POVERTY ACROSS VARIOUS CANAL COMMANDS IN IRRIGATED PUNJAB, PAKISTAN

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Abstract

Agricultural income occupies significant share of rural households' income. Only ample and reliable supplies of surface irrigation water can guarantee its improvement. As poverty is inversely correlated with improvement in incomes, provided other factors remain the same, the policy makers can use irrigation as a tool in poverty reduction programs. The inequity in surface water distribution not only affects the rural households across different irrigations but also influences the distribution of income and poverty situation in different reaches of each irrigation system. Since long, it is asserted that households in the tail reach areas have relatively poor access to irrigation water as compared to those situated in the head and middle reach areas. It is evident that more distance from irrigation source brings more households in the poverty trap are located at the tail reach area. Here, the intensity of poverty would be higher than in the head and middle reach areas. This paper tests this hypothesis with results showing that poverty increases in the tail reach areas as compared to head and middle reach areas. This calls for the need to address current hurdles exercising equity and reliability in irrigation supplies in order to provide this vital input for increasing agricultural productivity of the tail end farm households.

Introduction

Agriculture sector is a dominant sector of Pakistan, which contributes 25 percent of the gross domestic product (GDP) by employing around 44 percent of the country's labor force. Around 67 percent of Pakistan's population resides in rural areas (GoP 2001). Uplifting the living standards of the rural area means improvement for majority of the country's population.

Agriculture sector is essentially the producer of food and fiber requirement of the population. With constant population increase, this sector is facing stress regarding to optimally use of available resources for higher production. Yet, this objective can only be achieved through efficient use of land and water resources. With very limited options of expanding the agricultural land, the burden is shifted on efficient use of available irrigation water to increase productivity through most efficient use of every drop of available irrigation water for uplifting the welfare of the rural population.

Surface water plays vital role in increasing the productivity of farmers while the deficiency is met through extraction of groundwater when and where it is needed to augment the irrigation water supplies. However, groundwater quality does not allow the

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farmer to explore the full benefits of ample and reliable water supply by relatively lower productivity gain through its use as compared to the surface water supplies. It is already established that surface water supply is experiencing inequities and unreliability which hinders the farmers to exploit its benefits in a fully efficient manner. However, in the face of all these problems, the surface water supplies play a significant role in achieving higher productivity standards.

As higher productivity is synonyms to higher income and increasing capability of the farm households to spend more on fulfilling the basic necessities of the family members, irrigation water plays crucial role in ascertaining the welfare level of the households. It has been experienced that incidence of poverty is higher in rural areas of Pakistan (Arif et al. 2001). The inequity in surface water supplies has increased the scarcity of irrigation water across different irrigation systems as well as at different reaches within each system. This resulted in variation in agricultural productivity, income, and poverty incidence.

Poverty has diverse dimensions. In depth, exploration of these dimensions is always useful in understanding the phenomenon of poverty and differentiating between myths and realities attached with it. Incidence of poverty is directly dependent on income/expenditure of the households, which are not constant over all the months in a year. Moreover, good or poor harvest in different years is due to various agro-climatic and management factors. Income/expenditure dimension fluctuates over times and so does the incidence of poverty. It is also empirically established that incidence of poverty varies across different areas. Keeping in view of these facts, incidence of poverty and its relationship with variation in access to surface water supplies is explored in this paper for better comprehension of the phenomenon, which would lead to suggestions/policy implications for poverty reduction.

The paper is divided into six parts. General results are discussed in part III of the paper while in part IV, concentration is made on assessing the determinants of poverty. Part V comprises the conclusions and implications made on the basis of the current study.

Methodology

Study Area

The study is being 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 the Lower Jehlum Canal (LJC), Rechna Doab (comprising Jhang and Toba Tek Singh districts) being 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 1). The total geographic area of the Chaj Doab, Rechna Doab and Hakra area is reported to be 1.2 million hectares, 2.98 million hectares and 20,000 hectares, respectively. The salient features of irrigation system in the study area are shown in Table 1.

A stratified random sampling design was used to select the sample households in the study areas. The irrigated areas were divided into the following 5 irrigation systems:

1. UJC System 2. Gujrat System 3. LJC System 4. LCC System 5. Hakra System

Figure 1: Location of Chaj Doab, Rechna Doab and Hakra Area in Punjab, Pakistan.

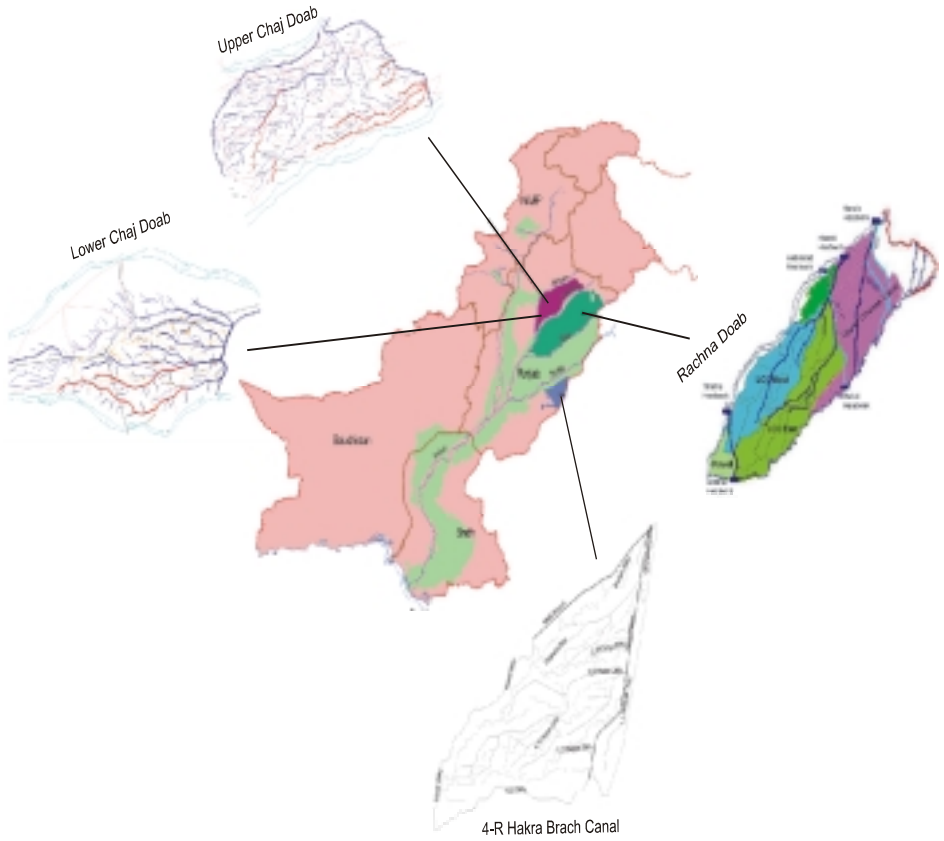


Table 1: Salient features of the selected irrigation systems in the study area.

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
Gujrat System	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
**NP=Non-perennial

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 irrigated systems in terms of cropping patterns and nature of perennial and non-perennial irrigation water supplies, therefore at the second stage, distributaries were selected on the basis of the agro-ecological characteristics based on cropping patterns, nature of water supplies (perennial/non-perennial) and location of the watercourses across head, middle and tail of the distributary. The selected areas of distributaries were homogenous in terms of these characteristics. The Upper Jehlum Canal (UJC) sub-system was divided into six distributaries, with two distributaries (9-R and 10-R) having rice-wheat as dominant 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 main crops grown in command areas of Kakowal and Phalia distributaries. Irrigation supplies in these distributaries were perennial in nature. Lalian, Khadir and Khikhi distributaries had mixed-wheat cropping pattern and received perennial irrigation supplies. The Hakra 4R distributary had cotton-wheat cropping pattern and received perennial irrigation system. 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 (head, middle and tail) due to differences in availability of water resulting from location differences. These intra-distributary variations were captured through sampling across head, middle and tail within a distributary.

Households from each of the selected watercourses were selected through systematic random sampling from a complete sampling frame for each watercourse (i.e. 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 distributaries and watercourses across head, middle and tail reaches of the selected distributaries and the sample households across each of the selected watercourses. A well-represented sample of 1224 households was selected for collecting information from the field through a well-designed pre-tested questionnaire. In case of first six distributaries in Gujrat and Mandi Bahauddin districts altogether, 540 households were selected along 36 watercourses located on the head, middle and tail areas. In each of the first six distributaries in irrigated areas, about 90 households were selected from every selected distributary in a way that equal number of 30 households from head, middle and tail reaches of the distributary was attained. In the case of last four distributaries (i.e. Lalian, Khadir, Khikhi and Hakra 4-R), about 171 households were selected from each distributary in such a way that equal number of households was interviewed from three watercourses of the head, middle and tail reaches of distributaries.

Monetary Measures of Poverty

Different measures of poverty are: 1) specification of an indicator of well being such as income or expenditure 2) specification of an income level or threshold below which a person or household is considered poor – the poverty line; and 3) construction of poverty measures. Foster-Greer-Thorbecke (FGT) class of measures is the most commonly used measure of poverty, which captures three aspects of poverty: incidence,

depth/intensity and severity of poverty. These measures are more commonly known as the Head Count Index, the Poverty Gap Index, and the Squared Poverty Gap Index.

1. Head Count 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. Suppose 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 can be defined as:

Head Count Index HC = q/n

2. 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. Non-poor are given a distance of zero. This measure can be mathematically represented as follows:

$$\text{Poverty Gap } PG = \frac{1}{n}\sum_{i=1}^{n}\frac{z - y_i}{z}$$

where z is the poverty line, y_i is the income of the individual i or household i, and the sum is taken only on those individuals who are considered poor (below poverty line).

The poverty gap can also be defined as the product of the income gap and the Head Count Index ratio, represented as follows:

PG = I*HC, where I is the income gap

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.

3. 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 simply the poverty gaps. It is represented as follows:

$$\text{Squared Poverty Gap } (PG)^2 = \frac{1}{n}\sum_{i=1}^{z}\left(\frac{z - y_1}{z}\right)^2$$

Both Poverty Gap Index and the Squared Poverty Gap Index put more emphasis on those who are further away from the poverty line. The general formula for all three measures is given below, which depends on parameter α, which takes a value of zero for the Head Count Index, one for the Poverty Gap Index 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 for various socio-economic groups and for different geographic locations (within irrigation systems).

For the poverty analysis, a rural poverty line of Rs. 676.31 per capita was used, which was established by Qureshi and Arif (1999) by using HIES survey data in 1998-99 prices on basic need basis. This was inflated to the prices of 2001, which resulted as inflated poverty line of Rs.730.78 per person. It should be noted that this poverty line in terms of money is almost equal to official poverty line as announced by the Government of Pakistan. Additionally for sensitivity analysis, another poverty line was used as Rs. 530.78 per person.

Results and Discussions

Monetary measures of poverty were estimated for the study area, which constitute ten distributaries spread over five different districts of Punjab, representing different physical, hydrological, agricultural, socio-economical, and institutional characteristics. The poverty head count, poverty gap, and squared poverty gap estimates were employed in order to fully analyze the current status, depth, and severity of the poverty across different reaches of the individual distributaries as well as for the study area as a whole. The analyses were aimed at understanding the extent and distribution of poverty due to variation in irrigation water supplies. For this purpose, two different poverty lines were used to estimate poverty, 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 generally accepted opinion that expenditure is a better reflector of the household's financial and economic position than income. The household expenditure approach is also used to circumvent under-reporting problem of income, which raises more concerns than exaggeration on the part of expenditures.

Spatial Dimension of Poverty across Irrigation Systems

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

Table 2 indicates that by using poverty line-I, overall comparison of poverty incidence at different reaches of the distributaries revealed that lowest number of poor households resided in the middle reach of the distributaries while highest head count poverty estimates were computed for head reach of the distributary. The overall incidence of poverty was estimated as 55, 58.9, and 62.9 percent for middle, tail, and head reach areas, respectively. Higher incidence of poverty in the head reach was due to high dependency ratio. At the head reach, highest poverty incidence is shown at Khikhi and Khadir distributaries where 81 and 77 percent of the household were poor, respectively. Across the head reach, the lowest poverty incidence was 37 percent, which was estimated for Kakowal distributary. In the middle reach areas, the highest incidence of poverty was 70.2 percent, again for Khadir distributary, while lowest was 37 percent, computed for 14-R Maggowal distributary. In the tail reach, highest head count poverty

estimate was 86 percent in case of Khadir distributary while lowest was 27 percent for 10-R Dhup Sari distributary.

Table 2: Estimates of poverty head count across different reaches at distributaries-based on annual expenditure.

	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

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

The comparison of estimates based on PL-I and PL-II shows that at head reach, the highest decline in head count poverty was observed 26.7 percent in case of 14-R Maggowal distributary while lowest reduction of 8.8 percent was estimated for Hakra 4-R distributary, indicating that more households at 14-R Maggowal distributary close to the poverty line would be able to shift above the poverty line if a productive push is provided to them. In the middle reach areas, the comparison of PL-I and PL-II estimates showed the probability of the highest decline in poverty to be 32 percent in case of 13-R Saroki distributary while lowest was computed to be 5.3 percent for Lalian distributary. Similarly, in the tail reach areas by comparing the estimates computed through PL-I and PL-II showed that the highest decline of poverty is possible (26.7 percent) for the command area of 14-R Maggowal distributary while lowest estimated (5.5 percent) was found for Khadir distributary. Overall comparison of incidence of poverty across head, middle and tail reach areas is shown in Figure 2 and spatial distribution of head count poverty across distributaries is revealed in Figure 3 and Figure 4 by using poverty line I and poverty line II, respectively.

Table 3 compares the poverty gap across different reaches of the distributaries by employing poverty line-I. It shows that depth of poverty was higher in tail reach areas (44.1 percent) 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 reach from their respective overall estimates as a whole. At head reach, the highest poverty gap was estimated to be 51.2 percent for Hakra 4-R distributary while the lowest was computed to be 26.5 percent for 13-R Saroki distributary.

Figure 2: Head count poverty according to location by using PL-I and PL-II.

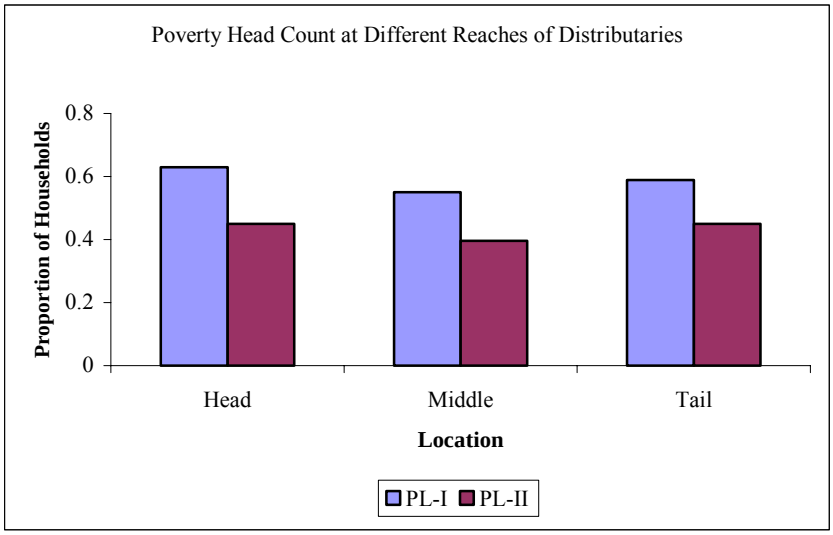


Figure 3: Head count poverty according to location at distributaries by using PL I.

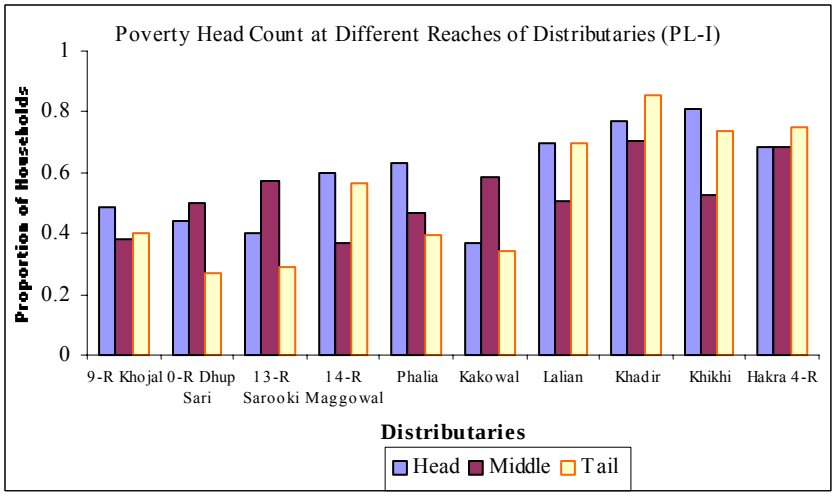


Figure 4: Head count poverty according to location at distributaries by using PL-II.

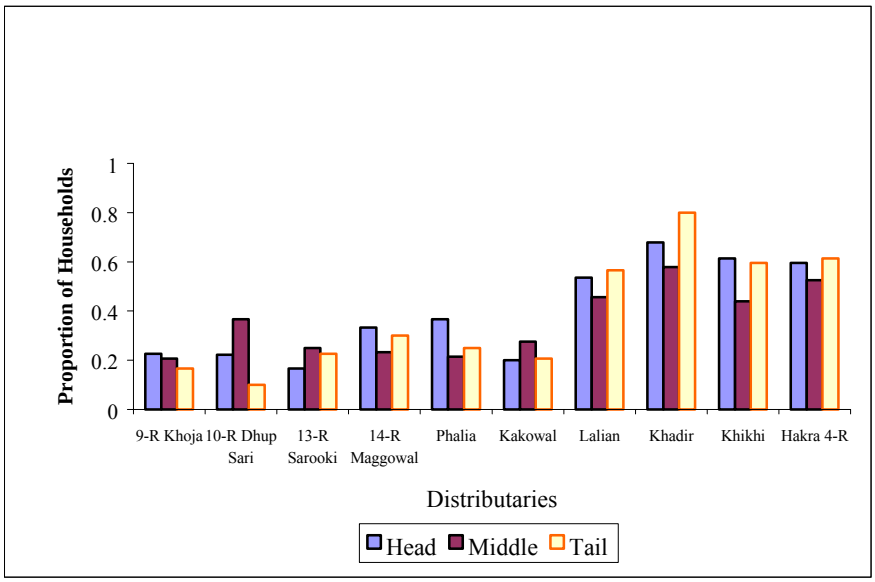


Table 3: Estimates of poverty gap and squared poverty gap across different reaches at distributaries - Indices based on annual expenditure (PL-I).

	PL-I = Rs. 730 per capita per month							
Distributaries	Head		Middle		Tail		Total	
	Poverty Gap	Squared Poverty Gap	Poverty Gap	Squared Poverty Gap	Poverty Gap	Squared Poverty Gap	Poverty Gap	Squared 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

Poor households at the middle reaches required an additional 39 percent of income to fill the poverty gap. The highest poverty gap prevailed in Khikhi distributary, which was 46.6 percent, while the lowest, 23.7 percent, appeared of 13-R Saroki distributary. At tail reaches, the highest poverty gap was estimated to be 55 percent Khadir distributary

while the lowest was estimated to be 25.7 percent for the tail reach at 9-R Khoja distributary.

Estimates of squared poverty gap indicated that the severity of poverty was lowest at middle reach and highest at the tail reach areas. At head reach, the highest squared poverty gap estimate was computed to be 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. On the other hand, the lowest estimate was reckoned to be 10.2 percent for 14-R Maggowal distributary and it was 11.2 percent lower than the overall estimate for households at head reach area. At the middle reach area, squared poverty gap was estimated 19 percent for all the households in study area. The highest severity of poverty appeared at Hakra 4-R distributary with a squared poverty gap estimate of 25.5 percent, which is around 6.5 percent higher than the overall estimate for all middle reach households. In the tail reach area, severity of poverty was estimated to be 23.9 percent for the households in that area. The highest and lowest estimates of squared poverty gap were estimated to be 33.4 percent and 10.8 percent for Kakowal distributary and Phalia distributary, respectively. Figure 5 reveals the comparison of poverty gap and squared poverty gap across head, middle and tail reaches for the whole study area by using poverty line-I (PL-I) while Figure 6 shows the poverty gap across different reaches of the selected distributaries by using PL-I.

Figure 5: Poverty gap and squared poverty gap according to location by using PL-I.

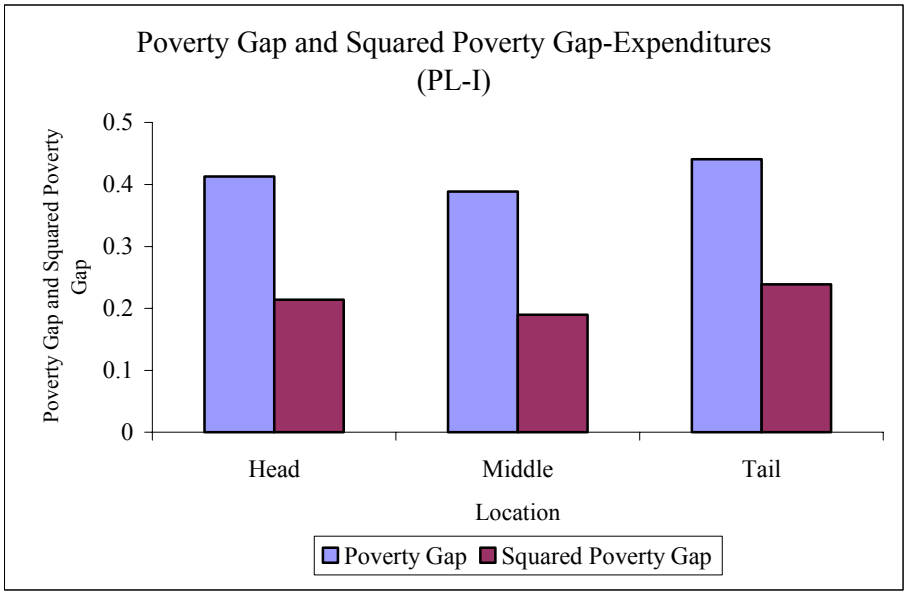
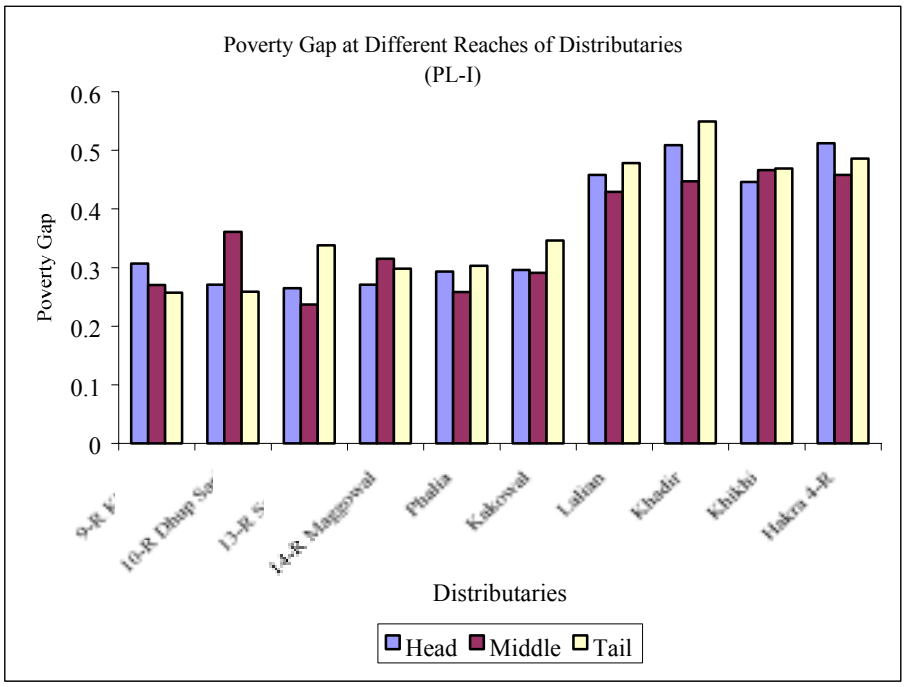


Figure 6: Spatial variation in poverty gap across distributaries using PL-I.



Comparison of poverty gap by using poverty line-II (PL-II_ as shown in Table 4 reveals that the depth of poverty was highest (35.8 %) at tail reach while the lowest (29 %) was prevailing at the middle reach area. At head reach, poor households required about 34 percent of additional expenditure to fill the poverty gap. The lowest depth of poverty was estimated to be 17.2 percent for the households at 14-R Maggowal at the head reach while the highest estimate was 39.5 percent for households at Hakra 4-R distributary.

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 worked out for 13-R Saroki distributary (13.3 percent). About 36 percent additional expenditure was required by tail reach households to bridge the gap from the poverty line.

Severity of poverty was estimated lowest at middle reach (11.8 %) and highest at the tail reach (17.3 %) areas. Highest squared poverty gap estimate (19.1 %) was computed at head reach of Hakra 4-R distributary while lowest 4.9 percent was worked out for the head reach of 14-R Maggowal distributary. In the middle reach area, the highest severity of poverty was found in Hakra 4-R distributary (18.5 %) while the lowest was 2.7 percent at middle reach of 13-R Saroki distributary. Similarly, in the tail reach area the lowest and the highest squared poverty gap estimates were calculated as 3 percent and 22.2 percent for 13-R Saroki distributary and Hakra 4-R distributary, respectively. Figure 7 shows the comparison of poverty gap and squared poverty gap across head,

middle and tail reaches for the study area while Figure 8 shows the poverty gap across different reaches of the selected distributaries by using poverty line-II.

Table 4: 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	Squared Poverty Gap	Poverty Gap	Squared Poverty Gap	Poverty Gap	Squared Poverty Gap	Poverty Gap	Squared 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 7: Poverty gap and squared poverty gap according to PL-II.

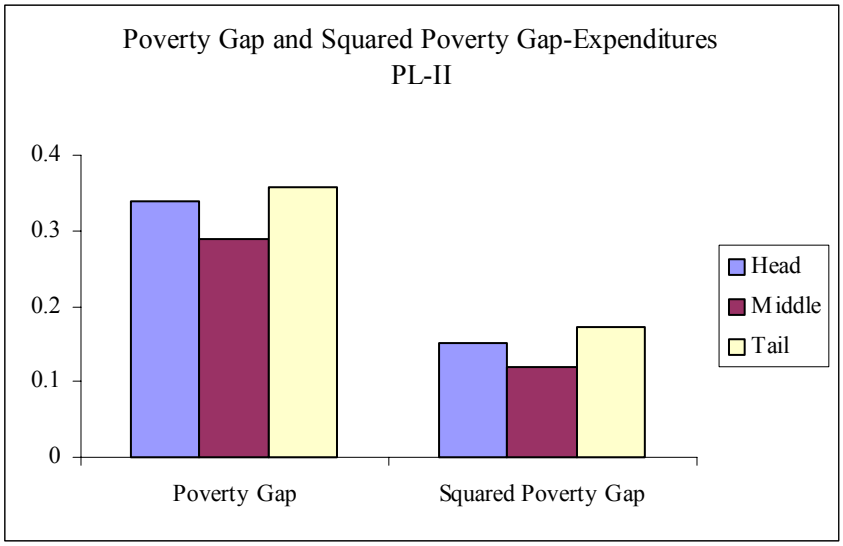
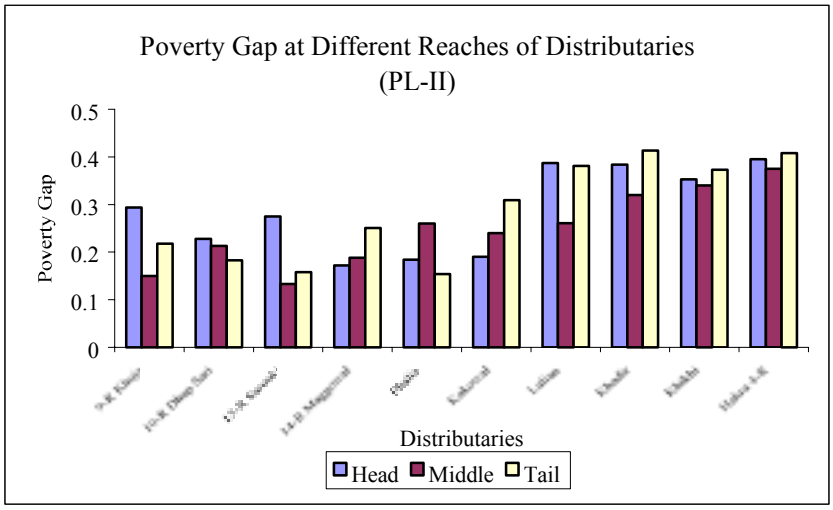


Figure 8: Poverty gap according to location at distributaries by using PL-II.



Determinants of Poverty

In order to determine the effect of differential access to ample and reliable surface irrigation water on poverty, Logit modeling was employed. Logit modeling technique is used when dependent variable is binary with values 1 or 0. The coefficients of independent variables tell about the probability of happening or not happening of one of the two possibilities of dependent variable.

From the estimated coefficients of the model, marginal effect of each independent variable was calculated. The marginal probability is defined as 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.

The model specifications are as follows:

Poverty	=	$\beta 0 + \beta 1 * FS + \beta 2 * DR + \beta 3 * Edu\_HH + \beta 4 * NLH ++ \beta 5 * GVP\_Ha + \beta 6 * DM + \beta 7 * DT + e$
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)
DM	=	Dummy for the Middle Location
DT	=	Dummy for the Tail Location
β0	=	Constant term
β1…β7	=	Coefficients to be estimated
e	=	Error Term

Family Size

It was expected that higher the family size, higher would be the probability of the household to be poor. Due to this fact, with increase in family size, higher amount of money would be required to meet the basic needs of all the members of household. It was expected that coefficient of family size would be positive with respect to sign.

Dependency Ratio

Dependency ratio was defined as the ratio of number of household members below 16 years and above 60 years divided by family size. It was expected that with increase in dependent members in the household, probability of being poor would be higher due to higher amount of money demanded to fulfill the basic needs of the households. Moreover, as these dependent members did not earn any money, it would be hard for the household to be above the poverty line. A positive sign for the coefficient of dependency ratio was expected, indicating an increased probability of the household to be poor with high dependency ratio.

Education of Household Head

More education simply leads to higher earning potential by better management of the household resources, and thus has negative effect on poverty. Consequently, more education of household head would lead the household out of vicious circle of poverty. Therefore, expected sign for the coefficient was negative.

Net Landholding

The occupation of more landholding was expected to result in more crop production leading to higher agricultural income. It was expected that increase in net landholding would decrease the probability of the household to become poor. So, a negative sign was expected for the coefficient of net landholding indicating inverse relationship with poverty.

Gross Value of Production per Hectare

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

Location of the Households

The location of the households along the irrigation system reflected the farmers' access to irrigation water in presence of inequities prevailing in distribution of this vital input

of agricultural production. It was expected that households at the head reach of the irrigation system would have better agricultural production and income leading to decreased probability of head reach households to become poor as compared to households at middle and tail reaches of the distributary.

Estimated Results

The results of the Logit regression are presented in Table 6. Signs of the explanatory variables were in conformity with the a priori expectations. All the coefficients except dummies for middle and tail reaches were found significant at 99 percent level. It was found that one member increase in family would increase the probability of being poor by 0.026. It indicates the positive correlation with poverty. It was also estimated that one unit increase in dependency ratio would increase the probability of being poor by 0.246. Keeping in view the positive correlation of increase in family size and dependency ratio, an inclusion of new born or exclusion of a family member from the category of working member and inclusion into dependents would increase the probability of the household to become poor. 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 one thousand rupees in gross value of production per hectare would diminish the probability of being poor by 0.009. It was also found that probability of being poor increases by 0.012 and 0.96, if households were located at middle and tail reach areas, respectively, instead of head reach. It clearly indicates that the probability of increase in poverty in the tail reach area was higher than in the head and middle reach areas.

Table 6: Regression results according to location at distributaries.

Variables	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 significance level
* Significant at 95 percent significance level

Conclusions and Implications

- Incidence of poverty was highest in the head reach area while it was lowest in the middle reach area.
- Higher proportion of the poor population in the head reach area was found sensitive to change in poverty line as compared to middle and tail reach areas.
- The highest poverty gap was estimated for the tail reach area while the lowest was found in case of poor households in the middle reach area.
- In case of change in poverty line, the highest decline in poverty gap estimate was experienced for poor households in the middle reach areas as compared to head and tail reach areas.
- The severity of poverty was higher in the tail reach areas as compared to the head and middle reach areas.
- In case of using lower poverty line, the highest decline in severity of poverty estimate was observed for households at the middle reach area as compared to head and tail reach areas.
- Though slightly lower incidence of poverty was estimated for tail reach areas, the depth and severity of poverty was higher in tail reach areas as compared to head and middle reach areas.
- Family size was found an important determinant of poverty. A rise in family size was expected to increase the probability of household to become poor.
- An increase in dependency ratio was expected to increase the probability of the household to become poor.
- Increase in net landholding was found capable of decreasing the probability of household to become poor.
- More education for all the family members, especially for the head of the household, would enhance the ability to fight against the poverty.
- Improvement in agricultural performance of household as reflected through gross value of product per hectare decreases the probability of household to become poor.
- Household located at the head reach of the distributary had lower probability of becoming poor as compared to households at the middle and tail reach areas of the distributary.
- The more investment in population planning and new round of land reforms for the creation of viable economic land units is necessary for poverty reduction.
- The improvement to surface irrigation water access would decrease the probability of the household to become poor.
- Measures to decrease the inequity and unreliability in surface water supplies should be addressed to decrease the chances of rise in poverty in middle and tail reach areas as compared to the head reach areas.

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