Part 2

Chapter IV Study Design and Settings

4.1 Selection of Study Area

The irrigation systems in districts Mandi Bahauddin and Gujrat were selected as case studies in Pakistan. The selected areas can be divided into sites with access to irrigation infrastructure and into sites that are presently rain-fed. The study area exhibits considerable variability in cropping patterns and access to irrigation water. Crops grown in the area are wheat, rice, sugarcane and other field crops.

4.2 Profile of the Study Settings

Gujrat district is in the northern most portion of the Chaj Doab lying between the Jehlum and Chenab rivers. The district lies between north latitudes 32^{o}– $19^{\backslash}$ to 33^{o}-$03^{\backslash}$ and east longitudes 73^{o}-$31^{\backslash}$ to 74^{o}-$28^{\backslash}$. It is bounded on the north-east by districts Mirpur and Bhimber of Azad Jammu and Kashmir; on the north-west by the river Jhelum (which separates it from Jhelum district); on the south-east by the river Chenab (separating it from the districts of Gujranwala and Sialkot); on the east by the river Ravi (which separates it from Sialkot district), and on the south-west by Mandi Bahauddin district. The total area of Gujrat district is 3,192 square Km. Jhelum River enters the district form Kashmir hills towards the northeast corner of the district and flows in a southwesterly direction forming its northwestern boundary with the Jhelum district. The riverbed of the Jhelum is better because the Jhelum carries more silt than the Chenab. The amount of good soil washed down from the Bar into the Jhelum riverine is larger than in the Chenab riverine. The water table is low and wells can easily be dug. Water table is closer to surface varying from 3 to 6 meters. Sub-soil is sandy and gets benefit form seepage. The old riverbed of the Chenab can be seen in a well-marked high bank, and the low lying land below it has received so much silt that it is not inferior in quality to the land above the original bank. The rest of the district is the old riverbed with sub-soil of sand and a thin top layer of silt. The Upper Jhelum canal (UJC) through its 13 distributaries and 427 watercourses irrigates the western half of the district. The UJC irrigates part of the Gujrat district and flows into the river Chenab to provide irrigation water for the Upper Chenab Canal (UCC) which irrigates partly Sialkot and Gujranwala districts and then goes on to cross the River Ravi, and with water from Ravi irrigates part of Sahiwal and Multan districts in the command areas of the Lower Bari Doab canal. Total irrigated area of UJC is about 28,000 hectares. Among the 13 distributaries of UJC, distributaries 3-R to 10 R are perennial and provide water throughout the year, remaining five distributaries 11–R to 15–R are non-perennial and supply irrigation water during the Kharif season only. Groundwater is another main source of irrigation in district. There are 12785 tubewells in Gujrat. Out of these, 10210 are run by diesel and 2575 by electric power. About 91000 hectares are estimated to be irrigated with tubewells.

Mandi Bahauddin district forms central portion of the Chaj Doab lying between Jhelum and Chenab rivers. It lies between 30^{0} – $8^{/}$ to 32^{0} - $40^{/}$ north latitudes and 73^{0} – $36^{/}$ to 37^{0}- $37^{/}$ east longitudes. Tehsil headquarters towns of Phalia and Malikwal are at the distance of 22.5 and 28.5 kilometers from Mandi Bahauddin, respectively. The shape of the district is like a parallelogram. It is bounded on the north by river Jhelum (which separates it from Jehlam district); on the west by Sargodha district; on the south by river Chenab (which

separates it from the Gujranwala and Hafizabad districts); and on the east by Gujrat district. Total area of the district is 2,673 square kilometers. The district comprises of three tehsils, namely, Mandi Bahauddin, Phalia and Malikwal. Mandi Bahaduddin is also a land of two rivers; Jhelum flows along the northern boundary and Chenab along southern boundary. Flows in both the rivers shrink to small steams in winter. In hot weather, the rivers are swollen by the melting snow in Kashmir and upper regions and by rains. Agricultural areas in Mandi Bahauddin are irrigated by an irrigation network comprised of 13 distributaries along with 961 watercourses and tubewells. The Upper Jhelum Canal (UJC) emanates from Mangla Dam and irrigates the eastern, central and major portion of the western part of the district, through Gujrat Branch and a network of distributaries and minors. The Lower Jhelum Canal (which originates from Rasul Barrage) irrigates a part of Tehsil Malikwal before flowing into Sargodha district. Groundwater is also used for irrigation in the district.

4.2.1 Agro-climate of Study Area

Summers in Gujrat are, generally hot. Winter, which begins in October, is dry. In January and February, frost is common and temperature falls below the freezing point over few nights. Weather gets warmer in April. The hottest months are May, June, July and August, and the coldest months are December and January. Minimum and maximum temperatures range between 5.00 ^{o}C to 25.80 ^{o}C and 19.70 ^{o}C to 40.60 ^{o}C, respectively. Annual average precipitation is reported to be 853 mm and average relative humidity is 56.2 percent. Rainfall in the district varies considerably across various parts of the district and decreases rapidly southwest away from the Himalayas. It is somewhat heavier near the rivers than in the dry uplands. The district is subject to floods from the rivers Jhelum and Chenab. The principal crops grown in Gujrat are wheat, rice and sugarcane. Other crops grown are barely, gram, lentils, bajra (millets), jowar (sorgham), maize, oil-seeds and tobacco. Rabi (winter) crops are sown following heavy rains in July, August and September. Winter rains are important for maturing of Rabi crops. Sowing of Kharif (summer) crops is generally done after the first monsoon rain. Rice is a major Kharif crop, and wheat and gram are Rabi crops.

District Mandi Bahauddin is located 244 meters from the sea level. Climate is extreme but favorable for agriculture. The district gets warmer from April onwards. The hottest months are May, June and July. Mean maximum and minimum temperatures during this period are about 39.5 and 25.4 centigrade respectively. Winters begin in October. Coldest months are December, January and February. Frost is common in January and February and temperature falls below the freezing points over few nights. Winter days are generally pleasant. Maximum and minimum temperatures during winters are about 21.5 and 5.1 degree centigrade respectively. Rainfall varies considerably across various parts of the district, with annual average rainfall at about 435 mm. Mandi Bahauddin is a fertile agricultural belt, with main crops grown are wheat, maize, sugarcane and tobacco. Tobacco covers the largest proportion of the total cropped areas, followed by wheat and rice. The district has immense potential for growing fruits such as citrus, guava, banana and mango. While there are relatively less opportunities to rear cattle in irrigated cropped areas of the district, there is enormous potential to raise cattle in the riverine of the Chenab and Jhelum where large grazing areas are available. There has been significant increase in the number of cows and buffaloes in recent years. There is a large increase reported in imported and local crossbreeds of cows in the riverine areas. In 1998, cattle population in the district was reported to be 1,471,720. Veterinary hospital and dispensaries are functioning at markaz and union council levels, where Veterinary Officers and Assistants are posted to administer prophylactic vaccines to the cattle heads of their area at the doorstep of farmers. There are 12

veterinary hospitals, 41 veterinary centers (Provisional) and 11 veterinary dispensaries in the area.

4.2.2 Socio-economy of Study Area

Total population of Gujrat District is 2048008 as estimated in March 1998 with an intercensal percentage increase of 45.5 since March 1981 (when it was 1408585 persons), with annual average growth rate of 2.1 percent during the period. Total area of the district is 3192 square kilometers, which gives population density of 642 persons per square kilometer as against 441 persons observed in 1981, indicating a fast growth rate of the district. Based on the population census, total lifetime in-migrants in Gujrat district is reported to be 5.8 percent of the total population of the district. Of total district migrants, 72.1 percent are reported to come from other districts of Punjab, 9.7 percent from Sindh, NWFP and Baluchistan, 2.5 percent repatriated from other countries. The recent population census defines economically active population as number of persons working most of the time during the year preceding the census date i.e. 5th March 1998. Out of the total male population, 38.4 percent were economically active, 61.6 percent were not economically active, 28.1 percent were children under 10 years, 18.5 percent were students, 2.4 percents were domestic workers while 12.6 percent were land lords, property owners, retired persons, and disabled. The participation rate of people is much higher in urban areas as compared to those living in rural areas. In 1998, unemployment rate in district Gujrat was estimated to be 21.6 percent, with unemployment being higher among male population (22 percent) compared to that in female population (6 percent) [unemployment rate is measured as ratio of persons looking for work and laid off in total economically active population comprising employed, looking for work, laid off and un-paid family helpers, generally representing in percentage]. Lower female unemployment rate was because of small proportion of female in total economically active population. Overall, unemployment rate is higher in urban (23 percent) as compared to rural areas (21 percent). According to population census of 1998, over 36 percent of total population have elementary occupations, followed by 29.4 percent skilled agricultural and fishery workers, 11.6 percent service workers, shops and market sales-workers, and 7.2 percent craft and related trade workers. In rural areas, skilled agricultural and fishery workers were in majority followed by elementary occupations and service workers, shop and market sales workers, representing 40.1, 37.4 and 7.2 percent of total population respectively. The latest population census reports that majority of employed persons in 1998 were working in construction industries, followed by agriculture, forestry, hunting and fishing industries, and community, social and personal services industries, representing 30.8, 29.5, and 12.6 percent, respectively. In rural areas, 40.7 percent were working in agriculture, forestry, hunting and fishing industries, 32.8 percent in construction industries and 8.5 percent in community, social and personal services industries. Altogether, there are 1991 educational institutions in Gujrat, providing education from primary to postgraduate levels. There are about 940 health units providing health facilities throughout the district.

Total population of Mandi Bahauddin is about 1,160,552, as estimated in 1998 census. Annual average growth rate of population is reported to be 1.9 percent during 1981-1998 while the population density is estimated to be 434 persons per square kilometer compared to 317 persons for 1981, indicating a fast growth rate of population in the district. In 1998, total number of lifetime in-migrants in Mandi Bahauddin district was 5.3 percent of district's total population. According to the population census, out of the total district migrants, 75.1 percent came from other districts of Punjab, 3.4 percent came from Sindh, NWFP and Baluchistan, 3.0 percent from Azad Kashmir and Northern Areas while

remaining 18.5 percent were Pakistanis who repatriated from other countries. The economically active population as estimated in the population census (1998) comprised of 41.6 percent of the total male population. Participation rate of population is much higher in urban areas as compared to that in rural areas. Unemployment rate in the district was reported to be 13.0 percent that was mainly due to unemployment amongst male population (13.3 percent) compared to only 1.8 percent for females. Low unemployment rate for female was because of their small proportion in total economically active population. Unemployment rate was higher in urban (21.8 percent) as compared to rural areas (11.5 percent).

Population census of 1998 reports that majority of employed persons in Mandi Bahauddin were working in agriculture, forestry, hunting and fishing industries (40.3 percent), followed by construction industries (36.5 percent) and community, social and personal services industries (8.3 percent). In rural areas, 44.4 percent were working in agriculture, forestry hunting and fishing industries, 37.4 percent in construction industries and 6.9 percent in community, social and personal services industries.

There are eight colleges in Mandi Bahauddin that provide graduate and postgraduate level education. There are 83 high schools, 108 elementary schools and 107 primary schools in the district. Tehsil Headquarters Hospital at MB was upgraded to a District Headquarters Hospital in 1993. In addition, there are a large number of private hospitals and health clinics in the district. Welfare organizations and NGOs are also running charity hospitals. Two such projects are, the Maternity Hospital managed by Shehri Ijtimai Taraqiyati Council (SHATIC), and a big free eye and general hospital functioning at Dera Mian Sahib (Tehsil Mandi Bahauddin) under the auspices of Rifahi Markaz. These two hospitals are rendering services to the deserving patients free of cost.

4.3 Sampling Procedures

A well-designed multistage stratified random sampling was adopted for selecting the specific sites and sample households within these sites. As there were variations in irrigated systems in terms of cropping patterns and nature of perennial and non-perennial irrigation water supplies, therefore, strata were defined based on the following agro-ecological characteristics:

1.Existence of irrigation infrastructure
2.Existence of improved /unimproved irrigation infrastructure
3.Nature of water supplies- perennial / non-perennial
4.Cropping patterns

Accordingly, the entire study area was divided into four distinct strata in stage 2:

1) Stratum - 1 characterized by rain fed farming in district Gujrat;
2) Stratum – II characterized by Rice–Wheat rotation with Perennial irrigation;
3) Stratum – III characterized by Rice–Wheat rotation with Non-Perennial irrigation;
4) Stratum – IV characterized by Mixed–Wheat rotation with Perennial irrigation.

After stratification at the higher level, each of the strata was divided into several clusters. These clusters were basically distributaries or villages (in the case of rain-fed stratum) in each stratum. At the first stage of 3-stage cluster sampling, two

clusters/distributaries in each of the above three strata were selected such that the selected clusters in a stratum were representative of all the clusters within a stratum. At the second stage, six watercourses (three improved and three unimproved) from each of the selected clusters were selected randomly across head, middle and tail reaches of the cluster. For this, each selected cluster/distributary was divided into three equal parts (based on the total distance of the distributary and total number of water courses along the distributary) and one unimproved watercourse from each of the three parts was selected randomly. Once the unimproved watercourses along the distributary were selected, the closest improved watercourse located in the respective part of the distributary was selected (for the purpose of having maximum possible homogeneity in conditions in making comparisons of unimproved with improved water courses).

At stage three, households from each of the selected watercourses were selected through systematic random sampling from a complete sampling frame for each watercourse (i.e from list of all households on the watercourse). Landless households were drawn through systematic random sampling based on their proportion in total number of households on each selected watercourse. While stratum 4 was relatively large in size than strata 2 and 3, there would not be any gains in selecting more than 2 clusters from this stratum because the selected clusters were representative of all clusters in the stratum. In short, equal allocation method was adopted for selecting clusters/distrubutaries, improved/unimproved watercourses across head, middle and tail reaches of the selected distributaries, and the sample households across each of the selected watercourses.

4.3.1 Sample Size

Altogether, 540 households were selected along 36 watercourses located on six distributaries in three strata in irrigated areas, and 180 households in rainfed stratum. In each of the three strata in irrigated area, 180 households were selected such that we have an equal sample of 270 households from each category of improved and unimproved watercourses. A sample of 90 households was selected from each distributary such that we have equal numbers from head, middle and tail reaches of the distributary (i.e 30 households). A total sample of 720 households was used for surveys. Details are provided in **Table 4.1**.

Table 4.1: Selected Stata and Sample Size

Sample Distribution	Number
Total Number of selected HH in Stratum 1	180
Total Number of selected HH in Stratum 2	180
Total Number of selected HH in Stratum 3	180
Total Number of selected HH in Stratum 4	180
Total Number of selected HH in Improved watercourses	270
Total Number of selected HH in Unimproved watercourses	270
Total Number of selected HH in each Distributary	90
Total Number of selected HH in each Water Course	15
Total Number of selected HH in each Head/Middle and Tail of the Distributary	30
Total Number of selected HH in Irrigated Area	540
Total Number of selected HH in Rain fed Area	180
Total Sample	720

4.4 Characteristics and Sample Selection Within Study Sites

4.4.1 Stratum I

The Stratum I (Rain fed area) lie in the northern part of district Gujrat (**Table 4.2**). There are altogether 138 villages in Tehsil Gujrat. Out of these, 35 villages are located in areas where groundwater is at relatively lesser depth and irrigation is practiced through tubewells. In the rest of 103 villages, agriculture is completely dependent upon rains. Stratum-I was surveyed thoroughly, and six representative villages (Dherkay, Gigian, Mianawal, Jalapur Sobbtian, Chack Kamala and Baru) were selected randomly. These constituted around 6 percent of the total number of villages in the stratum. The selected villages are located closer to towns of Gujrat, Jalal pur Jattan and Karianwala.

Table 4. 2: Number of villages in stratum 1 in rain fed area of Gujrat district.

Stratum 1	Number
Total No. of villages in Tehsil Gujrat	138
No. of villages in Rain fed area	103
No. of villages in Irrigated area	35
No. of selected villages in Rain fed area	6
Selected villages as % of total villages in Stratum1	6

Households in selected villages were drawn through systematic random sampling from comprehensive sampling frame. Sampling frame of households was developed using available recent voter lists for each of the selected villages. Data in voter lists suggest that there are 1843 households in selected six villages (482, 145, 235, 565, 109 and 307 in Dherkay, Gigian, Mianawal, Jalapur Sobbtian, Chack Kamala and Baru, respectively). A sample size of little less than 10 percent (180) of total of 1843 households (47, 14, 23, 55, 11 and 31 from Dherkay, Gigian, Mianawal, Jalapur Sobbtian, Chak Kamala and Baru, respectively) was selected from all the six selected villages. Selected households represented landless as well as farm households. Every 10^{th} household was selected through systematic random sampling from lists of households in selected villages.

4.4.2 Stratum-II

During inception activities for this study, it was observed that command areas of distributaries 3-R to 6-R of UJC system fall in the periphery of Kharian town. The team visited the agricultural area of Tehsil Kharian commanded by these distributaries, and observed that people living in this area were much better-off as compared to those in other areas of Tehsil Gujrat and Mandi Bahauddin. This was mainly due to inflow of remittances from abroad. The team had interviews with farmers at different locations in the area, and found that about 60 to 70 percent of households in the area have one or more household members abroad. Significant inflow of remittances was quite visible form quality of houses (luxury) in the area. This area was totally non-representative and was excluded from the study. With exclusion of this area, the only option available was to select distributaries among 7–R to 10-R. Since there was some influence of Kharian area on its neighboring areas, it was important to move as farther away from Kharian as possible to minimize the

bias. Consequently, two distributaries 9–R and 10–R were finally selected. These distributaries comprise of 72 watercourses, of which 30 are improved and 42 are unimproved. Farm size in the selected distrubutaries ranges from 2 to 6 hectare. Both distributaries are fair representations of cropping patterns (Rice –Wheat) in perennial systems of the stratum.

Table 4.3: Number of distributaries and watercourses in stratum-II.

Stratum 2	Total No.of Distys.	No. of WCs in Selected Distys	Selected WCs
Distributaries in Stratum 2	4		
Selected Distributaries in Stratum 2	2		
Water Courses in Stratum 2	72	52	12
Improved WCs in Stratum 2	30	16	6
Unimproved WCs in Stratum 2	42	36	6
WCs in 9-R distributary	29	29	6
Improved WCs in 9-R distributary	7	7	3
Unimproved WCs in 9-R distributary	22	22	3
WCs in 10-R distributary	23	23	6
Improved WCs in 10-R distributary	9	9	3
Unimproved WCs in 10-R distributary	14	14	3

There are altogether 72 watercourses, of which 30 are improved and 42 are unimproved. One watercourse each of improved and unimproved across head, middle and tail of the distributary was selected. Since each of the watercourse had a unique RD (Reduced Distance) Number, which increases from head to tail of the watercourse, each distributary was divided into head, middle and tail parts by dividing the RD numbers in three equal parts. Then, from each part, two watercourses (one each of improved and unimproved) were selected through simple random sampling (while unimproved watercourse was selected randomly, attempt was made to select improved watercourse that was closer to the selected unimproved watercourse). Thus six watercourses (three improved and three unimproved) were selected from each distributary. Watercourses selected from Distributary 9–R were 9580-L, 9700-R, 20830-L, 14600-L, 28288-R and 29500-TL (which are located in villages, namely, Sikar Wali, Chak Mehmood, Warraichanwala, Khoja, Suli Wind, Mahmood, and Bakhat Jamal). Watercourses selected from the Distributary 10–R were 8780-R, 9900-L, 20049-L, 22500-R, 27940-R and 23000-L. These watercourses irrigate the area in villages, namely, Bagrianwala, Mughali, Chak Hussa, Kalu Sahi Kalan, Kalu Sahi Khurd , Shergarh, Jamobola and Fattah Lama (**Table 4.3**).

In order to select households, a complete listing of the households in villages in the command areas of each of the 12 watercourses along distributaries 9-R and 10-R were compiled/prepared using both primary and secondary sources (including information from PID, OFWM, PGC). In the case of improved watercourses, these lists were compared with the lists provided by JBIC to make sure that the improved watercourses (for which the household lists were obtained) were also listed in the JBIC list. A sample of 15 households was selected along each watercourse by selecting every fourth household on the list through systematic random sampling. Total sample size for this stratum comprises of 180 households (15 households on each of the 12 selected water courses).

4.4.3 Stratum-III

Irrigation supplies in stratum III area are routed from UJC through 5 distributaries, 11-R to 15-R. These distributaries are non-perennial and irrigate rice-wheat cropping zone of districts Gujrat and Mandi Bahauddin. In this stratum, two distributaries, 13-R and 14-R were selected as representative distributaries for the stratum. These distributaries have both improved as well as unimproved watercourses.

There are altogether 237 watercourses in this stratum, of which 69 are improved and 168 are un-improved. Watercourses in this stratum were selected using the same procedure as followed for selecting watercourses in stratum II, as described above. Six watercourses (three improved and three unimproved) were selected from each 13-R and 14 –R. Watercourses selected from 13 – R are 18040-R, 17017-L, 21642-R, 18060-R, 38537-L and 42640-TL. They are located in villages, namely, Nagranwala, Musa, Chokori, Bakhu, Chak Mansoor, Kot Shamas Mogowal, Kot Kana and Kiru Munda. Watercourses selected from 14 – R are 86090-L, 81090-L, 97539-L, 94996-L, 132416-R and 129915-L. These watercourses irrigate areas in villages, namely, Kot Sher Muhamad, Musa Kalan, Chak Mitha, Kot Sattar, Thatha Alia, Phire and Kot Muhammad Shah (**Table 4.4**).

Households along selected watercourses in distributaries 13-R and 14-R were selected using same procedure as adopted for selecting households for stratum II, as described above. Total sample size for this stratum comprises of 180 households (15 households on each of the 12 selected water courses).

Table 4.4: Number of distributaries and watercourses in stratum III.

Stratum 3	Total No. of Distys	No.of WCs in Selected Distys	Selected WCs
Distributaries in Stratum 3	4		
Selected Distributaries in Stratum 3	2		
Water Courses in Stratum 3	237	157	12
Improved WCs in Stratum 3	69	27	6
Unimproved WCs in Stratum 3	168	126	6
WCs in 13-R distributary	18	18	6
Improved WCs in13-R distributary	4	4	3
Unimproved WCs in 13-R distributary	14	14	3
WCs in 14-R distributary	135	135	6
Improved WCs in 14-R distributary	23	23	3
Unimproved WCs in 14-R distributary	112	112	3

4.4.4 Stratum-IV

Command areas of stratum IV are irrigated through 13 distributaries. All these distibutaries are perennial except one minor of Phalia distributary. In all these distributaries, farmers practice mixed – wheat rotation. Wheat, maize, sugarcane are main crops grown in

these areas. Two representative distributaries, namely Kakowal and Phalia, were selected from Gujrat branch and Phalia branch respectively. Kakowal has 50 watercourses, of which 6 are improved and 44 are unimproved. Phalia has altogether 152 watercourses, of which 21 are improved and 131 are unimproved.

There are altogether 961 watercourses in this stratum, of which 199 are improved and 762 are un-improved. Watercourses in this stratum were selected using the same procedure as followed for selecting watercourses in stratum II and III, as described above. Six watercourses (three improved and three unimproved) were selected from each Kakowal and Phalia. Watercourses selected from Kakowal are 24400-L, 24000-L, 67500-R, 68798-R, 77650-L and 77129-R. These are located in villages, namely, Chak 40, Bhikhi and Busal. Watercourses selected from Phalia are 33610-L, 31000-L, 125392-R, 125061-L, 203000-R and 200103-R. These irrigate areas in villages namely, Charran wala, Chak Jewan, Takhat Mehal, Kot sher Mohammad and Musa Kalan (**Table 4.5**).

Table 4.5: Number of distributaries and watercourses in stratum IV.

Stratum 4	Total No. of Distys	No. of WCs in selected Distributaries	Selected WCs
Distributaries in Stratum 4	13		
Selected Distributaries in Stratum 4	2		
Water Courses in Stratum 4	961	202	12
Improved WCs in Stratum 4	199	27	6
Unimproved WCs in Stratum 4	762	175	6
WCs in Kakowal distributary	50	50	6
Improved WCs in Kakowal distributary	6	6	3
Unimproved WCs in Kakowal distributary	44	44	3
WCs in Phalia distributary	152	152	6
Improved WCs in Phalia distributary	21	21	3
Unimproved WCs in Phalia distributary	131	131	3

Full sampling plan and details of selected strata, distributors, and households are given in **Table 4.6**

Table 4.6: Summary of the system, strata, distributary, watercourse number total household size and sample population.

System	Stratum	Distributary	WCID	WC No.	Total FHH	Total LLHH	Total HH	Sample FHH	Sample LLHH	Sample HH	Every ith Person	Unimp/Imp	Location	Village	CCA (Ha)	Year of Improvement
Gujrat System (2)	Stratum 4 (4)	Kakowal (9)	31	24400-L	70	15	85	12	3	15	6	Unimproved	Head	Chak 40	297	
			32	24000-L	30	10	40	11	4	15	3	Improved	Head	Chak 40 & Bhikhi	176	1994-95
			33	67500-R	43	20	63	10	5	15	4	Unimproved	Middle	Busal	128	
			34	68798-R	55	25	80	10	5	15	5	Improved	Middle	Busal	154	1993-94
			35	77650-L	40	16	56	11	4	15	4	Unimproved	Tail	Busal	175	
			36	77129-R	86	22	108	12	3	15	7	Improved	Tail	Busal	197	1995-96
		Phalia (8)	37	33610-L	56	44	100	8	7	15	7	Unimproved	Head	Charran Wala	159	
			38	31000-L	26	24	50	8	7	15	3	Improved	Head	Chak Jewan	42	1995-96
			39	125392-R	27	23	50	8	7	15	3	Unimproved	Middle	Takhat Mehal	108	
			40	125061-L	52	48	100	8	7	15	7	Improved	Middle	Takhat Mehal	182	1995-96
			41	203000-R	1	119	120	1	14	15	8	Unimproved	Tail	Kot Sher M. & Musa Kalan	195	
			42	200103-R	32	23	55	9	6	15	4	Improved	Tail	Kot Sher M. & Musa Kalan	219	1995-96
UJC System (1)	Stratum 3 (3)	14-R Maggowal (7)	25	86090-L	50	18	68	11	4	15	5	Unimproved	Head	Chak Mitha	280	
			26	81090-L	23	11	35	10	5	15	2	Improved	Head	Chak Mitha	157	1995-96
			27	97539-L	33	17	50	10	5	15	3	Unimproved	Middle	Kot Sattar & Thatha Alia	326	
			28	94996-L	60	27	87	10	5	15	6	Improved	Middle	Kot Sattar	135	1996-97
			29	132416-R	59	27	86	10	5	15	6	Unimproved	Tail	Phire & Kot M. Shah	134	
			30	129915-L	47	23	70	10	5	15	5	Improved	Tail	Phire & Kot M. Shah	72	1992-93
		13-R Saroki (6)	19	18040-R	55	70	125	7	8	15	8	Unimproved	Head	Nagranwala & Musa	170	
			20	17017-L	35	23	58	9	6	15	4	Improved	Head	Chokori Bakhu	150	1995-96
			21	21642-R	44	25	69	10	5	15	5	Unimproved	Middle	Chokori Bakhu	106	
			22	18060-R	42	19	61	10	5	15	4	Improved	Middle	Chokori Bakhu, Chak Mansoora & Kot Shammas	142	1995-96
			23	38537-L	40	15	55	11	4	15	4	Unimproved	Tail	Maggowal	89	
			24	42640-TL	62	0	62	15	0	15	4	Improved	Tail	Kot Kana & Kiru Munda	204	1992-93
	Stratum 2 (2)	10-R Dhup Sari (5)	13	8780-R	20	19	39	7	8	15	3	Unimproved	Head	Bagrianwala & Mughali	156	
			14	9900-L	34	21	54	9	6	15	4	Unimproved	Head	Bagrianwala & Mughali	89	
			15	20049-L	48	13	61	12	3	15	4	Improved	Middle	Chak Hussa	200	1995-96
			16	22500-R	49	8	57	12	3	15	4	Improved	Middle	Kalu Sahi Kalan	118	1996-97
			17	27940-R	49	12	61	12	3	15	4	Unimproved	Tail	Kalu Sahi Khurd & Shergarh	236	
			18	23000-L	50	15	65	12	3	15	4	Improved	Tail	Jamobola & Fattah Lama	109	1995-96
		9-R Khoja (4)	7	9580-L	50	14	64	12	3	15	4	Unimproved	Head	Sikar Wali & Chak Mehmood	135	
			8	9700-R	33	17	52	10	5	15	3	Improved	Head	Warraichanwala	182	1992-93
			9	20830-L	37	14	51	11	4	15	3	Unimproved	Middle	Khoja & Suli Wind	239	
			10	14600-L	19	14	33	9	6	15	2	Improved	Middle	Mahmood	98	1994-95
			11	28288-R	97	56	153	10	5	15	10	Unimproved	Tail	Khoja, Warrichanwala & Bakhat Jamal	316	
			12	29500-TL	28	30	58	7	8	15	4	Improved (9R-1L)	Tail	Bakhat Jamal	330	1996-97
Rainfed (3)	Stratum 1 (1)	Gujrat Town (1)	1	Dherkay			482			47	10	Village	NA	Dherkay		
			2	Gigian			145			14	10	Village	NA	Gigian		
		Jalalpur Jattan Town (2)	3	Mianwal			235			23	10	Village	NA	Mianwal		
		Karianwala Town (3)	4	Jalalpur Sobtian			565			55	10	Village	NA	Jalalpur Sobtian		
			5	Chak Kamala			109			11	10	Village	NA	Chak Kamala		
			6	Baru			307			30	10	Village	NA	Baru		

Chapter V Survey Instrument and Data Collection

This chapter provides the details on field activities including household survey planning and administration carried out under all the surveys conducted during both the phases since the initiation of the project.

5.1 Survey Instrument and pre-testing

The questionnaire used for data collection consisted of six modules arranged as follows; Basic information, Infrastructure, Agricultural production, Expenditure, Credit and Retrospective questions.

- Basic Information Module:
  This module is designed to gather basic information about the household, such as household members, their ages, schooling, employment, non-farm income, housing, land ownership, and housing characteristics.

- Infrastructure Module:
  This module gathers information on the operating environment of the household, including information on sources of water, irrigation infrastructure, cultivated area, operation and maintenance of infrastructure and health facilities.

- Agricultural Production Module:
  This module attempts to obtain information on the farming situation, farm assets, cost and value of agricultural production, household organizations, and marketing of inputs and produce.

- Expenditure Module:
  This module gathers information on household expenditure, including food, clothing, medical care, transportation, education and other living expenses.

- Credit Module:
  This module obtains information on loans obtained, sources, repayment and problems in obtaining credit.

- Retrospective Questions Module:
  This module is designed to obtain historical information over the last ten years on crop yields, and production of the main crops and related problems.

The questionnaire was carefully edited to frame the questions to suit the local context, in so far as units of measurement, local connotations, or other common usage of phrases or words etc., were concerned. This made the questionnaire easier to understand by both the enumerators and the respondents as well as easier to administer and process. The enumerators also participated in the process as a part of their training program.

Table 5.1: Themes and Variables Covered by the Panel Data

Theme	Data details
Demographics	Age, sex, relationship to the household head, marital status, family size, number of members at schooling age, number of deaths below five year and above five years
Anthropometrics	Height, weight, and age of each household member (around 4300 household members per survey)
Education	Literacy level, highest grade completed, years of schooling, reasons for not attending school for all school aged persons
Health	Type of health facilities, who operates the health facility, number of visits, cost of using the facility, distance to health facility, mode of transportation to health facility, travel and time cost to the health facility
Housing	Material of roof, wall and floor, number of rooms, presence of toilets, type of toilets, kitchen type
Irrigation infrastructure	Sources of water, access to irrigation infrastructure, availability, condition, and timings of rehabilitation, operation and maintenance of the infrastructure, perceptions of benefits of irrigation infrastructure, willingness to pay for irrigation, and participation into farmer/community organizations
Other infrastructure	Access to piped water, electricity, paved road, distance to bus terminal (local/intercity), post office, markets, telephone and travel and time costs
Land	Land owned, type of land owned (irrigated/rainfed), land rented in/out, land rent, and mode of payment
Agriculture	Crops grown in each season, area under each crop, output produced, sold, and kept, product losses, itemized production costs, input and output outlets, operation-wise hired and family labor use, farm assets, and general and critical agricultural problems
Income sources	Primary occupation, secondary occupation, wage income, livestock and incomes from other enterprises
Food consumption	Quantities of own produced and purchased food items consumed, food given to labor, expenditure on food and non-food items using one day, one week, and one month recall periods
Other consumption	Household expenditure on clothing, medical care, transportation, education and other living expenses using monthly recall periods
Credit	Loans obtained, formal and informal credit sources, problems in obtaining credit, purpose of borrowing, repayments /defaults
Assets	Ownership of household/white goods, agricultural assets, livestock holdings, and their market values, and savings
Retrospective information	Major household level and village level shocks during the past ten years, price movements, yields, and risk coping and risk sharing mechanisms.

The revision of the questionnaire continued after pre-testing of the questionnaire and feedback from such pre-testing. Pre-testing was undertaken during each survey and in each stratum, but avoiding the clusters selected for actual surveys within each strata. Information such as the clarity of the questions, length of time required to complete a questionnaire, quality of the answers, relevancy of the questions, logistical requirements, etc. was gathered during the pre-test. Such information was reviewed and discussed in detail with the participation of the enumerators, and if deemed necessary, the questionnaire revised appropriately to incorporate the information gathered. This procedure was applied after each pre-test and a final revised questionnaire developed. Details of the schedule of pre-testing, including the number of sample pre-tests and other information is presented below in **Table 5.2**. The questionnaire was pre-tested during the training program. The enumerators were divided into two groups and all the selected strata were covered during pre-testing.

Table 5.2: Summary of Schedule of Pre-Testing Prior to Survey Implementation

Survey	Date	Group	Stratum	No. of Sample HHs
First Survey	June 11-13, 2001	A	Rainfed and Rice-wheat perennial	24
		B	Rice-wheat non-perennial and Mixed-wheat perennial	14
Second Survey	August 20, 2001	A	Rice-wheat perennial	10
		B	Mixed-wheat perennial	6
Third Survey	December 5, 2001	A	Rice-wheat perennial	15
		B	Mixed-wheat perennial	8
Fourth Survey	June 11, 2002	A	Rice-wheat perennial and mixed-wheat perennial	20
		B	Rice-wheat non-perennial	10
Fifth Survey	December 12, 2002	A	Rice-wheat perennial and non-perennial	15
		B	Non-sample Area	8

5.2 Enumerators Training

Starting with the first phase of project, 22 data enumerators were recruited for carrying out the surveys for the study -with 16 male and 6 female enumerators. All enumerators had graduate/post-graduate levels of qualifications and most of them had significant prior experience in conducting surveys. In addition, three data entry specialists were appointed for digitizing the collected data/ information.

Considering the nature of this study in terms of its intensity, size and structure of questionnaire and to ensure high quality of data, enumerators, data entry person and field supervisors were given intensive training by the project leader. In addition, refresher training was given before each of the five surveys. Enumerators' training was designed to provide an overview of the study including its background and objectives, use and importance of collected data/information, details on study areas, sampling procedures adopted, technical aspects (such as units of measurements, interview methods, cross-checking of questionnaires) and ethics in conducting household level surveys. The trainers emphasized on the need for adhering to the ethics and code of conduct of the surveys to inculcate a sense of discipline among the enumerators and to stress the

importance of upholding the standards of the institution. A general review of the questionnaire was conducted during each survey, in order to introduce the contents of the questionnaire, to discuss the methods or processes to be adopted in filling the questionnaire, and what was expected of the enumerators in this information collection process. This was followed by a detailed review of the questionnaire in both languages (English and local). Each and every question in the questionnaire, and all technical and non-technical problems and issues were discussed with the enumerators and any doubts cleared. A further period was set aside to allow the enumerators to discuss their individual problems in relation to the questionnaire. The exercise of measuring heights and weights was repeated and the correct use of measuring instruments as well as tips for accurate measurements was demonstrated. Each training session was followed by a field visit by the enumerators and subsequent discussion between pairs of enumerators. This included a hypothetical role-play among the enumerators to fill up the questionnaires. Both technical and non-technical problems and issues resulting from the hypothetical situations were discussed in a number of discussion/question-answer sessions. This was followed by several pre-tests and, if needed, further revision to the questionnaire, based on field observations. The training program, including the pre-testing and review of questionnaires was conducted over a period of one-week prior to the start of each survey. Data entry persons were also involved in the entire training program to (a) ensure that they also fully understand the data collection process and (b) enhance their interaction with enumerators.

5.3 Survey Schedule and Implementation

In order to establish multi-season panel data sets, five surveys were conducted to collect data from the *same* households for Rabi [1] and Kharif [2] seasons for agricultural year 2000-2001 (phase-I) and agricultural year 2001-2002 (Phase-II). On the whole, five household surveys were completed during the planned period, including phase-I and II. **Table 5.3** provides the implementation schedule of the five surveys.

During questionnaire pre-testing and actual surveys, two guides from local areas were recruited to identify the household locations and to make prior appointments with sampled households. Numberdars (Government appointed community representatives) were also consulted, who were very helpful in locating the selected households. Prior appointments with farmers were very useful in conducting the surveys more smoothly and efficiently. All primary data collection was undertaken by formal interviewing process using structured questionnaire. Supervisors/sub-supervisors assigned for the surveys remained with enumerators throughout the data collection period.

[1] It refers to a cropping season in Pakistan extending from 16th October to 15th April in which wheat and gram are the major crops.

[2] It refers to a cropping season in Pakistan extending from 16th May to 15th October in which rice, cotton, sugarcane and maize are the major crops.

Table 5.3: Summary of Survey Implementation Schedule

Stratum	Rainfed	Rice-wheat Perennial	Rice-wheat Non-perennial	Mixed-wheat Perennial	Total*
Number of Samples	180	180	180	180	720
Dates of First Survey	June 30-July 3, 2001	June 14-18, 2001	June 19-26, 2001	June 25-29, 2001	20 days
Number Interviewed	180	180	180	180	720
Dates of Second Survey	September 2-6, 2001	August 29 - September 1, 2001	August 25 - September 2, 2001	August 21 – 23, 2001	12 days
Number Interviewed	178	178	179	176	711
Dates of Third Survey	December 24-27, 2001	December 18-23, 2001	December 11-17, 2001	December 6-10, 2001	22 days
Number Interviewed	177	177	179	174	707
Dates of Fourth Survey	June 27-July 2, 2002	June 20-26, 2002	June 16-20, 2002	June 12-17, 2002	21 days
Number Interviewed	174	176	178	173	701
Dates of Fifth Survey	December 29-January 3, 2002	December 24-28, 2002	December 18-23, 2002	December 13-17, 2002	22 days
Number Interviewed	171	175	178	171	695

* Total number of days for surveys does not include the additional days in the field for undertaking interviews and measuring heights and weights of those households that were not available during the first visits by enumerators.

Basic information for the five surveys remained the same, however, some modifications were made on seasonal basis to incorporate the changes in the calendar months. The fourth survey conducted for the Phase II project was undertaken during the period from 11 June to 2 July 2002. A survey team of 22 enumerators, 16 male and 6 female was hired in June for the fourth survey. The fifth survey was designed to collect data for Kharif 2002 and completed during the period December 13, 2002 to January 3, 2003.

5.4 Data Collection Procedures

To manage and supervise the surveys in an effective and efficient manner, two Agricultural Economists were assigned to supervise the survey teams. All efforts were made to collect the quality data from households. A specific training was also imparted to the supervisors and data entry persons, in addition to the enumerators to maintain the quality of data at both collection and entry stages. The female enumerators were preferably sent where the household male members were not present at the time. However, at some places (where respondent female did not know about the agricultural module), the female enumerators had to wait for the male member. Furthermore, they also helped in measuring weights and heights, where sample households were reluctant to give chance to male enumerators to interact with their female members. Two of the best enumerators were chosen to act as sub-supervisors in addition to their routine work of conducting interviews. As sub-supervisors, they were responsible for daily attendance of their teams at the time of departure and arrival. Additionally, they facilitated the supervisor (Incharge of survey) in the preparation of Daily Visit Plan and lists of respondents along with their previous biographical record of two pages, as well as cross checking their IDs and names with the original list. They also assisted in allocating the

households to the enumerators**.** For evaluating the performance of enumerators, data entry persons, data checkers and sub-supervisors, a similar procedure was established and implemented during all the surveys.

During the first survey, on completion of questionnaire, the enumerators reviewed their own questionnaires in the evening/morning sessions. Secondly, these questionnaires were peer reviewed by the other colleague. Thirdly, sub-supervisors checked the questionnaires before submitting them to the supervisors. Finally the supervisors checked the questionnaire and endorsed the completeness of the information by putting their signatures on questionnaires. After supervisor's approval, questionnaires were given to the data entry persons. If any problem was detected at the data entry stage, questionnaires were sent back to the relevant enumerators with remarks for re-cross-checking them. In case of any serious errors, mistakes/problems or missing information, enumerators were sent-back to the respondents to complete the missing information. Thorough crosschecking at different levels and imposition of strict procedures helped in maintaining the quality of data set. In situations where enumerators were found to be facing any problem, supervisors were available to resolve the problem. In the second and on-ward surveys, two of the best enumerators who were considered above average in terms of their knowledge and understanding were assigned the responsibility of checking the entire questionnaire of every enumerator thoroughly and point out the mistakes and return it to him for correction so that the future chances of error could be minimized. The checkers were required to evaluate the quality of data gathered by the enumerators, using a grading system. The checkers looked for errors in the filling up of questionnaire such as, missing or illegibly entered values or responses, very high/low or improper values, faulty coding or numbering, not entering the responses logically or in the proper sequence. After the correction of such mistakes by the enumerators it was re-checked by the checkers and finally handed it over to data entry persons.

The checkers, after going through the questionnaire, submitted them to the supervisors who after final check-up endorsed reliability of information by putting their signatures on the questionnaires before passing them onto data editing persons. The performance of data checkers and data entry persons was evaluated in turn by the supervisors on the criteria of accuracy, completeness and reliability of data collected. In addition to this, the supervisor also checked one un-edited questionnaire of every enumerator to assess their method of filling questionnaire, i.e., writing information at its proper place and notes of justifications in case of abnormality. This was preferably done on the same day but due to excessive fieldwork load it was also done during an editing day decided by the supervisor to reduce the editing burden. The supervisor also evaluated the performance of every enumerator in the field during interview by assessing the way of conducting interview, the modus-operandy of their presentation and briefing regarding the project, their interaction with the respondent, method of filling questionnaire, their skills of tackling problem with immediate right solutions and their abilities to satisfy a "survey-sick' respondent bringing him to a level where he feels comfortable to give true information. At the end of each day the supervisors also reviewed the progress and problems of that day as well as finalized the next day plan and ensuring the appointments made by the two guides. This improved the quality of work as well as skills of the

enumerators. Frequent sessions were also conducted to discuss day-to-day problems arising during the interviews and editing, and their proper solutions were also sought to equalize the perception level of every enumerator. Certainly, the quality of data was improved through this process and every member of the team contributed to it. The same procedure was adopted in all the surveys of completing one stratum before moving to the other stratum was followed in all the surveys. It was found that every enumerator worked hard, keeping in mind the importance of data, feeling his/her responsibility as a team member, and showing a cooperative behavior.
On an average, each enumerator covered 31.5 households (farmers and non-farmers) ranging from 29 to 37 households during each survey, whereas on average each enumerator filled 1.57 questionnaires.

5.5 Data Entry and Cleaning

The data entry persons used the coded variables to enter the data. A useful and simple coding system was developed to identify each of the selected system, stratum, distributary, watercourse and households. Three main systems in the study area named as UJC, Gujrat and rainfed were coded as 1, 2, and 3, respectively. Then all the four strata were coded from 1-4 to represent the respective strata. The selected distributaries were coded from 1-9. The selected rain fed villages were coded as 1-6 and the selected watercourses were developed.

Most of the collected data were entered into electronic system during the survey period in the field office. Prior to data entry, a code book/data users' manual was prepared. The procedure followed in data entry was such that each data entry operator was required to complete all modules of the filled questionnaire, before moving on to the next questionnaire. They were also required to convert data entered in different units in the questionnaire to standard units, prior to entering in the database. After data entry, the data was cleaned first in the Excel Program, into which the data was initially entered. Specifically, the missing values, zeros, and not applicable cases were identified and classified. The minimum and maximum values were determined and outliers identified for verification or correction. The coding was completed for open ended questions and appropriate codes entered. The data was also examined cell by cell to detect any errors. The data base in Excel was converted into SPSS format and further cleaning undertaken. Frequency tables were generated for all variables and these tables examined for outliers, errors in coding, as well as other errors. Variables with such errors were sorted and the case number identified and doubtful cases were verified by checking back with the questionnaire. Subsequently, each data file was examined by individual row or column to detect any errors across variables or within a variable. The templates in the computer program (Excel) used for the first survey were adjusted to accommodate data entry for subsequent surveys.

5.6 Field Logistics

Considerable effort went into planning the logistics of the study in order to keep to the deadlines specified by the terms of reference. For undertaking all five surveys, field

office/station were established in Mandi Bahauddin. All necessary equipment including computers, printers, copiers, furniture etc was arranged at the field station. Since Mandi Bahauddin is a relatively remote area, accommodation facilities are not easily available. Male enumerators were accommodated at Government Technical College Rasool. For female enumerators, a separate house was rented-in. Overall, proper accommodation arrangements were made for the survey staff.

One 4-Wheel drive and two vans were arranged for transporting enumerators to and from house/hostel/office to field. Before leaving for the surveys, the route was decided by the supervisor/ sub-supervisors according to sample area to be surveyed. The population list of farmers belonging to each selected watercourse was obtained from: 1) Punjab Private Sector Ground Water Consultant (PGC), and, 2) Local Irrigation Water Management offices of OFWM located in Mandi-Bahauddin. Since the lists of non-farm households were not readily available from these sources, they were collected through primary sources. The guides visited each of the sample village and distributary and developed comprehensive lists of farm and non-farm households, in consultations with area Numberdars and other local people. Both farm and non-farm households were selected from this complete sampling frame

Due to geographical spread of sample distributaries/ villages and households, data enumerators were divided into two groups of 11- enumerators each during the first survey, which were led by two sub-supervisors. Each team was comprised of eight male and three female enumerators.

Logistical arrangements for Phase-II surveys were similar to the arrangements made for the first Phase. Accommodation for the male enumerators, date entry persons and supervisors was provided at the hostel of Government Technical College Rasool, and female staff was accommodated in a rented house. The field staff house was the focal point for all the filed activities. For quick and comfortable mobilization of the staff, one jeep and two vans were arranged for the second survey (during the third survey, two vans in addition to a jeep was used).

5.7 Survey Team

The survey team comprised the following members.

Dr. Intizar Hussain	:	Project Team Leader
DR. Waqar A. Jehangir	:	Project Sub-leader
Mr. Aamir Nazeer	:	Field Supervisor
Dr. Muhammad Ashfaq	:	Field Supervisor
Enumerators	:	22
Data Entry Persons	:	03
Field Guides	:	02

Chapter VI Study Approach, Methods and Framework

This chapter outlines the overall approach and analytical framework employed in assessing the impact of irrigation infrastructure development on poverty. It should be clear at the outset that irrigation water and infrastructure are complementary to each other. Access to irrigation water becomes possible only if infrastructure for conveyance and distribution of water is available. However, availability of physical irrigation infrastructure alone may not be a sufficient condition for access to water, it is only a necessary condition. Adequate water may be available, but without infrastructure, people may not be able to access it. The access to water, in addition to other factors, depends upon availability of both water and infrastructure. However, there may be spatial and temporal variations in availability of water and the degree of infrastructure development in a system, with varying impacts on poverty.

There are several approaches for assessing the impacts of development interventions, including irrigation infrastructure development, on poverty. Most commonly used approaches are those comparing 'before and after' interventions and 'with and without' interventions (under similar conditions). While each approach has its own set of limitations, availability of good quality data is a key determining factor in final selection of approach to be employed. In the absence of availability of consistent socio-economic data before irrigation interventions in the study settings, we employ 'with' and 'without' approach by comparing sample areas representing various states of infrastructure development: well developed/improved, less developed/unimproved, with no infrastructure, and without irrigation in order to establish irrigation accessibility.

This study departs from conventional irrigation-poverty related studies in two important aspects. First, it treats poverty as a dynamic concept and decomposes observable poverty into chronic and transitory components. Second, it considers both temporal and spatial dimensions while quantifying the impact of irrigation infrastructure development and rehabilitation on dynamics of incomes and poverty. In so doing, we develop household specific poverty profiles over the course of seasons and trace out movements into and out of poverty during four cropping seasons. This provides useful insights into the relative magnitude of chronic and transient poverty. The irrigation related poverty impacts are evaluated using a set of indicators and econometric analyses in dynamic poverty framework. The quantitative findings are validated by using qualitative perceptions of users regarding the benefits of irrigation infrastructure development and rehabilitation.

Like other types of infrastructure, development of irrigation infrastructure can be expected to generate positive outcomes for the poor in terms of overall increased productivity and production, improved incomes, increased consumption and employment, reduced vulnerability and food in-security, and enhanced overall welfare through both direct and indirect positive impacts. All these factors can be assumed to reduce not only the incidence of chronic poverty but also to positively influence temporary poverty in the study settings. Most of the secondary impacts within the local settings are captured in this study, estimates of secondary impacts outside study settings are not accounted for and are

beyond the scope of this study. Therefore, impact estimates presented in the next chapters should be seen as only partial level of impacts of irrigation infrastructure development on poverty.

6.1 Analytical Methods

Impact assessment in this study focuses on three key aspects of irrigation infrastructure – poverty nexus: (1) determine whether access to irrigation infrastructure raises household incomes and expenditures; (2) determine whether access to irrigation infrastructure influences variability in household incomes and expenditures; and (3) determine consumption smoothing effects of household access to irrigation infrastructure. Three major hypotheses tested in the study are specified as follows:

1. The incidence, depth and severity of poverty are lower in agricultural settings with irrigation infrastructure than in settings without infrastructure.

2. The variability in incomes and expenditures is less in agricultural settings with irrigation infrastructure than in settings without infrastructure or in other words irrigation infrastructure help smoothens incomes and expenditures.

3. If incomes in agricultural settings with irrigation infrastructure are higher (than in settings without infrastructure), consumption expenditure may not track incomes during the year. Or if incomes in agricultural settings without irrigation infrastructure are lower (than in settings with infrastructure), consumption expenditure may track incomes during the year.

For rigorously testing the above hypotheses, we use a range of qualitative and quantitative methods and analytical tools, as summarized below:

1. Inter-strata comparisons - using quantitative values on vaious socio-economic indicators (including household incomes and expenditures);

2. Inter-strata comparisons - using both monetary and qualitative indicators of poverty;

3. Econometric analyses - estimating household income/ consumption smoothing effects of irrigation infrastructure development on poverty; and

4. Econometric analyses - estimating key determinants of household incomes/ expenditures/poverty, including estimating the impacts of irrigation infrastructure development.

6.2 Measuring Poverty

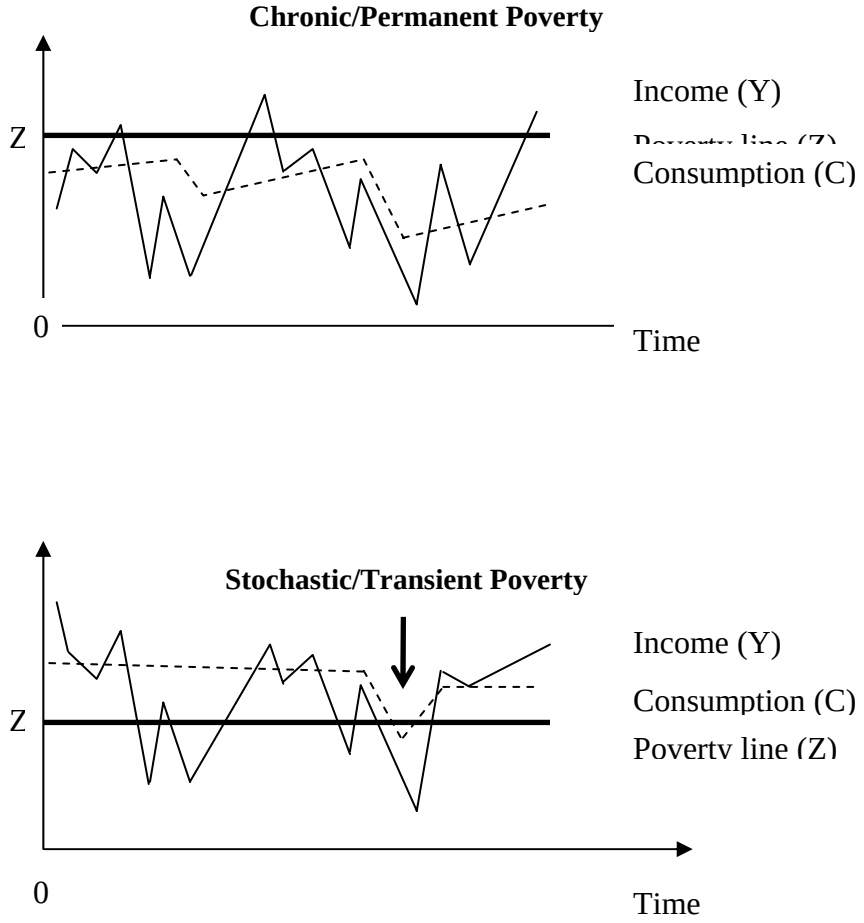
There are many different concepts and definitions of poverty. In recent years, it has been increasingly recognized that poverty is a multidimensional concept, extending from low levels of incomes and consumption to lack of education and poor health, and includes other social dimensions such as powerlessness, insecurity, vulnerability, isolation, social exclusion and gender disparities. Similarly, the concepts of livelihoods, basic capabilities and entitlements have broadened the concepts of poverty. While these concepts are useful in understanding various dimensions of poverty, most empirical work on measurements is based on incomes or consumption level. In simple words, poverty is a situation where household's or person's income or consumption level falls below some minimum level necessary to meet basic needs – this minimum level is called the poverty line. 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 mean income or consumption of a population as a whole. In this study, we measure poverty using (i) standard income/expenditure measures (ii) a set of qualitative indicators of poverty (such as health, education, access to basic social services, assets, etc).

6.2.1 Concepts of Chronic and Transient Poverty

It is important to distinguish between static and dynamic poverty. Static poverty provides only a snapshot of poverty, while concept of dynamic poverty captures changes in poverty overtime. This is because among '*the poor'* all poor are not the same: some are poor occasionally while others are often poor; and for each category of poor, their distance to poverty line is not the same; some are poor only marginally while others are poor severely, and often the former out numbers the latter. Formally, *chronic poverty* is defined as a state where a household's average income (consumption) is constantly below the poverty line in a given period of time. Transient poverty, on the other hand, is a state where a household's average income (consumption) is above the poverty line, but the household is confronted with the possibility of temporarily falling below the poverty line in a given period of time. Transient or temporary poverty is also called stochastic poverty.

Chronic poverty = a situation where $YP < Z$
Transient poverty = a state where $C < Z < YP$,

where YP= a household's permanent income/consumption
C = a household's current income/consumption level
Z = poverty line



Note: In the figures above, solid and dotted lines indicate income and consumption, respectively.

It is, generally, believed that different processes create the two types of poverty, implying that different policy instruments are needed to address them. For example, when chronic poverty is dominant, continuous long-term policy interventions are necessary. Such policies may include agricultural research and extension, land reforms, income re-distribution and price support policies. When transient poverty is more prevalent, some forms of insurance provision policies are more appropriate. For example, policies such as micro-credit, crop insurance, employment guarantee, or price stabilization policies may be needed. Recent literature from the Asian region suggests that transient poverty is more prevalent, with 50-70 percent of the population, identified as living in transient poverty (Sawada, 2000).

6.2.2 Income / Expenditure Measures of Poverty

The measurement of income poverty involves:

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.

In measuring chronic and transient poverty, our approach closely follows the framework developed by Jalan and Ravallion (1998; 2000) and Sawada (2000). Using standard notation, let (y_{i1}, $y_{i2,}$ $y_{i3,\ldots.}$ y_{it}) represents household *i*'s positive income streams over time *t* and let total poverty be defined as a function of income at each point in time such that:

$P_{it}=P(y_{i1}, y_{i2,}y_{i3,\ldots.}y_{it})$

Here P_{it} is an inter temporal measure of dynamic poverty as it measures both the level of mean income at each point in time and its variability over time.

The chronic component of poverty (C_i) is defined as the component of poverty when income does not vary around the time mean income, which we denote by (y_i), that is, by dropping the time subscript (*t*):

$C_i= P(y_{i,} y_{i,} y_{i,\ldots.} y_i)$

The transient poverty (T_{it}) is the component defined by the difference between total poverty at a point in time and its chronic component over time such that:

$T_{it} = P_{it} - C_{i =} P((y_{i1}, y_{i2,}y_{i3,\ldots.}y_{it}) - P(y_{i,} y_{i,} y_{i,\ldots.} y_i)$

Thus household specific dynamic poverty is defined as the sum of transient component (that changes over time) and chronic component (that stays the same during the reference period-which is 24 months for our empirical work in this report). For our analysis, total poverty is the time mean of $P(y_{it})$, and transitory poverty is the residual between total poverty and the chronic poverty

We used the standard Foster-Greer-Thorbecke (FGT, (Foster *et al*., 1984)) class of measures for estimating the incidence, depth, and severity of poverty. Three commonly used measures are: Headcount Index, the Poverty Gap Index and the Squared Poverty Gap Index, as defined below:

1. 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. 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 $\boldsymbol{HC = q/n}$……. (6.1)

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 is given a distance of zero. This measure can be mathematically represented as follows:

Poverty Gap $\boldsymbol{PG} = 1/n \sum_{i=1}^{n} \left[\frac{z - y_i}{z}\right]$…..…….. (6.2)

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 $y_q = 1/q \sum_{i=1}^{q} y_i$ 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:

Squared Poverty Gap $[PG]^2 = 1/n \sum_{i=1}^{n} \left[\frac{z - y_i}{z}\right]^2$ ……...……(6.3)

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

$$\mathbf{P(\alpha)} = 1/n \sum_{i=1}^{q} \left\lceil \frac{z - yi}{z} \right\rceil^{\alpha} \text{ ……..……..(6.4)}$$

Using FGT-class of poverty measures total and chronic poverty index can be defined as:

$$I_t = \frac{1}{n} \sum_{i=1}^{Pt} \left(\frac{Z - y_{it}}{Z}\right)^{\alpha} \text{ ……..(6.5)}$$

$$C_t = \frac{1}{n} \sum_{i=1}^{P^*} \left(\frac{Z - \overline{y_i}}{Z}\right)^{\alpha} \text{ ……. (6.6)}$$

$$T_t = I_t - C_t \text{ ……(6.7)}$$

I_t	total poverty index
C_t	chronic poverty index
T_t	transient poverty index
Z	poverty line
y	monthly income of household
$\overline{y}$	average monthly income of household
n	population

For each component of poverty measure, our poverty index becomes head count index, poverty gap index and squared poverty gap index when parameter $\alpha = 0,1,2$, respectively. These measures are analyzed for various socio-economic groups and for different geographic locations (within irrigation systems).

In this report, poverty indices are calculated for the base case using $\alpha = 0,1, and\ 2$, as defined above. Further, in order to test the sensitivity of these estimates to various definitions of chronic poor and alternative specifications of poverty line, poverty indices are computed for the following categories:

First category

1. Both average monthly income and highest monthly income are less than the poverty line (i.e. *strictly chronic poverty*)
2. Average monthly income < poverty line, lowest monthly income< poverty line (i.e. *semi-chronic poor*)
3. Average monthly income>poverty line, lowest monthly income<poverty line (i.e. *transient poor*)
4. Average monthly income>poverty line, lowest monthly income>poverty line (i.e. *the case of non-poor*)

Second category

1. Average monthly income<0.5*poverty line
2. 0.5*poverty line<average monthly income<0.75*poverty line
3. 0.75*poverty line<average monthly income<poverty line
4. Poverty line<average monthly income<1.25*poverty line
5. 1.25*poverty line<average income

6.2.3 Distribution Analysis- Measures

In addition to the above measures, we also undertake income distribution analysis both spatially and temporally and estimate welfare impact of income/expenditure fluctuations/variability using the following measures.

1. The Lorenz Curve,
2. The Gini-coefficient,
3. Coefficient of Variation, and
4. Standard Certainty Equivalence Measure -- measure of adverse welfare impact of income variability.

6.2.3.1 The Lorenz Curve

The Lorenz curve depicts the relationship between cumulative share of income and cumulative percentage of income recipients. When used as a measure of relative inequality, Lorenz curve indicates the relationship between income and population shares of whole population. The Lorenz curve is drawn by plotting cumulative percentage of income on the horizontal axis and cumulative percentage of the population (including poor and non-poor) on vertical axis. The Lorenz curve located on the 45 degree line shows completely equal distribution of income. As the Lorenz curve moves away from the 45 degree (equal distribution) line, income distribution becomes less equal. However, if the Lorenz curves, two or more, intersect each other, no definitive conclusion can be reached about the superiority of one over the other or the superiority of the income distribution implied by each Lorenz curve. Thus, Lorenz curve provides only 'partial ordering' of income distribution in each setting.

6.2.3.2 The Gini Coefficient

In geometric terms, the Gini coefficient (G) is defined as:

$G =$ Area between Lorenz curve and 45 degree line

Total area between 45 degree line and horizontal axis

Mathematically, as defined by Pyatt *et al*. (1980), it is written as:

$$G_i = \frac{2}{n\, y_i} Cov(y_i, r_i)$$

Where, n is the population size or number of observations, y_i is the time mean income and Y is the total income as defined earlier, and r_i refers to the series of corresponding income ranks for each household.

Gini value per capita, or per adult equivalent income, can serve as an indicator of equity impacts of resource allocation and use. Gini values for education (household head, mean and maximum years of schooling per household), household and agricultural assets, land, information sources etc. can depict inequality in access to resources.

The value of Gini coefficient ranges between zero to one. A zero value shows a completely equal distribution of income (Lorenz curve is located on 45 degree line so that the area between 45 line and Lorenz curve is zero). A value greater than zero shows inequality in distribution of income. And, higher values of Gini coefficient indicate higher degree of inequality in distribution of income.

Our empirical estimation of Gini is based on spreadsheet approach developed by Yao and Liu (1996) and Yao (1999). Stepwise procedure for Gini estimation can be

found in another IWMI study (Hussian and Hanjra, 2001)[1]. Briefly, Gini is computed by solving the following:

$$G = 1 - \sum_{i=1}^{n} p_i (2 Q_i - w_i)$$

Such that:

$$\sum_{i=1}^{n} p_i = 1,$$

$$\sum_{i=1}^{n} w_i = 1,$$

$$w_i = \frac{p_i y_i}{M}, \text{ and}$$

$$Q_i = \sum_{k=1}^{i} w_k$$

Where:

G= Gini coefficient

n = Number of income groups

M = Mean income of entire population

y_i = Mean income of group i with i= 1, 2, 3,.....n

p_i= Population share of group i

w_i = Income share of group i in total income, and

Q_i = Cumulative share of income from income group 1 to g

The p_i s and w_i s are arranged in an ascending order of y_is, that is, $y_1 \leq y_2 \leq y_3 ... \leq y_n$

6.2.3.3 Coefficient of Variation

Coefficient of variation is defined as the standard deviation of household income divided by the average income of the household (i.e. STD/Average). The coefficient of variation is a unit less measure of variability.

6.2.3.4 Standard Certainty Equivalence Measure

Standard Certainty Equivalence Measure is the coefficient of income variability weighted by household's degree of relative risk aversion. If coefficient of variation of household income is zero, standard certainty equivalence measure is zero. In general,

Hussain, I. and M. A. Hanjra (2001). A methodological framework for analyzing poverty in irrigated agriculture: In: Irrigation, poverty, and inequality: A performance based review of global evidence. Unpublished IWMI report

lower the standard certainty equivalence measure, lower the negative welfare cost of income fluctuations: therefore, we use standard certainty equivalence as a key measure of negative welfare costs.

Suppose a household's expected income and expected utility are denoted as follows:

$$E(y) = Y,$$
$$U(Y-m) = E[U(y)], \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6.8)$$

where y is stochastic income, Y is the expected value of income, and m is the certainty equivalent compensation of income risks. Then, the fraction of income which households would be willing to give up to eliminate risks will be approximately:[11]

$$\frac{m}{Y} = \frac{RRA(\sigma / Y)^2}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6.9)$$

Where *RRA* is the degree of relative risk aversion and σ is the standard deviation of household income. Note that m/Y represents the negative welfare effects of the existence of income fluctuations. When there is no income risk, i.e., σ =0, then there is no negative welfare impact. The certainty equivalent measure quantifies the amount that household would be willing to give-up to achieve perfect smoothing in incomes/expenditures, and measures the negative welfare cost of income/expenditure fluctuations (for more details see Morduch, 1995).

Empirically, the value of the standard deviation σ and the average monthly income Y are easily obtained from the data set. However, *RRA* is more difficult to estimate. Estimates obtained from South Asian data sets suggest that a value of R = 2 to 4 can be used to calculate the welfare impact, m/Y of each household.

6.2.4 Defining the Poverty Line

Specification of poverty line is an important step in estimating the above poverty measures. There are three approaches commonly used for estimating poverty line: (a) based on calories intake, (b) income /expenditure needed for required food energy intake (only food), and (c) cost of basic needs (food and non-food). For the purpose of this study, we review secondary estimates of national/regional poverty line available with the national statistical agencies, and finally, secondary estimates of poverty line from Qureshi & Arif (1999) was taken and updated by using CPI for the year 2001, which came to Rs. 730.78 per person. In addition, alternative poverty lines set at 25 and 50 percent higher and lower than this reference poverty lines are also used for sensitivity analysis.

[11] We can employ a second-order Taylor expansion around *Y*.

In Pakistan several studies have used a poverty line that has been estimated on the value of a food basket that provides the required minimum calorie and protein intake, as well as, allowing for a certain empirically determined proportion of expenditure on non-food items.

Wasey (1977) was the first author who determined the urban poverty line directly from calorie intake. He took in to consideration the food needs, clothing and shelter costs in the study. The absolute poverty line was arrived at Rs. 346 per month at 1971/72 prices. Afterwards Kruijk and Leeuwen (1985) estimated the poverty line by using the basic-needs approach. They arbitrarily fixed the basic-needs income of a household in 1979 at Rs. 700 per month. Havinga et al. (1989), used primary data of HIES 1984/85, and worked out the poverty line based on total household food and non-food expenditure. Jafri and Khattak (1995) used data of HIES for years 1985/86, 1986/87, 1987/88 and 1990/91 and determined the poverty lines. The estimated poverty lines reflected the cost of a minimum bundle of basic needs consisting of food, clothing, housing, health, education, transport, socialization and recreation facilities. Four national poverty lines at Rs. 203, Rs. 224, Rs. 234 and Rs. 323 had been determined for 1985/86, 1986/87, 1987/88 and 1990/91, respectively. Ahmad (1993), estimated absolute poverty based on the basic needs approach. The basic needs package used, was consist of food, clothing, housing, health, education, transport, social interaction and recreational facilities. Estimates of the expenditure required to meet the basic needs thus arrived at were: rural Rs. 300, urban Rs. 419 and Rs. 300 at 1991/92 prices

6.3 Defining Household Incomes

The concept of rural income used in this study is comprehensive as it includes incomes received in kind and in cash in a given month/season/year. A monetary value is imputed to receipts in kind at prices prevailing during the survey period. Household consumption of self-produced crops, and their by-products, forest products, and livestock, poultry and its products are considered as income receipts. Also, total income is computed net of all cash expenses but include the imputed value of resources owned by the household (land, draft animals, agricultural equipment etc). Receipts from disinvestments of assets and borrowings are excluded from income. Total income is decomposed by its source of origin as follows.

1. *Crop Income*: It includes income from crop production and accounts for incomes from sale of all crop outputs (including grains, vegetables and fruits), imputed value of all crop outputs retained for household consumption, and imputed value of crop by-products. The incomes are calculated net of all cash expenditures, material inputs (seeds, fertilizers, pesticides and fungicides), hired labor, rental payments for farm machinery, and a depreciation allowance for machinery owned by the household. Crop incomes for Rabi and Kharif season are computed separately.
2. *Non-Crop farm Income*: It includes income from non-crop agriculture such as incomes from livestock, fisheries and forest products and their by-products, and an imputed value of the produce retained for household consumption and land rent.
3. *Agricultural Wage Income*: It includes income earned from working in agricultural activities but on other's farm's and agribusinesses.

4. *Non-farm Income*: It includes income from trade, services and other non-agricultural activities and includes incomes from shop-keeping, petty trade, business and market intermediation, 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. This is also termed as non-agricultural income, or off-farm income.

Crop income and non-crop income together constitute agricultural incomes, *with all incomes are reported in real terms.*

6.4 Defining Household Expenditures

The consumption expenditures includes expenses incurred on purchase of goods and services in the market place, and imputed value of household supplied products and services during each month. Moreover, consumption expenditure is computed net of any transfers and as such food given to labor is excluded. Total consumption expenditure is decomposed into various expenditure categories.

Household expenditure is first divided into durable and non-durable expenditure. Non durable expenditure is divided into food and non-food expenditures. It includes expenditure on category 1 food items, expenditure on category 2 food items, expenditure on category 3 items, and expenditures on other non-food items as:

a. *Category 1 food items*: include wheat, rice, cereals, potato, fish, meat, vegetable, flour, eggs, milk and yogurt, fruits, and bread and pulses.
b. *Category 2 food items*: include tea and coffee, milk powder, soft drinks, cooking oil and ghee, sugar, salt, and spices and chilies.
c. *Category 3 items*: include tobacco and cigarette, soap and shampoo, electric charge, telephone bills, expenses on firewood, cooking fuel and liquid petroleum gas, lighting fuel and cow dung.

Category 4 items: include construction, repair, and maintenance, clothing and shoes, healthcare, education, recreation, ceremonies, transport and communication, domestic remittances, house rent, tax and loan repayments etc. Bank deposits and expenditure on marriages are excluded due to difficulty of treatment

Non-durable expenditures included food expenditure, which included all items in Categories I and II and non food expenditure, which included all other expenditure included in Category III and Other Category (i.e. non-durable expenditures other than those in the above three categories)

Durable expenditure included expenditure on agricultural assets and household assets. Agricultural assets included small and large tractors, animal/machine pulled plow and harrow, water pump, sprinkler, motorized and hand threshers, mechanized livestock feed processors, hand and mechanized sprayers, ox and hand carts, and other farm equipment. Other items included in agricultural assets are the ownership and amount spent on purchases of livestock such as cattle, buffalo, cows, goats, chicken and other

animals on a seasonal basis. Household assets include assets such as bicycles, motor cycles, television, radio, cassette recorder, sewing machine, refrigerator, petromax lamps, electric fans, telephone, clocks, gas cookers, electric cookers, trucks and pick up trucks, cars, land and buildings, and any other assets.

In the case of agricultural assets, data were obtained on the ownership of assets and the market value of such assets and not on expenditure or the date of purchase of such assets. Data on the value of sales of assets such as livestock during the season was also obtained. Household assets included the number owned, and if purchased, the price and the year of acquisition of such assets. Since monthly data on expenditure on assets was not obtained, it was not possible to analyze monthly movements on such expenditure. The only durable item for which monthly data were collected was the expenditure on repairs and maintenance of house. This was included under the other category expenditure in the analysis. Data on durable expenditure was obtained on a yearly basis.

The ratio of food expenditure to total expenditure may be a good indicator of poverty as poor households spend a large share of their incomes on food and may in fact spend very little or nothing on non-food items such as leisure, healthcare, education, and environment as these are not simply poor's priorities.

6.5 Allocation of Incomes and Expenditures

We sum expenditure transactions for each month, and household size weighted estimate generate per capita monthly consumption expenditure (computed in both nominal and real terms). Similarly, consumption / expenditure per capita is derived by dividing total expenditure by size of the household. The allocation of income among the months is as follows: non-agricultural incomes and agricultural wage incomes are allocated to the month(s) of income receipt. Incomes from non-crop activities are allocated equally over the season, or respective month of receipt where known. However, allocation of crop incomes is far more complex and challenging[2]. We developed a density function using information on date of sowing and harvesting of main crops in Rabi and Kharif season, and allocated crop incomes accordingly. Net crop income (GVP-costs of production) for each crop was distributed over the months during which crops were harvested (for example May-June for wheat). Monthly net crop income was also estimated by allocating production costs over the crop growing months and allocating gross value of product over the harvesting months (for instance, costs of wheat production were distributed over the period from November - May while GVP was distributed over May-June). However, differences in monthly incomes from the two approaches were marginal. Non-crop incomes were allocated equally among the survey months throughout each season. Non-crop income from the Rabi surveys was distributed evenly over months from December through to May while non-crop income from Kharif surveys was evenly distributed over months from June through to November. In addition to this, yearly land rent was also evenly distributed over 12 months during a year, while

2 And note that this is important too because wrong allocation of crop income may generate lot of income seasonality especially for households earning a larger pie of their income from this source.

calculating farm income. Income from equipment rentals is allocated equally among the first two and last two months of each season, as hiring of agricultural equipment is mainly confined to beginning (crop sowing) and terminal (crop harvesting) months. Household size weighted income estimate for each month generates mean per capita monthly income. Both nominal and real monthly incomes are computed for various strata and farm non-farm households.

6.6 Qualitative Indicators of Poverty

Frequently used qualitative indicators to determine the level of poverty, can be grouped into the following categories:

a. *Health Related Indicators:* These include: under five mortality rate, life expectancy, no of days not worked due to illness, prevalence of child malnutrition, child stunting, access to sanitation, access to hospitals, access to drinking water, type/housing condition, per capita calorie intake, and malnutrition index, and vaccination rates etc.

b. *Education Related Indicators*: Adult literacy rates, number of years of schooling, school drop out rate, school absenteeism rates (for those attending school), distance to school, and per capita educational expenditure.

c. *Infrastructure Indicators*: Distance to nearest bus terminal and day time market, post office, telephone, and availability of electricity in the dwelling, access to gas cooking, access to irrigation, access to upgraded lined irrigation.

d. *Asset Ownership*:Per capita land, per capita irrigated land, ownership of houses, and household assets.

e. *Household, Labor and Employmen*t: Primary and secondary occupation, percent unemployed, dependency ratio, and gender specific labor force participation rate.

For this study, following key qualitative indicators of poverty are used.

1. *Adult Malnutrition Index*: The Quetlet's index or Body Mass Index, defined for South Asian conditions (The Hindu, 2001), is used an indicator of malnutrition. It is defined as the weight in kilograms divided by height in meter squared. It is expected that poor households would have lower Quetlet index than non-poor households. If body weight is related to level of malnutrition, then Quetlet index should be good indicator of poverty.

2. *Dependency Ratio:* This is defined as the ratio of number of children and old persons to total potentially employable persons. One would expect poverty to decline with decline in dependency ratio.

3. *Educational Level:* The rationale for this indicator is that, higher levels of educational attainments opens up economic opportunities, including ability to absorb new technology, make better use of available services such as extension, credit, and marketing and venture into new enterprises or self-employment. The indicator is measured as the number of years of schooling of household head. It is assumed that higher levels of educational attainment would reduce poverty due to informed decision making by the household head.

4. *School Drop Out Rate:* Traditionally, it has been assumed that high drop out rates of children of schooling age is mainly due to the household not being able to afford schooling due to poverty. It could also be a result of schools being too far away, and/or lack of transport facilities. On the other hand, high drop out rates may be due to the availability of employment opportunities for children within the locality. The parents may rather opt to send their children to work than to school in order to earn an additional income.

5. *Rate of Unemployment/ Under-Employment:* The rate of unemployment and under-employment may also be related to poverty levels. A priori, one would expect greater levels of poverty in households reporting high levels of unemployment or under-employment.

6. *Housing Quality Index:* This index evaluates the quality of housing based on the materials used for the walls, roof and floor, the number of rooms in the house and the type of toilet. The maximum points for each component of housing is three points as follows; wall (mud -1, kacha brick -2, pacca brick-3, cemented – 3, other-2); roof (straw -1, wood -2, tile + wood -3, tile + iron – 3, cement – 3, iron + wood – 3, iron + wood + tile – 3 other-2) and floor (mud –1, bricks –3, cement 3-, brick, + cement + mud-3, others –2) . The water seal type of toilet was allocated 2 points and all other types 1 point. The maximum (-) score possible is 15 points, which translates to an index of 100 percent. Poor households would be expected to have poor quality housing, and therefore, lower housing index.

7. *Ownership of Household and Agricultural Assets:* One would expect households owning greater amount of each assets type to be less poor than those having little or no such assets. Especially, households with higher stock (wealth) should be better able to avert transitory poverty. This indicator captures the differences in asset ownership between farm and non-farm households, in addition to poor versus non-poor households. Value of household/agricultural assets per capita is therefore, used as an indicator of poverty.

8. *Land Holding:* This estimates the average land holding ownership by type of water source (both irrigated and non-irrigated). It is assumed that households owning larger irrigated tracts are less poor than those not having irrigated land.

9. *Access to Irrigation Water:* This is similar to the indicator on irrigated land holding described earlier. The difference here is that lands, officially classified as rainfed or un-irrigable, may be receiving irrigation water from some source, such as direct lifting, illegal diversion from canal, seepage water, tube well, or drainage water, etc. and would fall into this category. This indicator would capture the true irrigated extent and provide a more precise categorization of land by irrigation. This indicator is estimated as size of all irrigated land as a percent of total land. Higher access to irrigation should reduce poverty.

10. *Cropping Intensity:* This is the ratio of the gross cropped to the area actually operated per season/year. The higher the cropping intensity, the less poor the households are likely to be. The gross cropped area is the sum of operational area and area cultivated more than once. The operational area is total area owned

(irrigated, rainfed, chena, or home garden) by the household plus area rented-in minus area rented-out.

11. *Agricultural Productivity per Hectare:* The average productivity per unit of land (total output / total land owned) and average productivity per unit of land cropped (total output / total area cropped) provides a measure of the potential versus actual productivity. The productivity differential may be due to various causes such as, lack of irrigation facilities, poor water management, climate, input supply problems, lack of credit or finances, marketing problems, poor soils, poor drainage, or other problems. Higher productivity of land should reduce poverty.

12. *Total Agricultural Assets:* Agricultural asset ownership provides a measure of household wealth and would be a good indicator of poverty in rural areas. Agricultural assets may be owned solely or jointly, and include all equipment used in agricultural production, e.g. tractors, plows, threshers, trailers, sprayers etc. More the stock of agricultural assets, lower should be the poverty.

13. *Access to Electricity:* The proportion of households with access to electricity is another indicator of poverty. However, it is also possible that the household does not have electricity because of non-availability of electricity supply to the locality by the authorities and not due to poverty. These factors are considered when interpreting the results of this indicator. Poor households may lack access to electricity.

14. *Access to Piped Water Supply:* This indicator can be estimated as the proportion of households having access to piped water supply, which is used as a measure of poverty.

15. *Access to Credit:* Credit is an important input for modern agricultural production technology. The assumption here is that poor have less access to credit than non-poor households. The ability to borrow enough money in each growing season is used a proxy for access to credit. Non-poor household may have better access to credit or assets than poor households, and even transient poor may have better access to credit than the chronic poor. Those with access to credit, in each sub-division, may then be able to smooth income/consumption, i.e. their consumption may not be affected by shocks in general (say, poor rain fall, flood, crop damage) or household specific shocks (illness, asset losses, etc).

6.7 Econometric Analysis

6.7.1 Measurement of Income and Consumption Seasonality

For testing our third hypothesis, we use the empirical framework developed by Paxson (1993). Paxson suggests that in addition to constraints to borrowing there are other reasons that can cause consumption fluctuations. She tested the hypothesis that seasonal taste and price variations, as opposed to variations in incomes, is a major determinant of observed consumption variation in Thailand. Assuming two seasons, she develops a model of perfect smoothing, i.e. individuals do not have credit market

constraints. It implies that seasonal consumption patterns are unaffected by the timing of income inflows. The model is extended to allow for imperfect smoothing, and actual expenditure in any season, which is a weighted average of income in that season and desired expenditure given a perfect ability to smooth. This is expressed as follows:

$$E_{ji} = E_{ji}^{*}(1-\pi) + Y_{ji}\pi, \quad j = 0,1 \quad \ldots\ldots (6.10)$$

Where $0 \leq \pi \leq 1$. This yields the following equation for expenditure in each period.

$$E_{ji} = Y_i [\beta_j (1 - \pi) + A_{ji}\pi], \quad j = 0,1 \quad \ldots\ldots (6.11)$$

Where A_{ji} is the fraction of annual income earned by individual i, in season j (so that A_{ji} sums to one across seasons for any individual). As π increases, the effects of prices and preferences (measured by β_j) receive less weight in determining seasonal expenditure, and seasonal incomes receive more weight. If $\pi = 1$, then seasonal expenditure tracks seasonal income. Y_i is defined as total annual income divided by the number of seasons (12 months), or the average monthly income level of person i. The above equation yields the following log expenditure equation:

$$\ln (E_{ji}) = \ln (Y_i) + (1 - \pi)\beta_j + \pi A_{ji} - 1$$

where E_{ji} is the expenditure of individual i, for season j.
Y_i is the total annual income divided by the number of seasons.
A_{ji} is the fraction of annual income earned by individual i, for season j.
β_j is the effect of prices and preferences and
π is the smoothing coefficient

In the above equation, perfect smoothing ($\pi = 0$), implies seasonal expenditure is determined only by income, preferences and prices. Imperfect smoothing ($\pi>0$), implies that the timing of income flows A_{ji} is also a determinant of seasonal expenditure. The above equation can be estimated using OLS. For more details on the framework see Paxon (1993).

Separate OLS estimates for the six strata can be obtained for each season, in order to test the hypothesis that seasonal expenditure is dependant only on permanent income, prices and preferences and not on timing of income flows. A regression analysis based on the above framework using consumption as the dependent variable and dummy variables for 24 months as independent variables is undertaken. Regional differences and the differences in irrigation infrastructure development are also taken into account in this analysis. A graphical analysis of the outcome is produced to illustrate the differences (see chapter 11).

6.7.2 Estimation of the determinants of incomes/expenditures – Quantification of Impacts

Quantification of key determinants of household incomes and expenditures is undertaken by estimating a multivariate econometric model with annual household level data. It is hypothesized that household incomes/expenditures depend upon:

a) Household endowment of natural resources, particularly land;
b) Household productivity of natural resources, such as land productivity;
c) Household human resources and their characteristics, such as number of non-dependent working family members, education levels of family members, occupation;
d) Household capital resources, such as household non-land productive assets such as agricultural machinery, livestock;
e) Household access to irrigation/infrastructure.

Irrigation infrastructure and its state of development can be expected to contribute positively to household incomes through increased overall productivity and production, through enhanced employment and income earning opportunities associated with infrastructure induced improved economic activities in both farm and non-farm rural sectors.