional credit	Provision of soft term loans to the	High interest rates and the fear of default was a

Items	Strengths	Weaknesses	Opportunities	Threats
	provide inputs on credit	diverting farmers towards non-institutional credit sources	farmers	big threat regarding credit use for farm enterprise
Waterlogging & Salinity	-	With high rainfalls most of the areas at the head reaches of Hakra 4-R were prone to waterlogging and salinity symptoms	Land reclamation projects could be started to reduce salinity & maintain the soil fertility	Decrease in yield might result due to waterlogging and salinity leading towards increased poverty
Other socio-economic issues	Existence of Formation of farmer's organization	Dependence on farm income Lesser off-farm employment opportunities Poor economic conditions Low literacy rate	Further investment in educational facilities could provide a boost to increase literacy rate Off-farm employment opportunities could be provided through the establishment of the agro based industries	Unemployment among households in Hakra 4-R could lead the youth towards poverty

Appendix - III

Performa used for the billing of water charges to the farmers in H-4-R

Farmers' Organization at Hakra 4-R Distributary

Payment of Abiana (Water charges)
Name of Moza/Chak---------------------Crop name -----------------Due date----------------

Name		Bill serial #
Father's name		Book #
and home address		

Mogha # ------Minor ----------Reference # --------- Khata #---------- Date of issue ----------

Type/kind of crop	Rate/acre	Cultivated area	Type/kind of crop	Rate/acre	Cultivated area	Amount Rs.	Ps.
Fish farm	581/30 5812/95		Forest, rage land, reclamation area	62/02			
Sugarcane	177/16		Wheat, barley, oat, jantar	59/30			
Garden (approved)	139/50		Maize	53/14			
Vegetables, garden (unapproved)	95/22		Bajra, Pulses of all kinds	44/30			
Tobacco, cotton, reclamation area	93/02		Lucerne of all kind, jawar, guara, turnip	37/65			
Spices, medicines, fiber crop	77/52		Rural block of trees	22/14			
Rice	88/53		Ex-Rauni	15/51			
Oil seed crops	64.23		Total cultivated area				
Arrear with surcharge			Prepared by				
Total repayable bill							

Due date ---------------------------------- Repayable after due date -----------------------------

Revenue Assistant -----------------

Finance Officer ---------------------

Receipt: Rupees------------received
Signature of receiving authority--------------