

Part 2

Chapter IV Study Design, Approach and Sampling Framework

4.1 Study inception activities

4.1.1 Selection of study areas

A number of factors were considered in selecting suitable study areas. One such factor was that the selected infrastructure development projects should be the ones financed by JBIC. Another major consideration was that the selected areas should reflect sufficient variability in terms of irrigation infrastructure and related aspects. Based on these considerations, 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.

4.1.2 Field visits by team of economists

Prior to start of the surveys, the team of economists undertook a field-visit of the selected study area to make a visual assessment of field conditions in the area. This visit also involved collection of more information on the study area, particularly information on the major characteristics of the study area needed to develop sampling framework and to identify specific study sites. Additionally, the team was able to meet with relevant officials to appraise them of this study and to obtain their consent and cooperation for the study. The team was also able to make most of the logistical arrangements for undertaking the household level surveys.

The team visited both irrigated and rain-fed areas in the districts and met with government officials from various project areas of the On-Farm Water Management Department (OFWM). OFWM office in Gujrat is headed by one Coordinator and has 5 Water Management Specialists (WMSs). The offices of the WMSs are located in Gujrat, Kharian, MBD and Phalia. The OFWM department has assisted farmers in improving about 501 watercourses through brick lining under JBIC/OECF funding.

The team visited the Upper Jehlum Canal (UJC) system, which constitutes the major source of surface irrigation in the OFWM Project areas and provides irrigation to farms through distributaries, R1-R15. The distributary R-1 to R-10 originating from UJC are perennial channels and provide irrigation to the project area of OFWM in Tehsil Kharian and MBD. The distributaries R-11 to R-15 are non-perennial and provide irrigation to farms located in Gujrat and Phalia and part of MBD.

The northern part of the Tehsil Gujrat is mostly rain fed. Due to deep groundwater, tubewell density is also very low. The areas like Jalalpur Jattan, which are close to Gujrat in the northward direction, were considered to be the potential study sites for selection of sample in the rain fed area.

Due to presence of perennial and non-perennial irrigation systems in the area it was decided that the sample sites be selected across improved and unimproved watercourses in both perennial or non-perennial distributaries so that comparison could be made in homogeneous conditions

The team visited the improved watercourses in Kharian Tehsil and realized that due to the flow of remittances from abroad, the people living in this area are relatively better-off as compared to those in other nearby areas e.g. Gujrat district, even as compared to many other areas of Punjab. Farmers in Kharian area reported, during interviews by the team at different locations, that about 60 to 70 percent of the households in this area have one or more household members working abroad. Huge inflow of remittances was quite visible form type and quality of housing (luxury) in the area. The team concluded that such area may not be the representative site and should be excluded from selection of study sites. The team also visited distributaries 9-R and 10-R. The farm size in these distributaries ranges between 2-6 hectares. These distributaries were found to be fairly representative of perennial command areas. It was decided to include command areas of these distributaries for the sample selection for the study.

4.2 Characteristics of study area- General

4.2.1 Gujrat District

General

District Gujrat takes its name from the headquarters town of Gujrat. This town grew up around a fort established by the emperor Akbar in A.D. 1580 with the help of the Gujar inhabitants of the neighboring areas. Its shape is roughly that of a parallelogram. It forms the northern most portion of the Chaj Doab lying between the Jehlum and Chenab rivers. The district lies between north latitudes $32^{\circ}-19'$ to $33^{\circ}-03'$ and east longitudes $73^{\circ}-31'$ to $74^{\circ}-28'$. 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 Tawi (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.

4.2.2 Agro-climatics of Gujrat

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. Monthly data on temperature, precipitation and humidity are given in Table 4.1. Minimum and maximum temperatures

range between 5.00 °C– 25.80 °C and 19.70 °C – 40.60 °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.

Table 4.1. Month-wise mean temperature, precipitation and relative humidity, 1961-90.

Month	Mean Temperature		Precipitation (MM)	Relative Humidity (%)
	Maximum	Minimum		
January	19.7	5.0	33.8	66.2
February	21.6	7.7	50.0	60.2
March	26.6	12.5	60.6	53.8
April	33.0	17.7	36.6	41.9
May	38.1	22.0	31.8	32.5
June	40.6	25.8	51.9	37.2
July	35.7	25.8	237.3	62.3
August	34.4	25.3	221.2	70.8
September	35.0	23.0	77.7	65.5
October	33.1	16.6	12.2	55.6
November	27.6	9.9	9.9	62.9
December	21.5	5.7	30.4	68.9
Annual	30.6	16.4	853.2	56.2

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. Table 4.2 provides data on areas and production of main crops in the district during 1996-97.

Table 4.2. Area and production of major crops in Gujrat (1996 – 97)

Crop	Area (hectare)	Production (Tons)
Wheat	117000	189000
Rice	40000	50000
Sugarcane	4000	167000

Important livestock species reared in the Gujrat district are given in Table 4.3.

Table 4.3. Livestock in Gujarat

Livestock	Numbers
Cattle	89128
Buffalo	258238
Sheep	7509
Goat	145403
Camel	2534
Horse	4598
Mule	1809

Ass	55395
Domestic poultry	446247

4.2.3 Irrigation in Gujrat

Jhelum River enters the district from 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 always 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. Sub-soil is sandy and gets benefit from 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. Water table is closer to surface varying from 3 to 6 meters.

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.

4.2.4 Socio-economics of Gujrat

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. Total population, its intercensal increases and annual average growth rate since 1951 is given in Table 4.4.

Table 4.4 Population and intercensal increase and growth rates in Gujrat since 1951

Description	1951		1961		1972		1981		1998
Population (in 000's)	743		835		1177		1408		2048
Intercensal Increase (Percent)		12.4		41.0		19.6		45.5	
Average		1.1		2.9		2.1		2.2	

Annual Growth Rate (Percent)									
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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. Table 4.5 provides information on life time in-migrants with their decomposition by place of origin, and place of settlement in rural and urban areas of the district.

Table 4.5 Life Time Migrants in District Gujrat by Rural / Urban Areas, 1998.

Description	Migrants By Residence (Percent)		
	All Areas	Rural	Urban
Total in-migrants	100 (119,755)	100 (51,474)	100 (68,281)
Migrants from the same province	72.1	67.5	75.6
Migrants from other provinces*	9.7	9.3	10.0
Migrants from AK/NA	7.5	12.6	3.7
Migrants from other countries	10.7	10.6	10.7

* Including Federally Administer Tribal Areas and Islamabad Capital Territory

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. Table 5 shows that 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 (Table 6)

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) (Table 4.6).

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. Further details on occupations is given in Table 4.7.

Table 4.6. Disaggregation of District Population by Economic Categories, Sex and Rural/Urban Areas, 1998 (Percent)

Economic Category	All Areas			Rural			Urban		
	Both Sexes	Male	Female	Both Sexes	Male	Female	Both Sexes	Male	Female
Economically Active	20.0	38.4	1.4	18.5	36.7	1.1	23.7	42.7	2.4
Not Economically Active	80.0	61.6	98.6	81.5	63.3	98.9	76.3	57.3	97.6
Children Under 10	27.4	28.1	26.7	28.3	29.6	27.0	25.1	24.5	25.8
Students	9.6	18.5	0.7	8.9	17.9	0.2	11.4	19.9	1.8
Domestic Workers	36.6	2.4	71.0	37.9	2.8	71.6	33.3	1.3	69.1
Others	6.4	12.6	0.2	6.4	13.0	0.1	6.5	11.6	0.8
Unemployment Rate	21.6	22.2	6.0	21.0	21.5	3.7	23.0	23.7	8.9

Table 4.7. Employed Population by Occupation and Rural/Urban Areas in Gujrat-1998.

Occupation		All Areas	Rural	Urban
Code	Description			
1	Legislators, Senior Officials and Managers	0.2	0.2	0.4
2	Professional	5.6	4.1	8.8
3	Technicians and Associate Professionals	2.0	1.4	3.3
4	Clerks	1.8	1.5	2.5
5	Service Workers and Shop and Market Sales Workers	11.6	7.2	20.8
6	Skilled Agricultural and Fishery Workers	29.4	40.1	7.0
7	Craft and Related Trades Workers	7.2	3.9	14.1
8	Plant and Machine Operators and Assemblers	4.0	3.8	4.4
9	Elementary Occupations	36.3	37.4	33.7
10	Armed Forces	1.9	0.4	5.0

Table 4.8. Employment by industry in rural and urban areas of Gujrat.

Industry		All Areas	Rural	Urban
Code	Description			
1	Agriculture, Forestry, Hunting and Fishing	29.5	40.7	6.3
2	Mining and Quarrying	*	*	*
3	Manufacturing	8.2	4.9	15.0
4	Electricity, Gas and Water	0.3	0.3	0.2
5	Construction	30.8	32.8	26.6
6	Wholesale and Retail Trade and Restaurants and Hotels	10.1	6.3	18.0
7	Transport, Storage and Communication	4.0	3.7	4.7
8	Financing, Insurance, Real Estate and Business Services	1.9	1.0	3.8
9	Community, Social and Personal Services	12.6	8.5	21.2
10	Activities not Adequately Defined	2.6	1.8	4.2

* Refers to a very small number

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 (Table 4.8). 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.

Furniture making is one of the main industries in Gujrat. Shawls making in Jalapur and manufacturing of trunks and suitcases, soap and oil crushing, manufacturing of cycle spare parts, inks and agricultural implements are some of the other important industries in the district. Hosiery goods and other similar textile products are also produced in Gujrat. Hand and power looms are common in the district. In many villages, cotton is woven into coarse cloth called Khudar and is mainly for local use. Woodcarving is popular in towns. It is largely done for door panels and cornices but in villages especially in the west of the district the carved doorways form a special feature of building. Every well to do person has a carved door way in his/her house. A leading tannery has been established in Gujrat, which produces tanned leather mainly for exports. An industrial boys school is run by the government in Gujrat, which provides training in weaving and finishing of cotton textiles. A vocational training school for girls in the district provides training in tailoring machine, hand embroidery

and knitting. There are 268 registered factories in Gujrat, of which 245 have less than 100 employees each and 17 registered large scale factories have more than 100 employees each.

Altogether, there are 1991 educational institutions in Gujrat, providing education from primary to postgraduate levels. The number of institutions, enrolment and teaching staff of institutions in the district is given in Table 4.9.

Table 4.9. Number of educational institutions, enrolment and teaching staff available in Gujrat.

Level	Institution		Enrolment		Teaching Staff	
	Male	Female	Male	Female	Male	Female
Primary	576	615	73000	67000	2105	1876
Middle	130	86	34000	25000	1324	934
Secondary	148	60	84000	46000	2771	1320
Higher Secondary	6	3	4484	3839	225	98
Intermediate and Degree Colleges	6	6	6063	5804	176	101
Mosque Schools	355	0	12369	0	671	0
Total	1221	770	213916	147643	7272	4329

There are about 940 health units providing health facilities throughout the district. Table 10 provides data on health institutions by category with bed facilities available in the district for 1996.

Table 4.10. Health institutions by category with bed facilities available in the district (1996).

Institution	Number	Beds
Hospital	11	535
Dispensary	29	85
Rural Health Center	8	160
Basic Health Unit	80	160
Sub Health Center	25	0
M.C.H. Center	14	0
Total	167	940

4.2.4 Mandi Bahauddin District

District Mandi Bahauddin takes its name from the town headquarters. In 1506 A. D. a Gondal Jat Chief Bahauddin established a settlement namely Pindi Bahauddin, after his migration from Pindi Shah Jahanian to this area. The town grew up in early 20th century near the ancient village [Chak No. 51], where Sikh, Hindu and Muslim businessmen and land owners came to settle. The town was named Mandi Bahauddin after establishment of grain market in the area. The district forms central portion of the Chaj Doab lying between Jhelum

and Chenab rivers. It lies between $30^{\circ} - 8'$ to $32^{\circ} - 40'$ north latitudes and $73^{\circ} - 36'$ to $37^{\circ} - 37'$ 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.

4.2.5 Agro-climatics of Mandi Bahauddin

Height of the district from the sea level is 244 meters. 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 (Table 4. 11). 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 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.

Table 4.11 Monthly mean temperatures and precipitation in Mandi Bahauddin (1961-90)

Month	Mean Temperature (C)		Precipitation (Millimeters)
	Maximum	Minimum	
January	20.2	3.6	13.0
February	22.4	6.8	23.1
March	27.4	12.3	35.1
April	33.9	17.9	29.5
May	39.1	22.5	21.1
June	41.7	26.7	23.2
July	37.8	27.1	108.2
August	36.3	26.4	129.1
September	36.3	23.7	26.3
October	33.6	16.9	7.6
November	27.8	9.9	5.8
December	22.0	4.8	12.8
Annual	31.5	16.5	434.9

Table 4.12 Main crops by area, production and yield in Mandi Bahauddin (1996-97).

Crops	Area (in 000 Ha)	Production (In 000 tones)	Yield (kg/ha)
Wheat	10.9	220.9	2028
Rice	5.5.	85.4	1564
Maize	0.2	2.3	1352
Sugarcane	3.3.	1343.4	40832

Tobacco	49.6	560.0	1129
Total	69.5	2212.0	46905

As is clear from Table 4.12 that 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 (Table 4. 13).

Table 4.13 Important fruits by area, production and yield (1996-97).

Fruit	Area (in 000 Ha)	Production (in 000 Tones)	Yield (Kg/Ha)
Citrus	7240	71319	9850
Mango	8	60	7500
Banana	16	6	4125
Guava	399	2887	7235

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.

4.2.6 Irrigation in Mandi Bahauddin

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 streams 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 Bahaduddin 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.

4.2.7 Socio-economics of Mandi Bahauddin

Total population of Mandi Bahaduddin 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.

Table 4.14 gives total population, its intercensal increase and annual average growth rate since 1951.

Table 4.14 Population and intercensal increase and growth rates since 1951.

Description	1951	1961	1972	1981	1998
Population (in 000,s)	415	491	722	846	1,161
Intercensal Increase (percent)	18.3	47.1	17.2	37.2	
Average Annual Growth Rate (percent)	1.7	3.4	1.9	1.9	

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. Table 4.15 provides information on lifetime in-migrants with their decomposition by place of origin and place of settlement in rural and urban areas of the district.

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 (Table 4.16). 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).

Table 4.15 Lifetime migrants in the MB by rural urban areas, 1998

Description	Migrants By Residence		
	All Areas	Rural	Urban
Total in-migrants	100 (61,573)	100 (38,080)	100 (23,673)
Migrants from the same province	75.1	72.8	78.9
Migrants from other provinces	3.4	3.4	3.4
Migrants from Ak/NA	3.0	4.5	0.6
Migrants from other countries	18.5	19.3	17.1

Table 4.16. Population in MB by economic categories, sex and rural/Urban areas, 1998.

Economic Category	All Areas			Rural			Urban		
	Both Sexes	Male	Female	Both Sexes	Male	Female	Both Sexes	Male	Female
Economically Active	21.7	41.6	0.9	21.8	41.7	0.8	21.6	41.0	1.6
Not Economically Active	78.3	58.4	99.1	78.2	58.3	99.2	78.4	59.0	98.4

Children Under 10	28.1	28.4	27.8	28.7	28.7	28.2	26.6	26.9	26.3
Students	7.7	14.9	0.2	7.3	14.1	0.1	10.2	19.7	0.4
Domestic Workers	35.6	1.6	71.1	35.4	1.7	70.9	35.8	1.0	71.6
Others	6.9	13.5	*	7.1	13.8	*	5.8	11.4	0.1
Unemployment Rate	13.0	13.3	1.8	11.5	11.7	0.9	21.8	22.4	4.3

* Refers to a very small number.

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 (Table 4.17).

Table 4.17 Employed population in MB by industry in rural /urban areas, 1998

	Industry	All Areas	Rural	Urban
	Description			
1	Agricultural, Forestry, Hunting and Fishing	40.3	44.4	14.3
2	Mining and Quarrying	0	0	0
3	Manufacturing	3.6	3.1	6.8
4	Electricity, Gas and Water	0.2	0.2	0.3
5	Construction	36.5	37.4	30.8
6	Wholesale and Retail and Restaurants and Hotels	6.2	4.1	19.4
7	Transport, Storage and Communication	2.2	1.9	4.1
8	Financing Insurance, Real Estate and Business Services	1.2	0.6	5.0
9	Community, Social and Personal Services	8.3	6.9	17.2
10	Activities not adequately Defined	1.5	1.4	2.1

* Refers to a very small number.

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.

Table 4.1 8 Educational institutions by and enrolment in MB (1998).

Institution	Number	Enrollment
Colleges		
Degree	2	2,992
Intermediate	3	828
Professional	3	1,311
Schools		
Higher / Higher Secondary	83	50,229
Elementary	108	18,734

Primary	107	85,111
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Tehsil Headquarters Hospital at MB was upgraded to a District Headquarters Hospital in 1993. Details of health facilities in the districts are given in Table 19. 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.

Table 4.19 Type of health units by their number, beds and controlling authority (1998).

Health Unit	Number	Beds	Controlling Authority
District Headquarters			Health Department Govt. of the Punjab
Hospital	1	40	Do
Tehsil Headquarters Hospital	1	28	Do
Rural Health Centers	8	24	Do
Eye Hospital (Gulshan-e-Iqbal)	1	Nil	Do
Basic Health Units	50	100	Do
Mother & Child health Centers	5	Nil	Do
Dispensaries	15	-	Do

4.3 Sampling Procedures

A well-developed sampling design plays a critical role in ensuring that data are sufficient to draw the conclusions needed. A well-designed multistage stratified random sampling was adopted for selecting the specific sites and sample households within these sites. In stratified sampling, prior information about the area is used to determine the groups or strata that are sampled independently. Each of the sampling unit must belong to exactly one stratum. There can be no sampling units that do not belong to any of the strata and no sampling units that belong to more than one stratum. When the strata are appropriately constructed with respect to variables being estimated, a stratified sampling design can produce estimates of the overall population with greater precision.

Since we had the prior knowledge of the spatial distribution of the study area, total area of Gujrat and Mandi Bahauddin was first divided into three systems. Two systems were irrigated through Upper Jehlum Canal (UJC) and Gujrat Canal while the third system was the Rain fed system. However, 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 - I 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.

The strata were defined such that areas within each stratum were homogenous in terms of above characteristics. UJC sub-system was divided into two strata – with one stratum having rice -wheat as dominant cropping pattern with perennial irrigation supplies, and the second stratum having rice-wheat pattern with non-perennial supplies. Sugarcane and wheat are main crops grown in stratum 4 (Gujrat). Irrigation supplies in stratum 4 are of perennial nature.

While each stratum was fairly homogenous within its boundaries, in terms of above characteristics, however, there could be intra-stratum variations especially in terms of access to water (head, middle and tail) due to differences in availability of water resulting from locational differences. These intra-stratum variations were captured through cluster sampling within a stratum. Also, given the large size of population in the study area and its spread over wider geographical area, it was essential to follow three stage cluster sampling (particularly for strata 2, 3 and 4).

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 water course from each of the three parts was selected randomly. Once the unimproved watercourses along the distributary were selected, the closest improved water course 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 water courses were selected through systematic random sampling from a complete sampling frame for each water course (i.e 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/distributaries, improved/unimproved water courses across head, middle and tail reaches of the selected distributaries, and the sample households across each of the selected watercourses. More details are given in the following sections.

Information on number of irrigation structures and their rehabilitation /improvement status, and nature of canal water supplies in various parts of irrigation systems, was obtained from both primary and secondary sources (including Punjab Irrigation Department (PID), OFWM program and Punjab Groundwater Consultants (PGC) and Revenue records of the PID). Altogether, there are 26 distributaries and 1388 watercourses in the area. Out of these, 367 watercourses are reported to be improved under JBIC funded watercourse improvement programs. Remaining water courses are reported to be mostly unimproved.

Population list of farm households for each of the selected watercourse was obtained from: 1) Punjab Private Sector Ground Water Consultants (PGC), and 2) Local Irrigation Water Management offices of OFWM located in Mandi-Bahauddin. However, information on landless households were not available from these sources. These were prepared by survey guides through primary sources in consultation with Numberdards and with other local people. In short, a complete census of both farm and landless households was prepared before implementation of the actual survey.

Table 4. 20. Number of distributaries and watercourses in all the four strata.

Irrigation System	UJC System	Gujrat System
Number of Distributaries	13	13
Total No. of Water Courses	427	961
Total No. of Improved Water Courses	168	199
Total No. of Unimproved Water Courses	259	762
Total No. of Strata	2	1

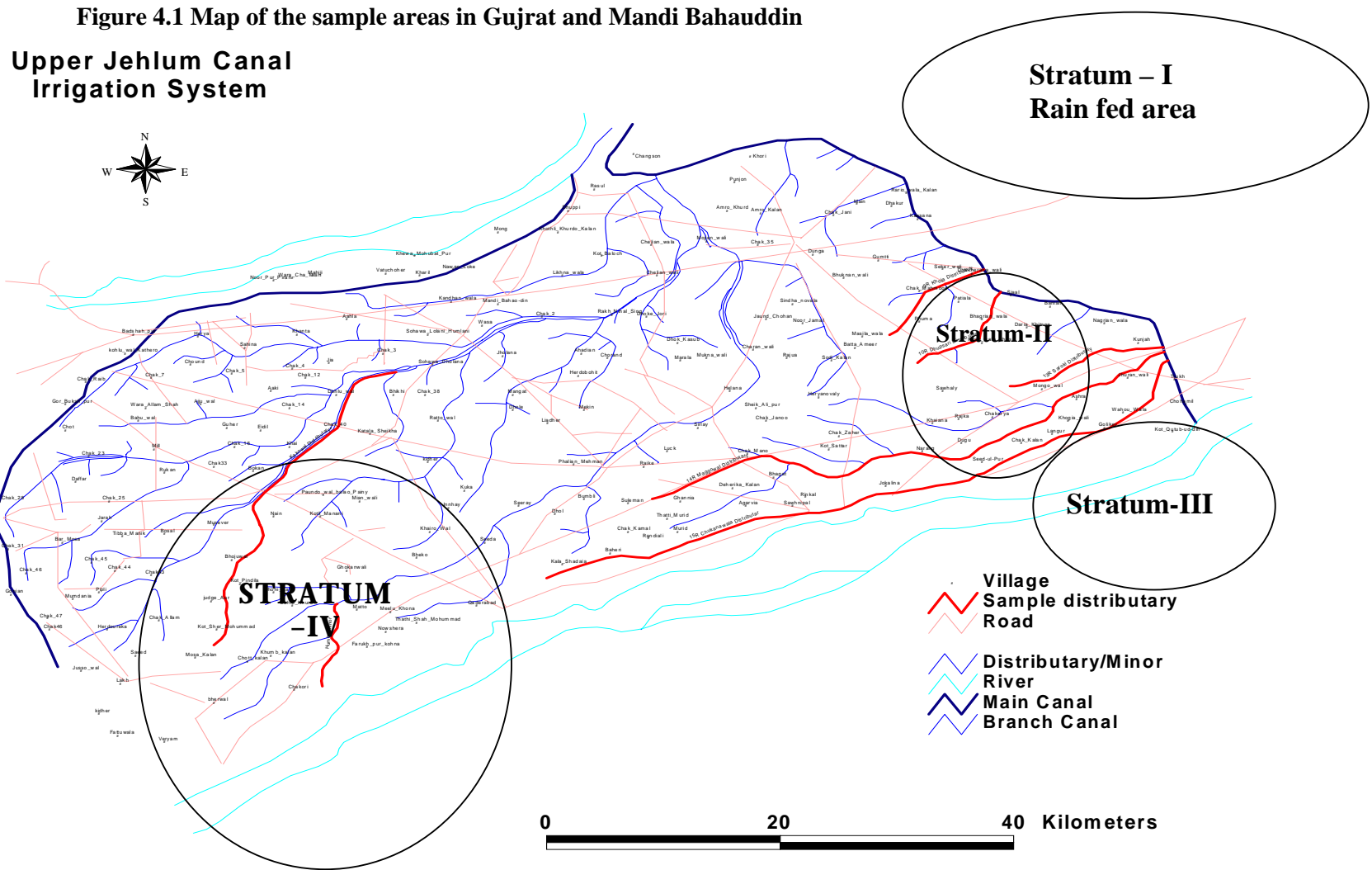
4.4 Sample Size

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 21.

Table 4. 21. Number of distributaries and watercourses in four strata.

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



4.5 Sample selection within strata

Stratum I

4.5.1 Selection of Villages

The Stratum I (Rain fed area) lie in the northern part of district Gujrat (Map 1-2, Table 4.22). 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.

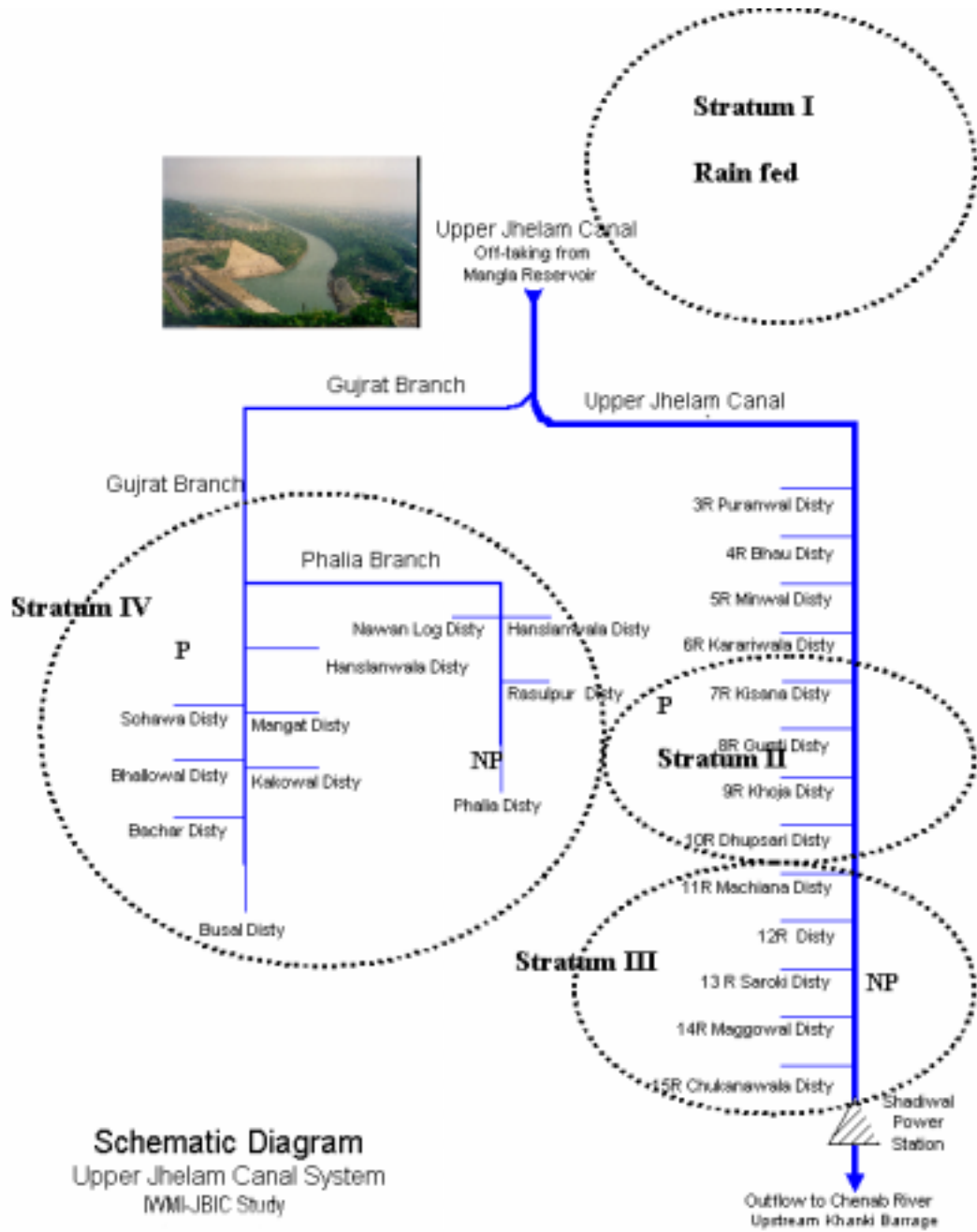
Table 4. 22 Number of villages in stratum 1 in rain fed area of Gujrat district.

Stratum I	
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 Stratum I	6

4.5.2 Selection of households

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 10th household was selected through systematic random sampling from lists of households in selected villages.

Figure 4.2. The Schematic diagram showing the irrigation network in the sample areas



Stratum-II

4.5.3 Selection of Distributaries

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 from 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 distributaries ranges from 2 to 6 hectare. Both distributaries are fair representations of cropping patterns (Rice –Wheat) in perennial systems of the stratum.

Table 4.23 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

4.5.4 Selection of Watercourses

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, Warrachanwala, 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 Husa, Kalu Sahi Kalan, Kalu Sahi Khurd, Shergarh, Jamobola and Fattah Lama (Table 4.27).

4.5.6 Selection of Households

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 water courses, 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. The information about the total number of households living across villages in the command areas of these watercourses is summarized in Table 26. 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).

Stratum-III

4.5.7 Selection of Distributaries

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.

4.5.8 Selection of Watercourses

There are altogether 237 watercourses in this stratum, of which 69 are improved and 168 are non 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 Muhammad, Musa Kalan, Chak Mitha, Kot Sattar, Thatha Alia, Phire and Kot Muhammad Shah (Table 4.26).

4.5.9 Selection of Households

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 4.24. 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 in 13-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

Stratum-IV

4.5.10 Selection of Distributaries

Command areas of stratum IV are irrigated through 13 distributaries. All these distributaries 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.

4.5.11 Selection of Watercourses

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 4.26).

Table 4.25. 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

4.5.12 Selection of Households

Households along selected watercourses in distributaries Kakowal and Phalia were selected using same procedure as adopted for selecting households in 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 4.26. Summary of the system, strata, distributary, watercourse number total household size and sample population.

System	Stratum	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)	Kakawal (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		
			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	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 Miha	280	
					26	81090-L	23	11	35	10	5	15	2	Improved	Head	Chak Miha	157	1995-96
27	97539-L				33	17	50	10	5	15	3	Unimproved	Middle	Kot Sattar & Thatha Alla	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		
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 Mansoor & Kot Shammass	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			
10-R Dhap Sar (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			
9-R Khoja (4)	18			23000-L	50	15	65	12	3	15	4	Improved	Tail	Jamobola & Fattah Lama	109	1995-96		
	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	Warrichanwala	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)	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					
		4	Jalalpur Sobtian			565			55	10	Village	NA	Jalalpur Sobtian					
	Karianwala Town (3)	5	Chak Kamala			109			11	10	Village	NA	Chak Kamala					
		6	Baru			307			30	10	Village	NA	Baru					

Chapter V Survey Administration and Data Collection

5.1 Questionnaire development and pre-testing

A common questionnaire was developed for both Pakistan and Sri Lanka. The questionnaire 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., was 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 contributed significantly to the development and refinement of the questionnaire. The revision of the questionnaire continued after pre-testing of the questionnaire and feedback from such pre-testing.

Pre-testing was undertaken in each stratum, but avoiding the selected clusters 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.

5.2 Implementation of first survey

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 selected 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 survey more smoothly and efficiently. The first survey was conducted during the period from 14 June to 6 July, 2001. All primary data collection was undertaken by formal interviewing process using structured questionnaire. Supervisors/sub-supervisors assigned for the survey remained with enumerators throughout during the data collection period. 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.

A useful and simple coding system was developed to identify each of the selected system, stratum, distributary, watercourse and households, as:

- System ID
- Stratum ID
- Distriburat ID
- Watercourse /rainfed village ID
- Household ID

The three main systems in the study area named as UJC, Gujrat and Rain fed 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 coded as 7-42 for identification purposes. A complete code book/data users' manual is provided as an attachment to this report.

Table 5.1 Identification codes for the system ID, Stratum ID, Distributary ID, Watercourse and Household ID.

System, SYID			
1	UJC		
2	Gujrat		
3	Rain fed		
Stratum, STID			
1	Rain fed		
2	9-R,10-R		
3	13-R,14-R		
4	Kakowal, Phalia		
Distributary, DID			
1	Gujrat Town		
2	Jalalpur Jattan Town		
3	Karianwala Town		
4	9-R		
5	10-R		
6	13-R		
7	14-R		
8	Kakowal		
9	Phalia		
Watercourses, WCID / Rain fed Area			
1	Dherkay	Rain fed	
2	Gigian	Rain fed	
3	Mianwal	Rain fed	
4	Jalalpur Sibtian	Rain fed	
5	Chak Kamala	Rain fed	
6	Baru	Rain fed	
7	9580-L	25	86090-L
8	9700-R	26	81090-L
9	20830-L	27	97539-L
10	14600-L	28	94996-L
11	28288-R	29	132416-R
12	29500-TL	30	129915-L
13	8780-R	31	24400-L
14	9900-L	32	24000-L
15	20049-L	33	67500-R
16	22500-R	34	68798-R
17	27940-R	35	77650-L
18	23000-L	36	77129-R
19	18040-R	37	33610-L
20	17017-L	38	31000-L
21	21642-R	39	125392-R
22	18060-R	40	125061 – L
23	38537-L	41	203000 – R
24	42640-TL	42	200103 - R

5.3 Enumerators Training

IWMI recruited 22 data enumerators for carrying out the surveys for the study. Most of them were drawn from IWMI's pool of enumerators- 16 were male and 6 were female enumerators. All enumerators had graduate/post-graduate levels of qualifications and most of them had significant prior experience in conducting surveys (for both IWMI and Non-IWMI projects). In addition, 3 data entry specialists were appointed for digitizing the collected data/information.

Considering the nature of this study in terms of intensity, size and structure of questionnaire and to ensure high quality of data, enumerators were given one-week intensive training on various aspects of data collection. These included detailed presentations on the purpose and rationale of the study, components of the study, 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. Enumerators were explained each and every question/variable in the questionnaire, and they were provided opportunity to fill-up questionnaires in hypothetical situations (Role-play) before pre-testing and actual surveys. Both technical and non-technical problems and issues resulting from the hypothetical situations were discussed in a number of discussion/question-answer sessions. During the later part of training, enumerators were provided opportunity to fill-up the questionnaire in the real world situation – during questionnaire pre-testing. The training program ended when the study team leaders/supervisors were fully satisfied with the performance of each of the enumerators. 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.

5.4 Logistical arrangements

For undertaking household survey, IWMI established a field station/office 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 within these, data enumerators were divided into two teams of 11- enumerators each, which were led by two sub-supervisors. Each team was comprised of eight male and three female enumerators.

Initially, measuring respondents' heights and weights was thought to be a problem in the rural culture. Particularly for measuring heights and weights of female respondents by male enumerators. In cases where respondents were having such reservations, female staff assisted male enumerators. There were few cases where respondents were not willing to provide information about their personal belongings/assets and their non-farm income because they thought that enumerators belonged to some agency that might impose taxes on their assets/incomes. However, after some clarifications and confidence building, such respondents agreed to provide the required information. In certain cases, the enumerators and sub-supervisors had to walk up to few kilometers to reach the respondents because of the poor road access to those areas.

For measuring flows in the unlined watercourses, Cut-Throat Flumes of 4''*3' and 12''*3' were used. In lined portions (usually near head of the watercourses) a pigmy current meter was used to measure velocity of water. Both current meter and flumes were checked and calibrated before the exercise. Other equipments used were a spirit level, a stopwatch and a spade. While measuring flows at all the points, Flumes were installed on free-flow condition. For current meter measurements at each point width, watercourses were divided into 3-4 sections, having width of 0.45 to 0.6 feet to see velocity of water at a particular section. Depths were measured from 0.2 to 0.25 ft width. Current meters were calibrated few days before the exercise. Time fixed for counting the turns of Current meter was 50 seconds for all the points and at least two readings were taken on each point. The discharge was measured in cusecs (cubic foot per second). There was an error of +0.03 in upstream gauge in flume of 12''*3' which was adjusted in calculations. There were 36 outlets to be measured, out of which 33 were measured at different length along the watercourse; the length varies from 1.25 to 15.89 hectares. There was no water at two tail side outlets of 13-R, so measurement was not possible at these outlets. One outlet at Phalia distributary was once measured at head but not measured at tail though tried twice because at both occasions tubewell or canal water from other watercourse entered the sample watercourse. The measurement exercise was completed during 12-22 July, 2001.

5.4 Income/Expenditure Dairies for Respondents

Households were provided with a diary (notebook) to record their daily expenditures and income for the following three-month period. Information on all income and expenditures was requested to be recorded by a literate person in the household. This diary was basically developed from the expenditure module of the questionnaire. The households were requested to list all income received and expenditure incurred on each day on a page in the diary or notebook. For ease of understanding of the households, the diary was translated into Urdu language. In addition, pictures of fruits/food items were printed on the dairies.

5.5 Data Checking, Quality and Reliability

All efforts were made to collect the quality data from households. In addition to the enumerators training, as mentioned above, supervisors were given special training to maintain the quality of data at both collection and entry stage. In situations where enumerators were found to be facing any problem, supervisors were available to resolve the problem. Data were checked at several stages. 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, the questionnaire were checked by sub-supervisors 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 on data collection, checking and entry procedures by the project leader). After supervisors 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 cross-checking at different levels and imposition of strict procedures helped in maintaining the quality of data set.

5.6 Second and Third Surveys

While some basic information for the three surveys remained the same, some modifications were made in the second and the third surveys to incorporate the changes in the calendar months (March to mid August for second survey and mid August to October/November for the third survey). For the second survey, the questionnaire was considerably shortened to obtain only the key information related to Kharif period. The basic information module was adjusted to obtain data on weights and heights and labor utilization during the period from June to mid August from each household member. Similarly, the expenditure and credit modules were adjusted to obtain information during June to mid August 2001. For the third survey, the questionnaire was almost same as that for first survey, except that some modifications were made to obtain complete information related to the last Kharif season.

Thus the initial period of preparation for the second and the third surveys involved making the required changes to the questionnaire. The templates in the computer program (Excel) were adjusted to accommodate data entry for the second and third surveys. The first two pages of the filled questionnaire from the first survey were photocopied and attached to the questionnaire of the second and third surveys, to match them with previously obtained basic data, and to avoid chance of any error in filling up the questionnaires. The respondent ID and code number of each respondent was written on questionnaires so as to avoid chance of any error that could potentially occur from torn pages and mix-ups of questionnaire pages.

Since the questionnaire was shorter for the second survey, it was feasible for the enumerators to complete four interviews per day. The second survey was completed in 18 days by 12 enumerators, from among those conducted the first survey interviews (with 6 male and 6 female enumerators). The enumerators were grouped into two teams, each consisting of 3 male and 3 female enumerators. Both the teams had field sub-supervisor (in addition to a overall field supervisor) selected from within the enumerators team. Since the

third survey was similar in length to the first survey, it was completed in 19 days by a team of 22 enumerators, with on average two interviews completed per day by each enumerator.

Before the beginning of the second and the third surveys, a refreshing training was provided to the enumerators and data entry operators by the project leader and the supervisors. The revised questionnaires for the second and third surveys were discussed in detail, and any doubts, problems or ambiguities arising from the questionnaires cleared by the project leader and the supervisors. The problems that were encountered in the first survey were also discussed and suggestions were made to resolve such problems, taking into account the views of the enumerators, in order to improve the quality of the data collected. Measurements of heights and weights of the household members were also emphasized during the refresher training. For the third survey, refresher training sessions were conducted for two days because 7 new enumerators joined the survey team (as seven among previous enumerators found permanent jobs and were no longer available). The need for adhering to the ethics and code of conduct of the surveys was repeatedly emphasized in order to inculcate a sense of discipline among the enumerators. Enumerators were provided all the necessary material in the form of a survey kit including weighing machines and measurement tapes. Overall, response from respondents was quite favorable, and both the surveys were completed as scheduled.

Those assigned for checking the questionnaires, were required to evaluate the quality of data gathered by the enumerators, using a grading system. The checkers were required to look for errors in the filling up of questionnaires such as, missing or illegibly entered values or responses, very high, low or improbable values, faulty coding or numbering, not entering the responses logically or in the proper sequence. The performance of data entry persons, was evaluated in turn by the supervisors using criteria such as accuracy, completeness and reliability of data entry. Log books were maintained and daily records kept of attendance of all staff, the number of questionnaires completed, number of questionnaires checked, the number of questionnaires entered in the data base, and the performance evaluation and grading of enumerators, checkers, data entry persons and supervisors. With all these measures put in place by the project leader, the quality of data collection was maintained at high levels in both second and the third surveys as in the first survey.

Logistical arrangements for the second and the third surveys were similar to the arrangements made for the first survey. Accommodation for the male enumerators, data entry persons and supervisors was provided at the hostel of Government Technical College Rasool, and female staff were accommodated in a rented house. The field staff house was the focal point for all the field activities. As for the first survey, computer lab was established for data entry during the second and the third surveys. For quick and comfortable mobilization of the staff, one jeep and one van was arranged for the second survey (during the third survey, two vans in addition to a jeep was used). Two field guides were hired to accompany the teams in the field. Throughout the surveys, prior appointments were made with the respondents. On the day of survey interviews, guides helped the team in locating the residences of the selected households. Prior appointments with respondents increased the probability of availability of sample respondents and it significantly improved the overall efficiency of survey team.

During second and the third surveys, all questionnaires were reviewed by enumerators, checked by their peers and then by field sub-supervisors on daily basis. The sub-supervisors, 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. Two persons were appointed full time for data editing. The data editing persons, after re-checking those questionnaires forwarded, them to the data entry persons; in case of any problems the concerned enumerators were asked to rectify the problems. The enumerators, after rectifying the problem (if any) returned the questionnaires back to the data editing persons, who after the final examination forwarded the questionnaire for final data entry on daily bases.

As for the first survey, consistent user manuals were developed for the second and the third survey data. After review of the data by the data editing person the completely checked questionnaires reached the data entry persons for the data entry. The data entry persons used the coded variables to enter the data (the templates used in the first survey was adjusted to facilitate data entry for the second and third survey data). In case if the data entry persons found any ambiguity in any of the questionnaire, those questionnaires were referred back to the enumerators for possible data correction. This crosschecking at different levels, introduction of data editing person and imposition of strict procedures helped in maintaining the quality of data sets collected during the second as well as third survey. Later on, five enumerators and data entry persons spent two weeks to complete the cleaning of the data according to the codebook.

Data entry and cleaning for the second and the third surveys commenced right from the initial phase of data collection. 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. Individual data entry operators divided the completed questionnaires equally among them, and entered all data in the questionnaire. They were also required to convert data entered in different units in the questionnaire to standard units, prior to entering in the database. Data clean-up was done through a filter facility in Excel as well as through frequency tables in SPSS.

5.7 Household Income/Expenditure Dairies for Respondents

In addition to questionnaire survey, the households were provided with a diary (notebook) to record their daily expenditures and income for the following three-month period. The premise was that data from daily records of income and expenditure would be more reliable than recall data obtained from the questionnaire survey. Furthermore, such data would help in assessing the quality of the data gathered using the structured questionnaire. Information on all income and expenditures was requested to be recorded by a literate person in the household. The households were also requested to include the quantity of produce consumed from home garden or from their agricultural lands. This diary was basically developed from the expenditure module of the questionnaire. The households were requested to list all income received and expenditure incurred on each day on a page in the diary or notebook. The enumerator selected a suitable person in the household to keep the diary. He would then instructed the selected person, on how to fill up the diary including examples of what should be included. For example, expenses on food, such as vegetables, fish, milk powder, etc. were included in this category. The quantity of produce used for home consumption was also included in the diary. This included such items as rice, vegetables and fruits. For ease of understanding of the households, the dairy was translated into Urdu language. In addition, pictures of fruits/food items were printed on the dairies.

These diaries were collected during the second survey in order to see the response. Out of 720 diaries delivered to the households, 614 dairies were returned. Out of these, only 192 respondents could fill the diaries completely, about 315 households returned the diaries which were partially filled and about 107 households could not fill the dairies at all. Illiteracy of the household members was one of the frequently given reasons for not completing the dairies.

5.8 Field Problems- Second Survey

During the second survey, the enumerators faced some difficulties. Firstly, six of the respondents from the first survey (mostly non-farmers) migrated to other areas along with their families to seek better employment. These respondents could not be located. Secondly, there were few respondents who were still there but due to certain reasons such as death of a family member or non-availability of respondents at the time of visit inhibited the enumerators to get information about those families. The enumerators were asked to revisit such households at the end of the survey. In the end, the enumerators were able to gather information on the questionnaire from most of them. Only two households refused to be interviewed due to certain myths related to agricultural taxation etc. In total the enumerators could get data from 712 selected households. As far as the overall response was concerned it was satisfactory, in some cases respondents really gave hard time to the enumerators.

5.9 Field Problems- Third Survey

During the third survey the enumerators encountered similar problems as in the second survey. Firstly, despite the prior appointments with respondents, few respondents were unable to meet the enumerators due to various reasons. Some of the farmers were busy in the sowing, fertilizer application and other wheat sowing activities. Interviews with these respondents were to be postponed till the end of the survey period (i.e during the last week of the survey). Secondly, during the last part of the survey, bad weather conditions caused problem. The weather was very foggy and visibility was very poor. As a result, the number of working hours had to increase substantially. As in the second survey, few respondents migrated and were not available for interviews during the third survey.

Chapter VI Analytical Framework

The major objective of this study is to assess the impact of irrigation infrastructure development on poverty. The study employs a ‘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. As for 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. The overall framework for this study is based on three key hypotheses as stated below.

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

The dynamic aspect of poverty to be examined in this study is to determine whether irrigation infrastructure can reduce the variability in incomes and expenditures in rural households. The second hypothesis to be tested can be stated as follows:

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

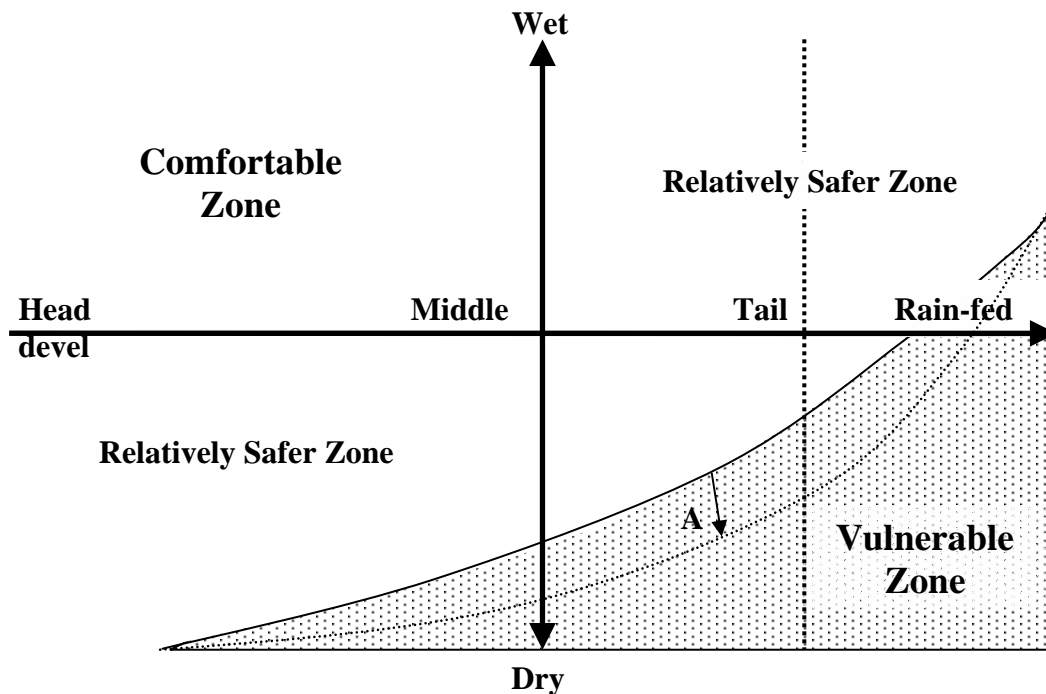
The relationship between consumption smoothing and irrigation infrastructure, specifically the question of whether households with access to irrigation infrastructure receive higher incomes and thus able to smooth consumption, is another dynamic poverty aspect that will be addressed in this study. The third hypothesis can be stated as follows;

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

In assessing the impact of irrigation infrastructure on poverty, it is important to understand 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, while availability of physical irrigation infrastructure alone may not be a sufficient condition for access to water, it is surely a necessary condition. Adequate water may be available, but without infrastructure, people may not be able to access it. The access to water depends upon availability of both water and infrastructure. However, there may be variations in availability of water and the degree of infrastructure development, with varying impacts on poverty.

The hypothesized spatial and temporal relationships between infrastructure development and poverty are depicted in Figure 1. The horizontal axis represents the irrigation system with the arrow illustrating the flow of water from the head down to the tail reach. The rainfed area relies on rain as its primary source of water. The vertical axis represents the time dimension and is characterized as either the wet or dry season. Based on the location and season/ timing each area is classified by the state of infrastructure development and relative security of access to adequate irrigation water supplies.

Figure A1: Spatial and Temporal Dimensions of Irrigation and Poverty



Near the head of the irrigation system, where infrastructure is most likely to be well developed (compared to, for example, tail reaches, a farmer is most likely to be guaranteed an adequate supply of water during the rainy season. This is because during the wet season surface water flows will be at their highest and because head-end farmers will have first opportunity to take water. Farms located further down the irrigation system will experience diminished relative security of their access to irrigation water. The diagram presented illustrates that there are seasonal vulnerability patterns for access to irrigation water, as well as distinct spatial patterns. Policy interventions to alleviate the vulnerability, should attempt to reduce the vulnerability zone both in time and location, illustrated by the lower dashed curve.

6.1 Analytical Methods

There is no single indicator or method for testing the above hypotheses. In this study, we use the following approach to comprehensively assess the impacts of irrigation infrastructure on poverty covering both its spatial and temporal aspects.

1. Compare various strata representing the state of infrastructure development – quantify the difference in the value of relevant variables by developing a socio-economic profile for each stratum.
2. Develop and quantify key indicators of poverty – covering both monetary and non-monetary dimensions of poverty.
3. Estimate household income/consumption smoothing effects or irrigation infrastructure development through econometric analysis.
4. Identify and quantify key determinants of household income/expenditures/poverty including quantifying the impact of irrigation infrastructure development on these variables through econometric analysis.

Details on indicators of poverty and econometric framework are provided in the following section.

6.2 Defining the Poor and Measuring Poverty

A basic problem in any work on poverty is how to define the poor and how to measure poverty. There could be as many definitions of poverty as the number of poor themselves, or at least as many as the number of people who have attempted to define poverty. Traditional approaches to measure poverty have centered around the concepts of incomes and consumption levels, with poverty generally perceived in two distinct ways: absolute poverty and relative poverty. Absolute poverty is defined in terms of minimum consumption needs without reference to income or consumption levels of the general population. A relative poverty situation, on the other hand, is generally defined in relation to mean income or consumption of a population as a whole. A person is considered poor, in absolute terms, if his/her income or consumption level falls below some minimum level necessary to meet basic needs – this minimum level is called the poverty line.

However, it has been argued that income is a narrow concept and is not an adequate measure of poverty and well-being. 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 looking at poverty from both economic and non-economic dimensions provide a comprehensive and holistic approach for understanding poverty, analytical and measurement problems pose difficulties in the application of most of the above concepts. Consequently much of the empirical work in poverty relies on traditional income and consumption measures – estimating poverty lines using a basic needs approach. As the basic needs vary across time and

space, poverty lines also vary over time and across societies – depending upon the level of socio-economic development, social norms and values within regions in a country or across countries.

6.3 For the purpose of this study, we will measure poverty in terms of the following two major dimensions:

1. Monetary Dimensions of Poverty – Income Poverty
2. Non-monetary Dimensions of Poverty

6.4 Monetary Measures of Poverty

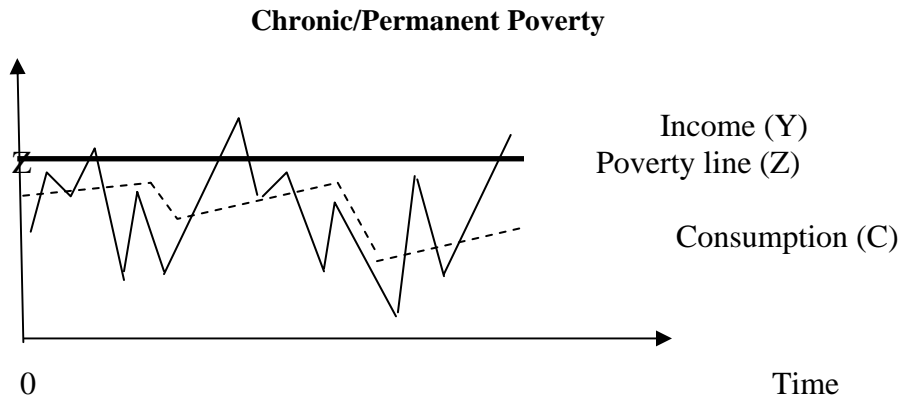
6.4.1 Income Poverty – Concepts of Chronic and Transient Poverty

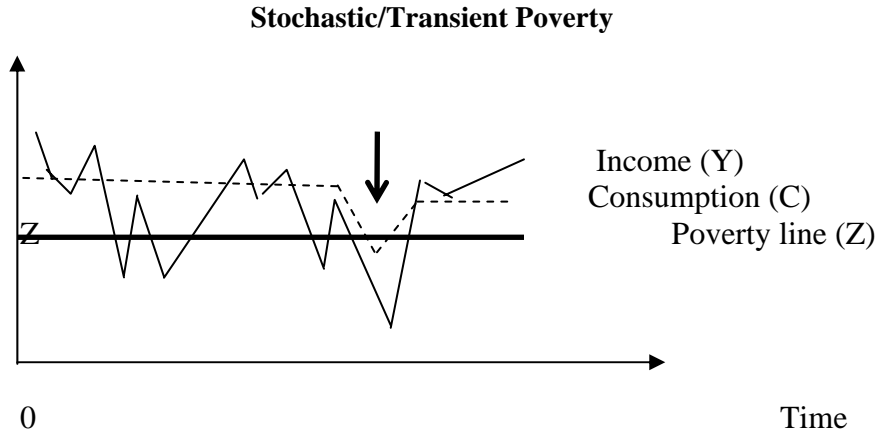
There are two basic concepts of income poverty, static and dynamic. Static concepts relate to measurement of poverty at a point in time. Dynamic poverty relates to changes in poverty over time. The concept of dynamic poverty is further analyzed as chronic poverty and transient poverty. Chronic poverty is defined as a state where a household’s income (consumption) is constantly below the poverty line. 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. Transient poverty is also called stochastic poverty.

Chronic poverty = a situation where $Y^P < Z$

Transient poverty = a state where $C < Z < Y^P$,

- where Y^P = a household’s permanent income
 C = a household’s current consumption level
 Z = poverty line





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

There are distinct policy implications underlying the two dynamic concepts of poverty. 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 form 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).

Some of the monetary indicators of income poverty include:

- 1) Average income per month
- 2) Average farm income per month
- 3) Average non-farm income per month
- 4) Average expenditure per month
- 5) Ratio of food expenditure to total expenditure

The relationship between income and consumption is embodied in the Engel's law, put forward by a German statistician Ernst Engel, who concluded that as incomes increase a smaller and smaller proportion of income is spent on food. In general, the function denoting the relationship between income and consumption, keeping prices constant is called the Engel curve. As incomes increase, the quantity demanded increases for a normal good, like food, a necessity. As incomes increase further, the quantity of necessities consumed does not increase in proportion to income increases. Consumption does not cease altogether, because they are necessities. For luxury goods, there is little or no consumption at low levels of income, but consumption increases as income increases. For inferior goods, consumption declines with increases in incomes. A good cannot be inferior at all levels of income, at zero income there are no purchases, as income increases a little, consumption increases a little, and eventually as income gets high enough, the consumer ceases to purchase it altogether. Thus at high poverty levels one may observe a high proportion of income being spent on food, and as poverty levels decline, the

proportion spent on food declines while the proportion spent on luxury and other normal goods increases.

6.4.2 Monetary 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. Foster-Greer-Thorbecke (FGT) class of measures is the most commonly used measure of poverty, which captures three aspects of poverty: incidence, depth/intensity and severity of poverty. These measures are the Headcount Index, the Poverty Gap Index and the Squared Poverty Gap Index.

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:

$$\text{Head Count Index } HC = q/n \dots\dots\dots (6.1)$$

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

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

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:

$$PG = I * HC, \text{ where } I \text{ is the income gap}$$

$$\text{Where } I = \frac{z - y_q}{z} \quad \text{and} \quad y_q = 1/q \sum_{i=1}^q y_i \text{ is the average income of the poor.}$$

Squared Poverty Gap Index is a measure of the severity of poverty. The poverty gap takes into account the distance separating the poor from the poverty line, while the squared poverty gap $[PG]^2$ takes into account the square of the distance. The squared poverty gap index

gives more weight to the poor, by taking into account the inequality among the poor—greater weights are given to larger gaps and the weights are simply the poverty gaps. It is represented as follows:

$$\text{Squared Poverty Gap } [PG]^2 = \frac{1}{n} \sum_{i=1}^n \left[\frac{Z - y_i}{Z} \right]^2 \dots\dots\dots (6.3)$$

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

$$P(\alpha) = \frac{1}{n} \sum_{i=1}^n \left| \frac{Z - y_i}{Z} \right|^\alpha \dots\dots\dots (6.4)$$

The above measures can be analyzed for various socio-economic groups and for different geographic locations (within irrigation systems).

The above general monetary measures of poverty can be used to estimate the incidence of chronic poverty and transient poverty. The households can be divided into three groups: a. non-poor b. chronic poor, and c. transient poor.

- a. Households that never experienced income at levels below the poverty line
- b. Households whose income sometimes fell below the poverty line during the study period
- c. Households with income levels that are always below the poverty line

$$I_t = \frac{1}{n} \sum_{i=1}^{P_t} \left(\frac{Z - y_{it}}{Z} \right)^\alpha \dots\dots\dots (6.5)$$

$$C_t = \frac{1}{n} \sum_{i=1}^{P^*} \left(\frac{Z - \bar{y}_i}{Z} \right)^\alpha \dots\dots\dots (6.6)$$

$$T_t = I_t - C_t \dots\dots\dots (6.7)$$

- I_t poverty index
- C_t chronic poverty index
- T_t transient poverty index
- Z poverty line
- y monthly income of household

\bar{y} average monthly income of household
 n population

Poverty indices are calculated as per the following categories, with $\alpha = 0$ or 2 .

First category

1. both average monthly income and highest monthly income are less than the poverty line (i.e. chronic poverty)
3. average monthly income > poverty line, lowest monthly income < poverty line (i.e. transient poverty)
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

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

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

The first two measures are self explanatory. The third measure is explained below.

6.4.3 Standard Certainty Equivalence Measure

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

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

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

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

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

where *RRA* is the degree of relative risk aversion and σ is the standard deviation of household income. Note that m/Y represents the welfare effects of the existence of income fluctuations. When there is no income risk, i.e., $\sigma=0$, 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 welfare cost of income/expenditure fluctuations (for more details see Morduch, 1995).

Empirically, the value of the standard deviation σ and the average of 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.

6.4.5 Defining the poverty line

As mentioned above, specification of poverty line is an important step in estimating the above measures. There are three commonly used approaches 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, 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 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

6.4.6 Defining income —sources of rural income

The concept of rural income, as used in methodological discussions above, is defined as the total income received in both cash and kind in a given season/year. Income received in kind was in monetary value using the prevailing prices. The total income used is net of all cash expenses but exclude the imputed value of all resources owned by the household (family labor, draft animals etc)

Total income may be disaggregated by its source of origin as follows.

1. Income from crop production – includes incomes from the 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 income is calculated net of all cash expenditures on material inputs (seeds, fertilizers, chemicals), hired labor, rental payments for farm machinery.
2. Income from non-crop agriculture – includes incomes from livestock, fisheries and forest products and their by-products. This includes the imputed value of the produce retained for household consumption.
3. Income from agricultural wages – includes incomes from working in agricultural activities on others' farms.
4. Incomes from trade, services and other non-agricultural sources – 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.

6.4.7 Definition Household Expenditures and Assets.

Household expenditure is first divided into durable and non-durable expenditures. Non-durable expenditure is divided into three categories. Category I comprised wheat and rice, both purchased and consumed from own farm, other cereals (Maize, Jawar, Bajra, oats etc), pulses, potato, vegetables, fruits, sea fish, pond fish, , meat, flour, bread, eggs and milk, category II comprises tea, coffee, milk powder, , soft drinks, , cooking oil/ghee, , sugar, salt, and spices. Category III comprised of tobacco, cigarettes, soap, shampoo, electricity charges, expenses for firewood, cooking fuel, LP gas, and lighting fuel. Other category of expenditure included expenses for house repairs and maintenance, clothing and shoes, medical care, education, recreation, ceremonies, transport and communication, remittances to family/relatives, rent, loan repayment, taxes, bank deposits, weddings, and other miscellaneous expenditures. Non-durable expenditures included food expenditures, which included all items in Categories I and II and non-food expenditures, 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). Since wedding expenditures, was considered to be one time expense it was excluded from the non-food category of expenditures. Household expenditure data was obtained on a monthly basis from December 2000 to November 2001.

Durable expenditure included expenditure on agricultural assets and household assets. Agricultural assets included small and large tractors, plow and harrow, water pumps sprinkler

systems, motorized 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, milk 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 data 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.

6.5 Non – monetary indicators of poverty

Frequently used non-monetary indicators to determine the level of poverty can be grouped into the following categories.

- 1) Health related indicators: under 5 mortality rate, life expectancy, number of days absent from work due to illness, prevalence of child malnutrition, access to sanitation, access to hospitals access to drinking water, type/housing condition, per capita calorie intake;
- 2) Education related indicators: Adult literacy rates, number of years of schooling, school drop out rate, distance to school;
- 3) Infrastructure indicators: Distance to nearest bus station, market, post office, telephone, availability of electricity, access to gas cooking, access to irrigation, access to upgraded lined irrigation;
- 4) Asset ownership: per capita land, per capita irrigated land, ownership of houses, household assets,
- 5) Household, Labor and Employment: Primary and secondary occupation, percent unemployed, dependency ratio, labor force participation rate

For this study the following key non-monetary indicators have been selected, on the basis of information collected in the survey. These indicators will be estimated for each stratum.

1. *Dependency ratio:* This is defined as the ratio of the number of children and elderly persons to total potentially employable persons. This indicator can be calculated on the basis of a household, stratum, group or sector of the population. One would expect the dependency ratio to decline with the decline in poverty.
2. *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, 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 educational attainments would reduce poverty.

3. *School drop out rate:* Traditionally, it has been assumed that high drop out rates of children of school going age was mainly due to the household not being able to afford schooling due to poverty. It could also be a result of schools being 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 prefer to send their children to work than to school in order to earn an additional income.
4. *Under-five mortality rate:* Poverty can result in higher mortality of children under five years old, as they are the most vulnerable group. Thus, one would expect a higher mortality rate of this group within poor households. A measure of mortality of children under five would be a good indicator of poverty.
5. *Housing 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.
6. *Ownership of household assets:* One would expect households owning greater amount of assets to be less poor than those having little or no such assets. Data has been collected on the current value of household assets owned by households. Value of household assets per household or per capita, would be good indicators of poverty (household assets here include only non-agricultural assets).
7. *Average land holding – irrigated and non irrigated:* This estimates the average land holding ownership by type of water source. It is assumed that households owning larger irrigated holdings are less poor than those not having irrigation facilities.
8. *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 agrowell, illegal diversion of canal, seepage water, tube well, drainage water, etc. and would fall into this category. This indicator and would capture the true irrigated extent and provide a more precise categorization of land by irrigation.
9. *Cropping intensity:* This is the ratio of the area cropped to the area actually owned, per season. The higher the cropping intensity the less poor the household.

10. *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) will provide a measure of the potential versus actual productivity. The difference 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, drainage problems or other problems.
11. *Total agricultural assets:* Agricultural asset ownership provides a measure of wealth and would be a good indicator of poverty in rural areas. Data has been collected on the current value of agricultural assets owned by the household. Thus the value of agricultural assets per household or per capita would be a good indicator of the level of poverty of the household. Agricultural assets would include, all equipment used in agricultural production, e.g. tractors, plows, threshers, trailers, sprayers etc.
12. *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 should be considered when interpreting the results of this indicator.
13. *Access to piped water supply:* This indicator can be estimated as the proportion of households having access to piped supplies of water, which can be used as a measure of poverty.
14. *Access to credit:* The assumption here is that the poor have less access to credit than non-poor households.

6.6 Econometric Analysis

a). *Seasonality in Incomes and Expenditures*

The third hypothesis on the issue of income and expenditure smoothing is tested using the model developed by Paxson (1983). 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:

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

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

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

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) receives 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 log expenditure equation as:

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

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 null hypothesis that $\pi = 0$ or that seasonal expenditure is dependant only on permanent income, prices and preferences and not on timing of income flows. Separate OLS estimates of π can also be obtained for the poor and non-poor groups within each stratum. A regression analysis based on the above framework using consumption as the dependent variable and dummy variables for seasons/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 (chapter 10).

b) 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.

Income/expenditures/poverty is modeled as a function of range of independent variables, which may include: location of the house, family size, education level of household head, number of working members, household non-land and non-agricultural assets, household agricultural assets, farm size- landholding, cropped/cultivated area, proportion of area under high value crops (i.e. non rice area), and state of infrastructure development (dummy, well developed, less developed, not developed/unimproved, and no infrastructure). For more details on the model specification and estimation, see chapter 10.