Research Report-5 2004

IMPACT EVALUATION OF WATER RESOURCES DEVELOPMENT IN THE COMMAND AREAS OF SMALL DAMS

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2004

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ISBN 969-8469-12-5

Acknowledgement

The study was conducted under the Financial Support of Pakistan Foundation (PSF) vide Project No. R&D/CDYST/C-PCRWR/AGR(15). The author would like to thank PSF for providing assistance to conduct this study and also to publish this report. The author would thank Dr. Muhammad Akram Kahlown Chairman PCRWR for his encouragement, support, guidance and stimulating criticism during the course of this study. The author is also grateful to Dr Ashfaq Ahmed Sheikh Deputy Director and Mr. Samar Gul Assistant Director for their help during data collection and analysis. The help of Mr. Naheed Ijaz Deputy Director in editing and Mr. Zia-ud-Din UDC in compiling the report is also acknowledged.

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FOREWORD

Water is a limiting factor for sustainable agriculture in Pothwar. Rainfall is the only source of water, the spatial and temporal variation of which is very high. Therefore, conservation and management of this source is vital for agriculture development and socio-economic uplift of the area. The Government of the Punjab has constructed 31 small dams in Pothwar to store and conserve water for agricultural and other uses. These dams, however, have been under criticisms due to their under utilization of the available water resources. This study was under taken to evaluate the existing performance and identify the issues related to the effective utilization of the water stored and to propose strategies for the efficient utilization of these dams. The dams studied included: Jawa; Kasala; and Dhok Sandy Mar. The study revealed that these dams had been partially successful to improve the socio-economic conditions of the local inhabitants. Due to recharge from the dams, a local aquifer has developed due to which the number of dugwells has increased by many folds. The land use and cropping intensities, and crop yield have also been increased by many folds after the construction of these dams. There is a shift in the cropping pattern from traditional cropping to high value crops due to the availability of more water supply. These dams, however, are subject to many problems such as: (i) illegal water diversions; (ii) non-existence/non-functional water user associations; (iii) improper maintenance of watercourses; (iv) tempered outlets (*moghas*); and (v) lack of agricultural support services *etc*. The study also proposes strategies for efficient management of available water resources in the Pothwar area. The study was sponsored by Pakistan Science Foundation (PSF) and was conducted by Dr Muhammad Ashraf, Director, Pakistan Council of Research in Water Resources (PCRWR) Islamabad and his team. I commend the work done and hope that it would help the stakeholders to solve their water management problems.

(Dr Muhammad Akram Kahlown)
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SUMMARY

Government of the Punjab has constructed 31 small dams in Pothwar to store and conserve water for agriculture production and other uses. The effective utilization of these dams can bring green revolution in the area. These dams, however, are subject to huge evaporation losses due to which significant amount of water returned to atmosphere without any use. The estimated loss of water due to evaporation is 1.74 m/year that is about 20% of the storage capacity. Moreover, the storage capacity of these dams has depleted drastically due to silt deposition and vegetative growth. Since the cost of water storage in small dams is very high (about 4 to 7 times greater than large dams), therefore it is imperative that the stored water should be used judiciously and efficiently. Seepage of water from these dams to underlying aquifers is not always a real loss because the water can be recovered by pumping it through open wells or tubewells. Maximum efforts should be made to control evaporation from the dams since it is an irreversible loss of water.

A study was conducted to document the existing status of agricultural practices in the command area and the impact of water resources development on the socio-economic conditions of three small dams namely: Jawa; Kasala; and Dhok Sandy Mar. These dams have been successful to improve the socio-economic conditions of the local inhabitants. Due to the recharge from the dams, the water has become accessible for pumping due to which number of dugwells has increased many folds. This has reduced drudgery on the local inhabitants particularly women who have to fetch water from far away for their domestic uses. After the construction of these dams, the land use and crop intensities, and crop yield have also increased many folds. There is a shift of cropping pattern from the traditional cropping towards high valued crops due to the availability of water. An analysis of the dams inflow-outflow shows that inflow may be sufficient to irrigate the command area. However, if properly managed, more area could be irrigated with the same infrastructure/existing facilities and with the same availability of water.

Nevertheless, there are several bottlenecks in the full utilization of these dams. These include: (i) illegal water cutting; (ii) non-existence/non-functional water user associations; (iii) improper maintenance of watercourses; (iv) broken outlets (*moghas*); (v) poor field channels; (vi) lack of agricultural support services etc. Well co-ordinated efforts by Small Dams Organization (SDO), Agriculture Extension and On Farm Water Management (OFWM) departments could help overcome these issues. This study also proposes strategies for the efficient management of available water resources.

Chapter 1

INTRODUCTION

1.1 Background

Pakistan's economy depends on agriculture which contributes 24% of the Gross Domestic Product (GDP). Apart from producing food, it provides raw material for agro-based industry. Out of about 22.16 million hectares (Mha) of country's total culturable land, 17 Mha are irrigated with a culturable waste of about 9.30 Mha (MINFAL, 2002).

The Pothwar Plateau spreads over 2.2 Mha and has great potential for agricultural and social development. Total cultivated area of Pothwar Plateau is around 1.0 Mha. These areas are characterized by limited availability of water, which is the most important input for agriculture development. Agriculture in this area is just at subsistence level, primarily due to acute shortage of assured irrigation supplies. Other factors contributing to meagre agriculture in the area include fragmentation, obsolete methods of farming, lack of institutional and infrastructure facilities. The present average land holding is generally less than 1 hectare. The trend of division of land holdings and migration has disrupted the social balance in the Pothwar Plateau and is hindering further economic development (Bhutta, 1999).

The occurrence of rainfall in barani areas is highly erratic both in space and time with most of the rainfall occurring during monsoon period (July to September). Due to this, about 3.40 million-acre feet (MAF) of water is lost as surface runoff annually (Bhutta, 1999). This water, therefore, is not available for agriculture. Moreover, due to the uncertainty of rainfall, farmers normally minimize inputs to reduce the risk of loss in the event of drought and mainly depend on off-farm incomes for their sustenance. However, in the context of crop production, barani lands have often been underestimated. More than 1200 kg/acre of wheat have been produced in these areas under rainfed conditions (Ashraf and Mian, 1979) which reveals a high potential for maximizing crop production.

In Pothwar, there is potential for both water resource development (surface and subsurface) and its management to improve the efficiency of the existing systems (Ashraf *et al*., 1999). Water resource development broadly refers to projects such as construction of small dams, mini dams, ponds, dugwells, tubewells *etc*. The collection, storage, conservation, utilization and management of these sources are of paramount importance in these areas. Each millimetre of water collected, stored, conserved and saved in these areas could increase yield of wheat by an average of about 10 kg/ha (Marshall and Holmes, 1988).

The Government of Punjab through Small Dams Organization (SDO) has constructed 31 small dams in Pothwar plateau since 1961. These dams are designed to irrigate over 35000 acres. However, a study conducted by NESPAK (1991) has concluded that only 32% of the anticipated command area has been developed (Table 1). Further, the average cropping intensity is also low being only 35% against planned average of 96%. On an average, 69% water is being released from these reservoirs. Bhutta (1999) also reported that only 42% of command area has been developed.

Due to high surface area to volume ratio, these small reservoirs are subject to high evaporation losses. On an average, small reservoir loss 50% of their impoundments to evaporation in arid and semi-arid areas (Sakthivadivel *et al*., 1997). The seepage and percolation loss in small reservoirs is about 20% of reservoir volume against 5% in large dams (Keller *et al*., 2000). The unit cost of small dams is also relatively high. The cost per acre-foot (AF) of water is from Rs. 62 to Rs. 1975 for large reservoirs whereas it is from Rs. 430 to Rs. 6800 for medium and small dams (Keller *et al*., 2000). Table 1 shows that the small dams in Pothwar are also subject to high evaporation losses. On an average these dams loss about 1.74 m/year, which is about 20% of their storage capacity and the cost of water, is about Rs. 2000 per 1000 m^3 (Rs. 2400 per acre-foot).

Table 1: *Cropping Intensity and Command Area Development of Some Selected Small Dams*

Name of Dam	*Cropping intensity (%)*		*Command area developed (%)*	*Evaporation losses (m/year)*	*Release of water (% of storage)*	*Cost of water (Rs m^{-3})*
	Field survey	*Proposed in PC-1*				
Grat	14.7	120	22	1.55	78	2.18
Dungi	32	150	14	1.73	21	1.98
Khasala	50.2	140	44.8	2.03	41	4.36
Misriot	58.10	150	39	1.77	30	2.83
Narali	25.5	63	41	1.73	58.5	2.07
Dhok Tahlian	46.6	100	70	1.70	191	0.46
Dhurnal	32.1	67	19	1.70	67.3	1.74
Ghurab	17.9	50	18	1.70	53	3.06
Khokar Zeer	36	90	40.6	1.73	117	2.16
Walana	10.6	90	57.1	1.73	56	2.57
Bango	18	87.4	25	1.73	100	1.39
Channi Bor	48.9	100	49	1.72	53.5	1.49
Kanjoor	42.2	80	6.1	1.79	60	0.97
Qibla Bandi	81.3	75	34.5	1.73	66.6	0.71
Ratti Kassi	16.9	77	16	1.73	65	0.48
Sipialia	18.8	93.3	15	1.70	33	3.17
Average	34.4	95.8	31.9	1.74	68.2	1.98

Source: NESPAK (1991).

Inadequate watershed management and natural and man induced erosion of the fragile barani soils has also led to the depletion of the soil and water resources. The high runoff in these areas is associated with the erosion and sediment transport and a huge amount of soil is being transported to these reservoirs. The vegetative growth in these dams indicates that top fertile soil from the catchments is being brought into these reservoirs, thus converting the productive land into non-productive (Ashraf *et al*., 2000).

Since the evaporation losses and unit cost of water stored in small dams are relatively high, therefore it becomes imperative that the stored water should be used judiciously and efficiently. Without proper management, the water resource developed would be lost without playing a significant role in the crop production and socio-economic development of the area. This study aimed to identify causes of low land and water productivity and low cropping intensity in the command area of selected small dams and to suggest possible strategies for improving land and water productivity in the command area.

1.2. Objectives

The overall objective of the project is to study the causes of low land and water productivity in the command area of small dams. The specific objectives, however, are as follows:

1. To document the existing agricultural practices in the command area;
2. To study the impact of water resource development on the socio-economic conditions of the area; and
3. To provide strategies for the better land and water utilization of the command area to increase land and water productivity.

Chapter 2

REVIEW OF LITERATURE

2.1 Past Investigations on the Subject

Shah (1984) evaluated Small dams in Punjab and found that due to the availability of water, the crop yield has been increased by 36% in case of wheat and by 51% in case of maize. However, the programme was not successful in term of economics, as the benefit-cost ratio was less than 1.0. They attributed this to the technical, socio-economic, institutional problems and lack of agricultural support services.

Khan *et al*. (1988) evaluated 22 small dams in Punjab and found that average cropping intensity was 110.9% and average land use intensity was 92.3%. He suggested that formal and informal organizations of the farmers could play a significant role in the effective utilization of the water, proper construction, rehabilitation, operation and maintenance of watercourses.

NESPAK (1991) reported that the achieved crop intensities were very low compared to the set targets. These ranged from 22 to 29% at dams in Punjab against an average target of 84%, whereas, in NWFP it ranged from 33 to 39% against a target of 81%.

Iqbal and Shahid (1992) concluded that less than one third of the proposed area was being irrigated by small dams. Therefore, desired changes in cropping pattern could not be accomplished. They suggested weekly rotational schedule/warabandi in which equitable and reliable distribution of water could be made possible to every farmer located at different reaches of water channels. An enlightened and imaginative extension service was required to motivate farmers to bring about desired changes in cropping pattern and adopt recommended practices.

Azhar (1995) attributed low land and water productivity to the lack of knowledge about irrigation scheduling in the command areas. He reported that 75% of the farmers apply less water than the crop water requirements, two third of the farmers apply first irrigation very late.

Shahid *et al*. (1996) reported that the SDO has been quite successful in achieving construction related physical targets of the small dams project. However, follow up activities after dams construction have been weak. After dam construction, efforts should be made to bring culturable command area under irrigation, which ultimately could contribute towards better quality of life and living standards of rural community. They considered a slight shift in cropping pattern towards the high value crops including *Rabi* fodder, *Rabi* and *Kharif* vegetables as a positive contribution of Small Dams Project at both newly built and rehabilitated small dams.

Cheema and Bandaragoda (1997) conducted base line survey for farmers organizations of Mirwal and Shahpur dams. The cropping and land use intensities were 123.4 and 63.5% under the irrigated area of Mirwal dam, respectively whereas these were

117.7 and 90% at Shahpur dam, respectively. Iqbal (1989) reported cropping intensity of 121.3% in the irrigated area of Shahpur dam.

Bhatti *et al*. (1999) pointed out that the distribution of water in the command areas due to poorly maintained watercourses were deficient. The level of the serving channels was frequently below the elevation of command area fields. Furthermore, farmers had operated the irrigation systems without an allocation and distribution schedules. As a consequence, substantial amounts of irrigation water were wasted and the distribution and application of water were inequitable and inefficient.

Bhutta (1999) suggested that to fully exploit the benefits of additional investment made at small dams in the form of improved irrigation network, not only the share of high value crops in the cropping pattern should be improved, but some non-traditional crops may also be introduced.

IIMI (1999) reported that the small dams system offered a precious opportunity for the sincere promotion of reforms in the irrigation sector. They were independent of the large scale Indus Basin Irrigation System and therefore, more easily manageable by smaller units of water users organizations and support service personnel.

Tarar (1999) reported that the institutional arrangements by which water was distributed appeared to be a key point. The farmers who had better size of holding, social status/influential personalities, have appropriate farm location at irrigation channel tend to have better water distribution relative to other farmers in the command area of newly built as well as previously existing dams. As a result, inequalities in access to irrigation water existed. He suggested changing the water distribution practices from the existing natural co-operation basis to weekly rotational schedule by giving share according to the size of land holdings in which water could be made available to every farmer in the command area according to his weekly turn.

These studies show that the potential of small dams have not been fully explored and are being under utilized. There is however, need to identify the underlying limitations of low land and water productivity to suggest possible strategies to enhance the crop production.

2.2 Scope of the Project

The present study envisaged a comprehensive impact assessment of water resources development in command areas of small dams covering social, technical, economic and agricultural aspects in relation to sustainability of developed interventions. The study was under taken using Participatory Rural Appraisal (PRA) techniques in command areas of three small dams in Rawalpindi Division, Punjab *viz*. Khasala, Jawa and Dhok Sandy Mar.

Chapter 3

METHODOLOGY

Three small dams namely Khasala, Jawa and Dhok Sandy Mar, situated in Pothwar region were selected for the study (Annexure-I). These dams were constructed by Small Dams Organisation, Punjab, mainly for irrigation purposes. The salient features of the selected small dams are given in Annexure-II. Different Participatory Rural Appraisal (PRA) techniques were used to collect data for impact assessment of the developed water resources. The methodology use for assessment survey is described in the following sections.

Plate 1: *A View of Khasala Dam*

Plate 2: *A View of the Jawa Lake*

3.1 Reconnaissance Survey

Reconnaissance survey was conducted to obtain preliminary information about the dams and their command areas including location, accessibility to dams, command area, sources of relevant data *etc*.

3.2 Data Collection from Small Dams Organization

Data such as inflow, outflow of water, warabandi, *aabiana* (water charges) were collected from Small Dams Organization, Islamabad.

3.3 Questionnaire Development and Pre Testing

On the basis of information obtained during Reconnaissance Survey, a questionnaire was developed and pre-tested in the field. After pre-testing, necessary changes were made in the questionnaire. The questionnaire is enclosed as Annexure-III. It covers land utilization pattern, farmers existing irrigation and cultural practices, cropping pattern, cropping intensity, crop yield *etc*. in the dams command area. Farmers attitude towards innovative water management techniques were also recorded. Moreover, data on social and economic conditions were also documented.

3.4 Selection of Respondents

Selection of respondents was based on the total number of farmers at each dam. The criterion was to involve maximum number of beneficiaries from small, medium and big land holders, including farmers at the upstream and tail of the main canal. The farmers of all categories were selected randomly.

3.5 Regular Survey

The regular survey was conducted by the field team of PCRWR. The required information of the selected dams was collected through pre-tested questionnaire and the field data was also collected including groundwater table etc. The data were collected directly from the farmers and filled in the questionnaire. Ten percent questionnaires were cross checked by another team. Mostly first hand data such as cropping pattern, land use intensity, crop yield etc. was collected and analysed.

Plate 3: *A View of Dhok Sandy Mar Dam*

Chapter 4

RESULTS AND DISCUSSION

Two types of data were collected. First set of data was collected from the Dams authorities such as inflow-outflow of the dam, water rates (*aabiana*) and the second set of data was collected from the farmers of the command areas directly through questionnaire. The data collected were analysed and are discussed in the following paragraphs:

4.1. Data Collected from Small Dams Organization

4.1.1 *Inflow-Outflow of the Dams*

The inflow-outflow data of the selected dams were collected from the dams authorities. The outflow data represents only the releases for irrigation. The Khasala Dam has been designed to release 2.75 million cubic metre (MCM) (2229.3 AF) of water annually for irrigation. Figure 1 shows annual inflow-outflow data of Khasala dam. The inflow has been greater or equal to the outflow of Khasala dam except during the years 2000 and 2002. This was due to relatively less rainfalls during these years. However, during 1997 and 1998, the inflow was much greater than the outflow. Figure 2 shows average monthly inflow-outflow from the dams. It is based on the last ten years average. Maximum inflow was obtained during July-August and maximum releases were also during these months. There was no inflow during November-December. During May and June, outflow was greater than inflow. This was due to hot weather conditions and lack of rainfall during these months. The rainfall data was not available at the dam site , however, the inflow data also reflect the rainfall pattern in the area.

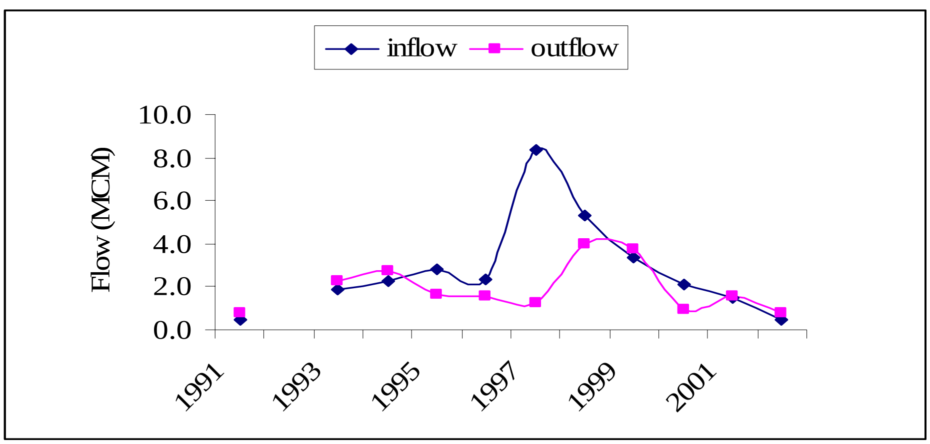

Figure 1: *Yearly inflow-outflow of Khasala Dam*

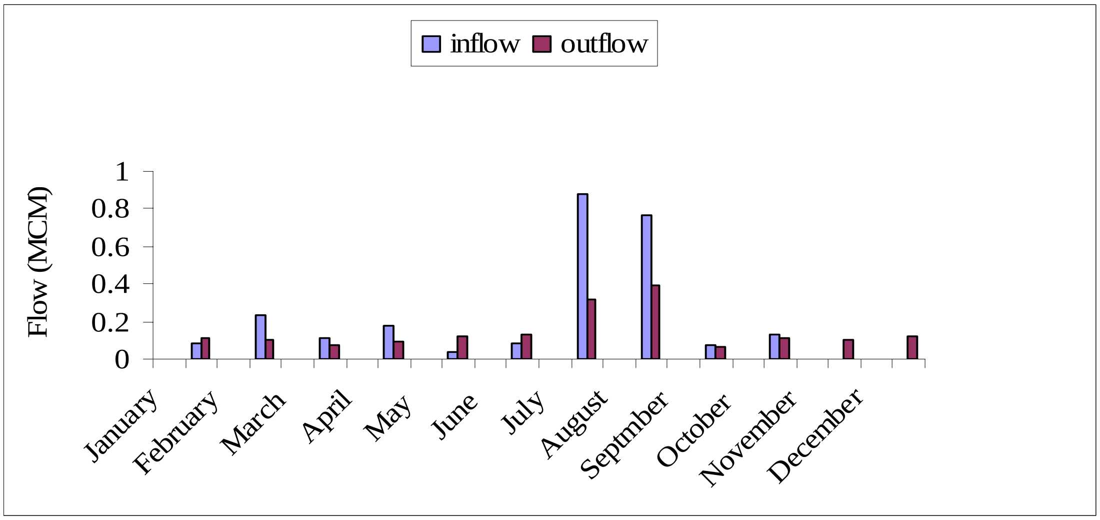

Figure 2: ***Average inflow-outflow at Khasala dam (1992-2002)***

Figure 3 shows inflow-outflow at Jawa dam. It became operational in 1997. Since its inception, the dam received almost constant inflow till 2000. However, after 2000, the inflow decreased gradually, most probably due to decreased rainfall. Except for the year 1998 and 2002, the outflow has been less than the inflow. Figure 4 shows monthly inflow-outflow pattern at the dam. The data presented is an average for the last six years. Because this dam is built on a perennial stream, it received regular and constant flow throughout the year. However, the flow was relatively high from June to August due to monsoon.

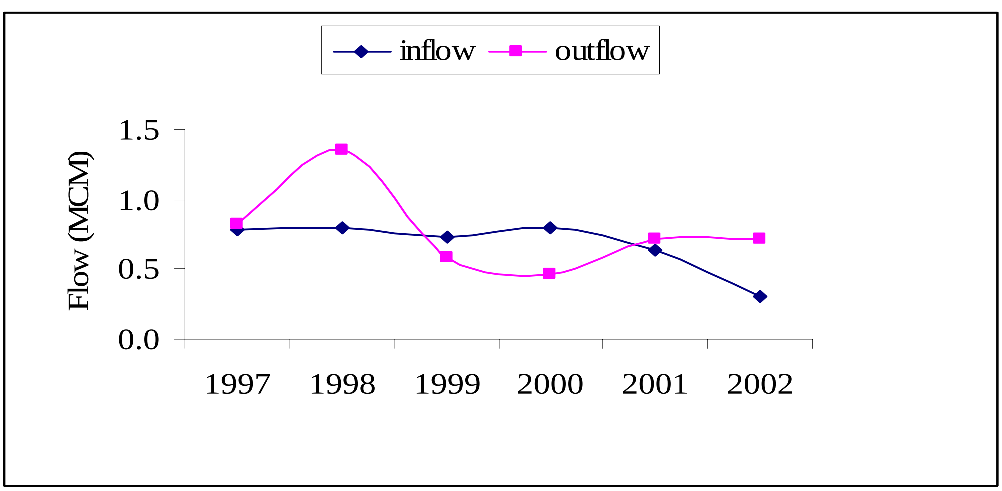

Figure 3: *Yearly inflow-outflow of Jawa Dam*

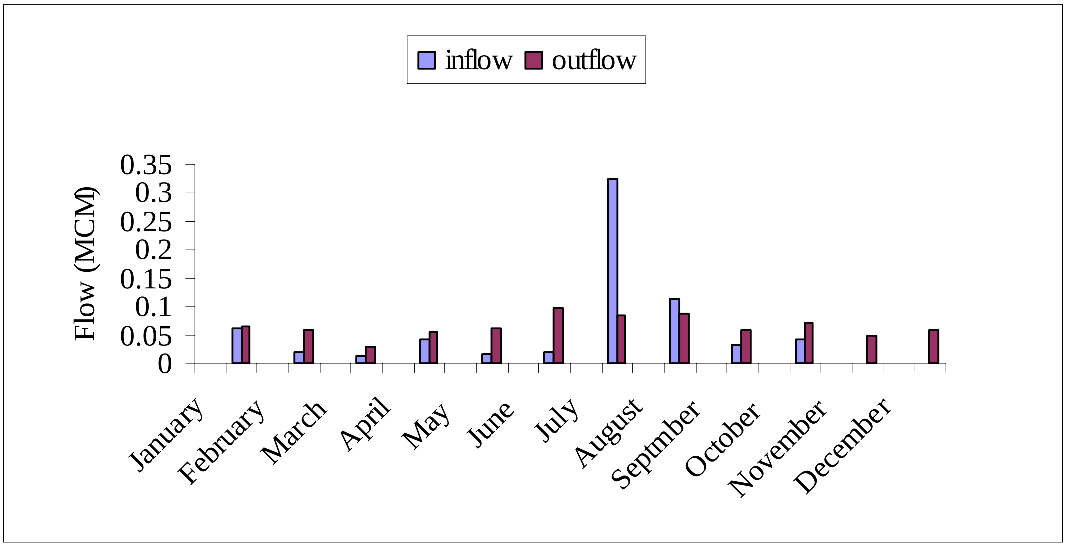

Figure 4: *Average inflow-outflow at Jawa Dam (1997-2002)*

Inflow-outflow at the Dhok Sandy Mar dam is presented in Figure 5. The data presented is the average for the last ten years. Except for 1997 and 1998, the inflow has been less than the outflow. The catchment area of this dam has been taken up by many housing societies, which might have blocked the runoff of water. Moreover, a large quantity of water from the dam is also being used by these societies. Overall this dam is the smallest of the studied dams and both inflow and outflow are less than the other two dams. Figure 6 shows ten years average monthly inflow-outflow pattern. Maximum inflow was received during the month of August due to monsoon rainfall. During most of the months, the inflow has been less than the outflow. It seems that inflow at this dam is insufficient to fill the requirements.

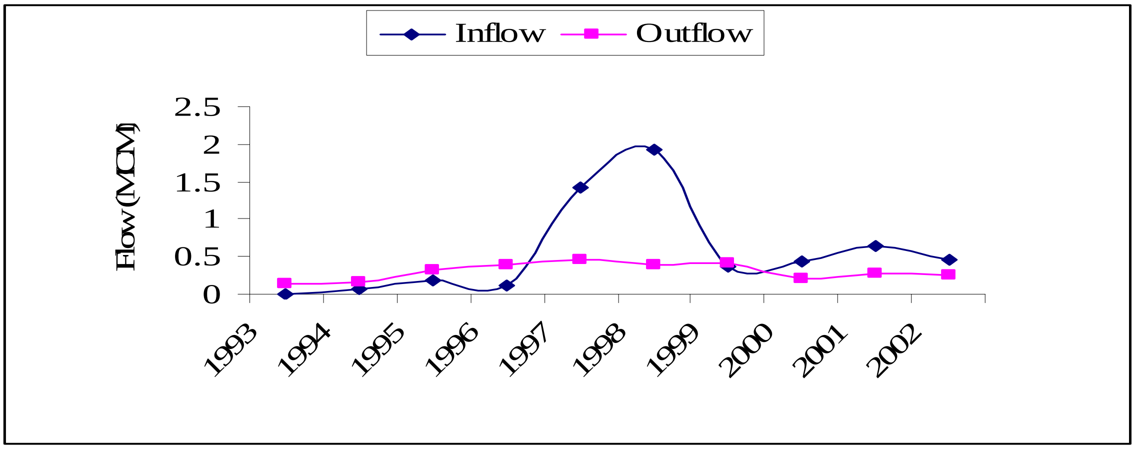

Figure 5: *Yearly inflow-outflow of Dhok Sanday Mar Dam*

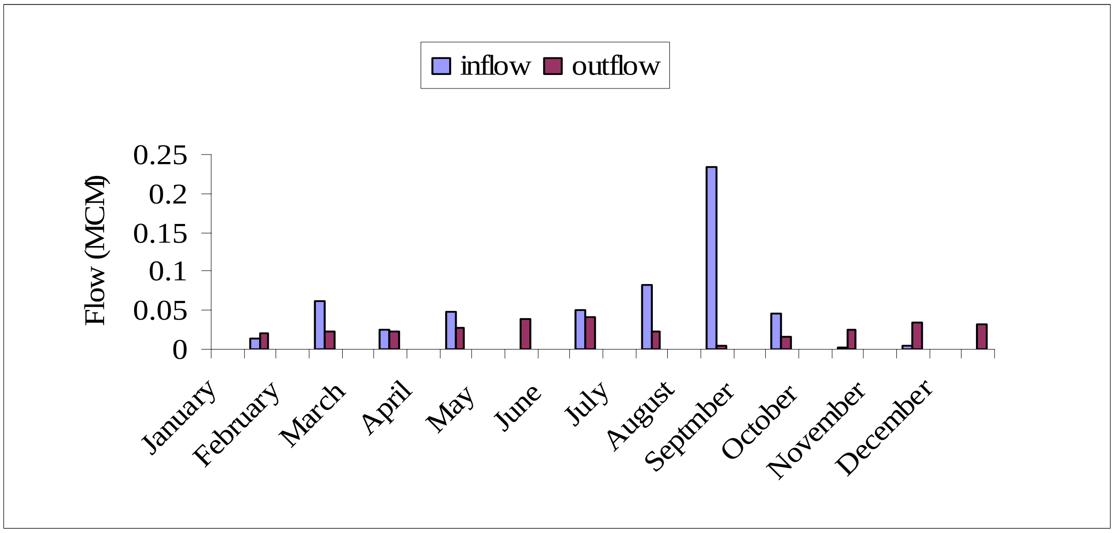

Figure 6: *Average inflow-outflow at Dhok Sunday Mar Dam (1997-2002)*

4.1.2 *Water Rates (Aabiana)*

Aabiana is the water charges paid by the farmers to the dam authorities. Figure 7 shows water rates charged by the dam authorities per year. It reflects that water rates increased gradually for almost all the dams, most probably due to increase in area under irrigation with time. However, at D. S. Mar dam, the total water charges per year decreased after 1998 possibly due to decrease in water released from the dam. The water charges received each from Khasala and Jawa dams in 2002 were about Rs. 50,000 per year, which was about 3 times less than the operation and maintenance cost of Khasala dam and about 5 times less than Jawa dam (Figure 8). Whereas in case of D. S. Mar dam, the water charges received in 2002 was about Rs. 13000. Therefore, its operation and maintenance cost was 12 times greater than it's earning (Annexure-II). The total water released from Khasala, Jawa, and D. S. Mar dams is 21.13, 4.66 and 3.02 MCM, respectively. The cost of water in small dams is in the order of Rs. 2000 per 1000 m^3. Therefore, cost of water released from Khasala, Jawa, and Dhok Sandy Mar dams are about Rs.42, 9 and 6 million, respectively.

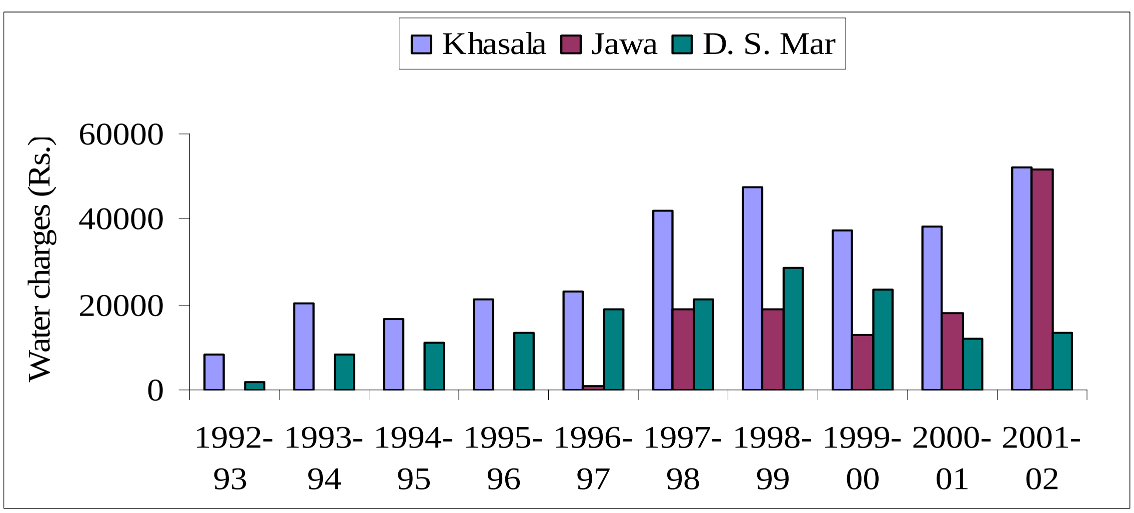

Figure 7: *Water Charges Collected by Dam Authorities at the Selected Dams*

The number of farmers according to the warabandi list is 292, 181 and 21 at Khasala, Jawa and D. S. Mar dams, respectively. If we take average of the last ten years, in case of Kahasala and D. S. Mar dams and six years in case of Jawa dam, the water charges per farmer per year at Khasala, Jawa and D. S. Mar dams are Rs. 105, 112 and 727, respectively. In case of D. S. Mar dam, the water charges received were the highest (Figure 8) mainly due to relatively less number of farmers receiving the water.

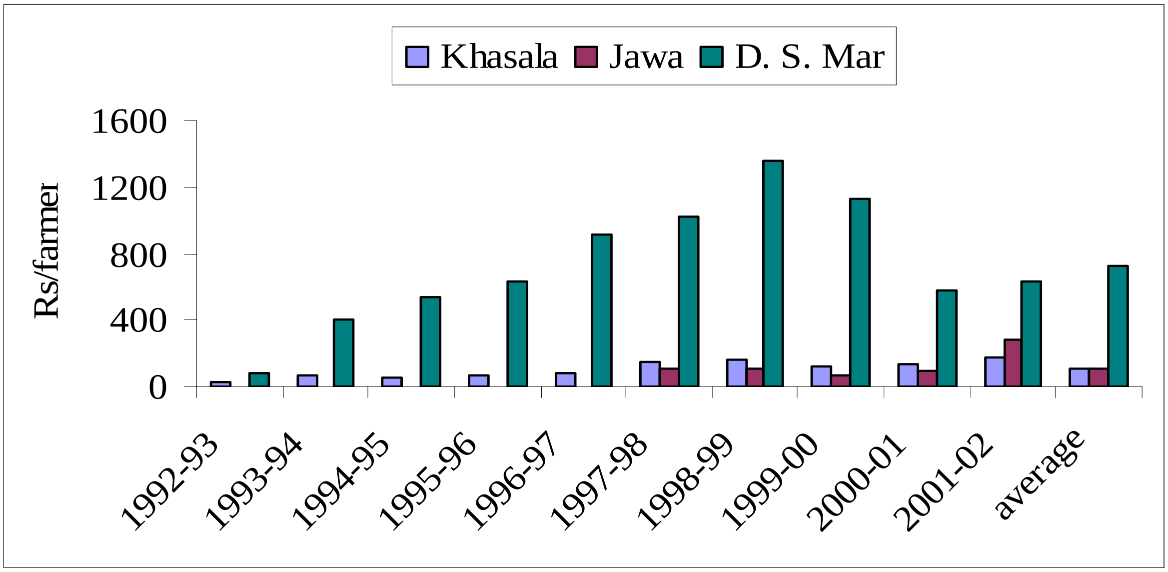

Figure 8: *Water Charges Per Farmer Collected by Dam Authorities at the Selected Dams*

4.2. Data Collected Through Field Survey

4.2.1 *Respondents*

Table 2 shows total number of farmers and number of farmers interviewed at each dam. Total number of farmers, according to the warabandi list provided by Small Dam Authority are 292, 181, and 21 on Khasala, Jawa and D. S Mar dams, respectively. Most of the farmers were reluctant to provide information with the fear that this interview might be used for tax purpose. The percentage of the farmers who were interviewed was not much encouraging. The percentage was 42.5, 38.7 and 52.4 on Khasala, Jawa, and D. S. Mar, respectively. The farmers, who were interviewed, were hesitating to provide the actual facts and figures.

Table 2: ***Number of Respondents Interviewed from Study Area***

Name of Dam	*Total No. of farmers at the dam*	*No. of farmers interviewed*	*% of farmers interviewed*
Khasala	**292**	**124**	**42.5**
Jawa	**181**	**70**	**38.7**
D. S. Mar	**21**	**11**	**52.4**

4.2.2 *Land Holdings and Family Size*

The farmers were taken into confidence during the survey and then they agreed to provide the relevant information. Though they agreed to provide the right information but still the land holding mentioned by the farmers was not matching with what is showing in the warabandi list. Some of the farmers were irrigating the land from the dam but their land was not included in the list. Majority of the farmers of the project area are holding land less than an acre. Only few farmers are holding land greater than 10 acres. The farmers at Khasala and Jawa dams are close to the watercourse as compared to D. S. Mar Dam, which are far from the dam sight. The number of farmers irrigating the land at Khasala dam is greater than the other two dams.

Table 3 shows that the average family size of the farmers is 16, 7and 8 members at Khasala, Jawa, and Dhok Sandy Mar, respectively. The average land holding ranges from 2.5 to 21.5 acres in the survey area. At Dock Sandy Mar dam, people have larger land holdings than the Jawa and Khasala dams. The average irrigated land is 2.8, 2.4 and 6.4 acres at Khasala, Jawa and D. S. Mar dams, respectively. Beside this, on Jawa and Khasala Dam, most of the land is irrigated from wells, though the wells are only used when there is shortage of water in the dams. A large area of land is irrigated through these dams but still there is sufficient (about 35%) land, which could be irrigated with dams water.

Table 3*: Average Land Holding and Family Size*

Description	*Khasala*	*Jawa*	*D. S. Mar*
Land holding (acre)	3.3	2.5	21.5
- Irrigated	2.8	2.4	6.4
- Barani	6.4	5.4	15.0
Family size (No)	16	7	8

4.2.3 *Land Use and Cropping Intensities*

The whole area is under terraces and land is very fertile possessing high potential for agricultural development. Before the construction of these dams, the area was totally dependent on rainfall. Wheat and fodders were the major crops at that time and the cropping intensity was 65%, 77.6% and 60% at, Khasala, Jawa & D. S. Mar dams, respectively. After the construction of these dams, the cropping intensity as well as cropping pattern has totally changed. During the survey, it was recorded that before dam construction, the land used intensity was less than 50% at these dams. However, after the construction of these dams, the cropping intensity and land use intensity has increased significantly (Table 4). Cheema and Bandaragoda (1997) reported cropping and land use intensities 123.4 and 63.5% under the irrigated area of Mirwal dam, respectively whereas these were 117.7 and 90% at Shahpur dam, respectively. Iqbal (1989) reported cropping intensity of 121.3% in the irrigated area of Shahpur dam. Therefore, the land use and cropping intensities were relatively less at the selected dams as compared to Mirwal and Shahpur dams.

Table 4*: Effect of Water Resources Development on Land and Crop Intensities (%)*

Name of Dam	***Average crop intensity***		***Average land use intensity***	
	Before dam construction	***Present***	***Before Dam construction***	***Present***
Khasala	**65**	**120**	**43**	**100**
Jawa	**77.6**	**100**	**45**	**70**
D. S. Mar	**60**	**80**	**40**	**100**

4.2.4 Source of Irrigation Water

The Khasala Dam irrigates large area. The number of farmers in this area is greater than Jawa and D. S. Mar dam. Table 5 shows that at Khasala dam, about 75% water is obtained from the dam whereas at D. S. Mar dam, 100% water is received from the dam. The wells also play significant role in the agriculture production. About 5% of water for irrigation is used from wells, when there is no supply from the dam. Also 20% of the land is barani which wholly depends on rainwater.

Table 5: Source of Irrigation in the Study Area (%)

Source of Irrigation	*Khasala*	*Jawa*	*D. S. Mar*
Dam	75	25	100
Well	5	22	-
Lift pump	-	-	-
Barani	20	53	-
Total	100	100	100

Similar is the case of Jawa dam where 25% of land is irrigated through dam water. As the topography of this area is different from Khasala dam, majority of the farmers utilizes water from wells and they have installed motor pumps on their wells. About 22% of land is irrigated with well water, whereas 53% of land depends on rainwater. Whereas the case at D. S. Mar dam is entirely different and there is no well. 100% of the farmers get water supply from dam. The reason of 100% supply is that there are only a small number of farmers in this area. Most of the irrigated land has now been covered by housing schemes. There are three major schemes namely: Margalla Housing Scheme; Twin City Islamabad Engineering Co-operation Housing Society and Army Welfare Trust Housing Society. Development work is in progress

under these schemes. Therefore, the number of farmers has reduced at this dam. This is the main reason of 100% supply to the farmers of D. S. Mar dam. In all the cases, the first farmers is located at a distance of more than one km but in case of D. S. Mar dam, the first farmer is located at 100 feet from the dam but the other farmers are located at least at 4 km on the right side and similarly the case is with left side of the canal. The total length of the irrigation channels are 3.4 km, 7.2 km, and 4.7 km, Khasala, Jawa and D. S. Mar dam, respectively.

4.2.5 *Availability of Irrigation Water*

The Khasala dam is highly populated as compared with Jawa and D. S. Mar dams. The number of farmers at Khasala dam is greater and the irrigated land is also greater than the other two dams studied. The people at the head region of both the dams have complaints regarding non-availability of water. They showed that though the watercourse is passing through their lands yet water is not being supplied to them. Also there are farmers who use the dam water as per allocation from the dam but excess water is used for irrigation and even the well land at Khasala dam is irrigated by dam water. Table 6 depicts that the availability of the water for kharif season is 60-65%, 100%, and 70% respectively at these three dams. However, in rabi season the water is 40%, 100% and 30%, respectively. When there is no supply from dams or there is shortage of water or limited water supply from dams, then the farmers use wells for irrigation purpose.

Table 6: Availability of Irrigation Water in Study Area (%)

Season	*Khasala*	*Jawa*	*D. S. Mar*
Kharif	70	60-65	100
Rabi	30	35-40	100
Total	100	100	100

4.2.6 *Groundwater Development*

Besides supplying water for irrigation, these dams have many indirect benefits. They help recharge the groundwater, provide water for domestic and municipal purposes, control erosion, control floods in hilly and plain tracts, help to develop fish culture and also provide recreational activities (Ashraf *et al*., 1999).

Prior to the construction of dams, the water table depth was too deep and the farmers were unable to irrigate their land from the well due to acute shortage of water in the area. Majority of the people migrated from this area due to the scarcity of water. The number of deep wells and dugwells could be counted on fingers before dam construction. Table 7 shows that at present, the water table varies from 6-15 m and 7-39 m near to the dam area of Khasala and Jawa, respectively which was at 9-25 and 12-45 before the construction of dams, respectively. At the tail region however, the water table depth is 5-7 m from the ground surface. The basic reason is that the tail region lies in between the dam and Soan River. The entire wells either deep well or dugwell are recharged both from the dam and

Soan River. The number of wells in this area has increased manifold (Table 7). This shows a positive impact of the dam in the area. The most important indirect benefit of small dams is the recharge of groundwater. High water table is a boon for the residents of Indus plain and has many advantages (Nazir, 1993). The pertinent advantages of groundwater recharge are: (i) the groundwater is a flexible source of water and can be used at any time in any capacity; (ii) the cost of recharge may be less than equivalent surface schemes; (iii) the water is available at the farm therefore eliminates the need for surface distribution system; (iv) water stored at the surface is subject to evaporation and contamination, which may be avoided by underground storage; (v) minimum area is required to store the given volume of water; (vi) the water is within the easy reach for extraction; and (vii) pumping lift is small which reduces the operational and installation cost of tubewell.

Oosambadi Peria Eri in Tamil Nadu India is a classical example of groundwater recharge. It is a small reservoir with 80-hectare command area, 53 farmer beneficiaries, and 60 dugwells. Prior to 1986, only one crop was grown. Even this crop could not be successfully irrigated without supplementing well water, because full reservoir, when directly used for irrigation, was sufficient only for about 70 days. In 1986, only four farmers in the command area did not own wells. However, the Water Users Association decided that these four farmers would be provided with water at the common cost and that the reservoir water would be used only for recharging the aquifer. In 1986, the sluices of the reservoir were permanently closed. Since then the farmers are growing two crops, paddy and another crop. Conjunctive use of surface water and sub-surface water has been practised for the last 14 years (Keller *et al.*, 2000).

Table 7*: Effect of Dams on Watertable Depth*

Name of Dam	***Water table depth (m)***		***No of Tubewell/dugwell***	
	Before dam construction	***Present***	***Before dam Construction***	***Present***
Khasala	**9-25**	**6-15**	**75**	**130**
Jawa	**12-45**	**7-39**	**60**	**120**
D. S. Mar	**5-90**	**2-7**	**-**	**25**

<u>*4.2.7* Irrigation Methods</u>

Since water availability is limited hence flood irrigation is not a feasible irrigation technique. Table 8 shows that farmers are now moving from flood irrigation to high efficiency surface irrigation such as furrow irrigation which is now commonly practised in the area. However, the pressurized irrigation system, the most efficient one is not installed by any farmer. The reasons are the regular supply of water, high capital cost of the system, and farmers' lack of knowledge about the system. At Khasala dam some farmers show their keen interest in the installation of pressurized irrigation system with the request that some subsidy be given by the government for the installation of the system.

At most of the dam sites, the main canal is flowing to some distance without irrigating the land available at the elevated portion of both sides. This land could easily be brought under irrigation with lift irrigation and by installing pressurized irrigation systems.

Table 8: *Irrigation Methods in the Study Area*

Irrigation methods	*Khasala*	*Jawa*	*D. S. Mar*
Number of farmers	292	181	21
Basin/flooding (%)	35	55	70
Furrow (%)	65	45	30

4.2.8 Satisfaction of Farmers

The dam water is supplied from 8.00 a.m. to 8 p.m. and especially at Khasala dam, 24 hours supply is also being provided during the summer season. The theft of water is common at Jawa and Khasala dam, particularly at Jawa dam. This is why the level of satisfaction at this dam is very low. Table 9 shows that only 15% of the farmers are fully satisfied with the irrigation water supplies, 25% were satisfied to some extent whereas 60% farmers were not satisfied at all with the supply of dam water. The case of Khasala dam is different from Jawa dam. Here, 60% of the farmers are fully satisfied with the dam water supply and 25% of farmers are satisfied to some extent and only 15% are not satisfied. This 15% farmers fall mainly in the tail region of the command area. As theft of water is a common practice in this area, so the farmers at the tail region hardly get any water.

Table 9: *Extent of Farmers Satisfaction from Source of Irrigation (%)*

Extent of Satisfaction	*Khasala*	*Jawa*	*D. S. Mar*
Full	60	15	80
To some extent	25	25	20
Not at all	15	60	-
Total	100	100	100

At D. S. Mar dam the situation, however, is entirely different. There is no shortage of water. The number of farmers at this dam is limited. The supply of water is according to warabandi and 80% of the farmers are fully satisfied. The 20% farmers who are satisfied to some extant with the water availability are those whose land is far from the dam.

4.2.9 *Cropping Pattern*

After the construction of small dams, there is a shift of cropping pattern from low valued crops towards high valued crops. However, wheat being the staple food crop is grown at all dams during rabi season (Table 10). Before construction of these dams, the people of the area were totally dependent on rainwater. However, now they are sowing different crops. Main crops are grain, wheat and vegetables. Other crops are also cultivated but the vegetables and wheat are the main cash crops. Being vegetables and wheat as cash crops, the economic status of the area is good as compared to other areas of the same locality.

Table 10: Cropping Pattern in Study Area

Season	*Khasala*	*Jawa*	*D. S. Mar*
Kharif	Maize/fodder/vegetables	Maize/fodder/vegetables	Fodder/vegetable
Rabi	wheat /vegetables	wheat /vegetables	wheat

Even some people are growing early season vegetables and earning good money. Wheat is an essential crop of rabi season and is grown almost on all farms. Wheat is seldom sold to the market. Mostly people grow wheat for their domestic use. Due to easy accessibility to market i.e. Rawalpindi/Islamabad and also good return value, people normally prefer to grow vegetables.

4.2.10 *Yield of Crops*

Different vegetables and grains are cultivated in different seasons. Table 13 shows that about 960 kg of wheat from an average field of one acre is obtained. The people of the area specially Khasala dam are very happy and prospers. On an average one acre field can yield 1200-3500 kg of vegetables.

Table 11: ***Yield of Different Crops (kg/acre)***

Crop	*Khasala*	*Jawa*	*D. S. Mar*
Maize	Irrigated: 640-960 Barani: 480-640	Irrigated: 640-960 Barani: 480-640	Irrigated: 640-960 Barani: 480-640
Wheat	Irrigated: 960 Barani: 800	Irrigated: 960 Barani: 800	Irrigated: 960 Barani: 800
Vegetables	12,00-35,00	12,00-35,00	-

4.2.11 *Income of Farmers*

In kharif and rabi season there is a little difference in their earnings (Table 12). In kharif the income ranges from Rs.20,000-25,000 and in rabi it is Rs.25,000-35,000. But actually the income is multiple of these figures. During the interviews one farmer told that during the season, he earns Rs.70,000 from an area of one kanal and when there is a good season it may be more than Rs. 100,000. He roughly calculated the income, which comes out more than 50,000/- per season. The people on D. S. Mar dam are from business community. They grow only wheat and grain but some of them are growing sugarcane and orchards. Mostly wheat is not sold in the market.

Table 12: ***Average Income of Farmers in Study Area (Rs/acre)***

Season	*Khasala*	*Jawa*	*D. S. Mar*
Kharif	20,000-25,000	20,000-25,000	5,000-15,000
Rabi	25,000-35,000	25,000-35,000	10,000-25,000
Total	45,000-60,000	45,000-60,000	15,000-40,000

4.2.12 *Livestock*

Livestock is an important sector of agriculture in Pakistan, and accounts for nearly 37 percent of agricultural value added and about 9 percent of the GDP. Its net foreign exchange earnings were to the tune of Rs. 35.0 billion in 1998-99, which was about 9 percent of the overall export earnings of the country during the same period. The role of livestock in rural economy may be realized from the fact that 30-35 million rural population is engaged in Livestock raising (Govt. of Pakistan, 1999-2000). Livestock are an important source of motive power for land cultivation, milk and milk Products. Almost every rural household maintain livestock in order to supplement their cash income (Iqbal, 1989). People keep buffaloes to get milk and their dung for fuel. Livestock are handsome source of their cash income.

Table 13 shows that people of Khasala and D. S. Mar dams have relatively large number of livestock. Generally, they do not sell the milk in the market whereas the farmers of the D. S. Mar dam sell out their milk in the market. The average quantity of the milk produced by the livestock in the Jawa and Khasala dam is 5 litres from buffalos and 3 litres from cows. The average milk produced by a buffalo is 10 litres and from cow is 5 litres at D. S. Mar dam. The people of D. S. Mar dam are also running dairy industry and supply milk to the main cities. Donkey plays an important role in this area. Due to hard topography, farmers normally use donkeys to transport their crops to the farm roads.

Table 13: ***No of Livestock at the Selected Dams***

Livestock	*Khasala*	*Jawa*	*D. S. Mar*
Cow	215	28	110
Buffalo	99	50	75
Sheep	-	-	-
Goat	81	39	117
Ox	36	2	27
Donkey	30	-	53
Other	210	32	153

4.2.13 *Education*

Education plays an important role in the overall growth and development of the country. The type and level of education of farmers affect the extent of farmers' adoption of innovations, resource allocation, efficiency and the demographic behaviour (Iqbal, 1989). Most of the people of the area are poor however, they have shown their interest in education. The main reason of low literacy rate in the area is lack of government schools. Those who are educated, their level of education are very low. Most of the old are illiterate and their children are educated up to the level of matric only (Table 14). It is hard to find any professional graduates in the surveyed area.

Table 14*: Education Level of People in Study Area (%)*

Education	*Khasala*	*Jawa*	*D. S. Mar*
Illiterate	82	25	13
Primary	40	53	6
Middle	-	5	-
Matric	40	32	8
FA/FSc	7	21	5
BA/BSc	10	6	7
MA/MSc	3	1	-
Other	-	-	-

The other reason of low literacy rate is that all the family members, whether male or female, work at the farms with their elders. The other reason is the non availability or expensive labour. The reasons for large number of farmers illiterate in the Khasala dam area is that the families consist of many heterogeneous groups of tribes living here. Their common habits and traditions developed by topographic features are the main reasons which also prevent them from education.

Lack of educational institutions, poor economic condition and lack of access to the far distant educational institutions were observed to be the conspicuous reasons for the low literacy rate in the area. It was also observed during survey that the percentage of formal technical education among respondent farmers was nil.

Chapter 5

GENERAL DISCUSSIONS

5.1 Main Issues

5.1.1 *Lack of Sufficient Water*

The annual rainfall is a limited factor for barani agriculture practised in this area. The extreme variation in annual rainfall is very much responsible for crop failures. The other major problems of the area are acute shortage of water for drinking and domestic purposes. People have to walk long distances to fetch drinking water from wells. Further, the water is unhygienic and unhealthy for human consumption and causes serious diseases to the health of local population. Most of the land which is the enough fertile, is not irrigated from the dam in the head region, and the farmers are interested to irrigate from the dam.

5.1.2 *Illegal Water Diversion*

The influential people divert the water without their turn. The watercourses are broken at several points and water is being illegally diverted to their fields. The farmers at the tail region were not receiving sufficient water for their farms. The result of non-supply of water automatically reduced the crops yield and farmer income. Shahid *et al*. (1996) reported that the obvious reason contributing to the relatively low potential explored with respect to irrigated area was irregular blockage of water by influential farmers to keep the irrigation water supplies confined to their farms. This practice had not only skewed the distribution of irrigated area but also resulted in wastage of huge investment made on construction of water channels which remain dry most of the time. They attributed this to the lack of weekly rotation schedule, non-provision of field staff to operate the system smoothly and non provision of posts of supervisory staff to check irregular blockage of irrigation water on the way.

5.1.3 *Poor Maintenance of Watercourses*

The watercourses of the areas are too lengthy and it is very difficult to look after the watercourses through the season. The entire watercourse was not properly maintained, full of sand and bushes and the water overtopped the watercourse. The watercourses are broken at several places and also the cleaning of watercourses is not regularly done.

5.1.4 *Inequity in Water Supply (distribution)*

The issue of ensured water supply is arising due to lack of a proper warabandi system in the area. Though the dam authorities supply water according to warabandi system, yet farmers are not strictly following it. Some times, the upstream farmers open the nakka and start irrigating their fields due to which the farmers at the tail end hardly get water. This results in the frustration of farmers at the tail end. Therefore, the dam authorities should ensure equity in water supply to all users through an effective warabandi system.

Plate 4: *A Fully Choked Watercourse at Khasala Dam*

Plate 5: *A Watercourse Full of Vegetation at Jawa Dam*

5.1.5 *Broken Outlets (moghas)*

The designed moghas at several points have been broken at upstream areas and excess of water is delivered at several places due to which farmers at lower end are not receiving sufficient supply of water from the dam.

5.1.6 *Poor Field Channels*

The field channels are earthen and are constructed unscientifically and are poorly maintained. A considerable amount of water is wasted in the watercourses.

5.1.7 *Undulated Fields*

Farmers normally try to level their fields conventionally with tractor and scraper. However, precision levelling is far away. Due to undulated fields, huge amount of water is wasted. There is need to level these fields precisely, so that scared water could be used efficiently. The On Farm Water Management, alongwith Agricultural Extension services could help level the fields and increase water productivity.

Plate 6: *Distorted, Vegetative and Poorly Maintained Watercourse with Broken Outlet at Jawa Dam*

Plate 7: *A Poorly Maintained Field Channel, Full of Silt and Vegetation at D. S. Mar Dam*

5.1.8 *Non-Existence of Water User Associations*

The dam's authorities have recorded a warabandi on the basis of land holding in the area. The warabandi circulated to the framers does not match with the actual on the site. The Water User Association does not exist in this area. The warabandi is not properly followed. The watercourses are not properly maintained and there is no formal body to look after the watercourses of the area. Due to non-functional/non-existence of Water User Association, there are many disputes among the framers on water distribution issues.

5.1.9 *Lack of Agricultural Support Services*

Agricultural extension services play a pivotal role in the motivation of farmers towards the adaptation of improved irrigation and cultural practices, introduction of high valued crops, efficient use of water and proper use of non-water inputs. However, it was observed that extension services were hardly available at any dam. Similarly, On Farm Water Management (OFWM) activities were rarely seen in these areas. It is suggested that a well co-ordinated and integrated approach by the SDO, OFWM and Agriculture Extension Department should be adopted to get maximum benefits from the available water. This would ultimately improve the socio-economic conditions of the area.

5.2 General Observations

5.2.1 *Khasala Dam*

The farmers on Khasala dam as compared to Jawa dam are larger in numbers. At the tail region, the water table is relatively shallow ranging from 3-6 metres. The tail region is closed to Soan River. The command area lies between dam and Soan River, which is recharged from both, the dam and the river. The farmers located at the upstream are satisfied with the distribution of dam water. However, waradandi is not followed strictly and the farmers at the tail are not fully satisfied. Due to tampering of moghas, theft of water is a common practice. There is no water user association to look after the watercourse and warabandi system. The watercourses are broken at several places and the cleaning of watercourses is not regularly done. The water overtops the watercourse at several places. The water supply from the dam is from 8:00 am till late evening. The actual number of farmers is greater than the warabandi list provided by the dam authorities. Due to poorly maintained farm roads, the farmers face great difficulties to bring their crop to the main road. The farmers usually use donkeys to bring the crops from the fields to the roads. Some farmers have installed diesel/motor pumps for lifting the water from dugwells. Those farmers who are not financially sound, they use Persian wheels operated by donkeys. The women of the area play a significant role in the development of agriculture. They work hard side by side with their men in the field.

5.2.2 *Jawa Dam*

Being elevated, most of the fertile land at the head region is not irrigated from the dam though the farmers are interested to irrigate these lands. There is sufficient water supply in the watercourse and lot of land can be irrigated and the farmers showed their willingness to cooperate in the rehabilitation as well as reconstruction of new

watercourses. Theft of water is a common factor here. Even the warabandi system is not followed properly and the influential people divert the water without their turn to irrigate extra land. The people are not satisfied with the waradani system. During the survey, it was observed that the entire watercourse was poorly maintained, full of sand and bushes and the water was over topping. The authorized or legal moghas were broken at different places and framers below the moghas were deprived off from their right. The people of the area are not well-educated mainly due to lack of educational institutions in the area. The water supply and sanitation problems are also not satisfactory. The roads to the farmer's fields are not maintained in the area. The farmers use donkey to bring their crops to the roads.

5.2.3 *Dhok Sandy Mar Dam*

This dam is situated near Sung Jhani at a beautiful location. The aim of the dam was to supply water for irrigation purposes. Due to construction and development of residential schemes in the area, lot of agriculture land has been included in the residential schemes. Presently only twelve farmers are irrigating their land from this dam. Only 1.12 acre of land is being irrigated just a few feet away from the dam in the head region and 4.87 acres of land is irrigated by the Margalla housing authority for horticulture purpose. The main watercourse is diverted into two branches left and right. According to warabandi list, the left side of the watercourse irrigate about 9.1 acres of land whereas at the right side, the watercourse is irrigating 3.62 acres of land. Similarly, at the right branch of watercourse, the farmers irrigate more than 18.75 acres. A 60 cm concrete pipe has been installed by the housing societies in the main watercourse to take water to the housing societies. The levels of education as compared to other dams are higher. The farmers of the area are interested to supply the dam water for irrigation rather than for housing schemes.

Plate 8: *Main Canal at D. S. Mar Dam, the Land is being Developed for Housing Schemes.*

Chapter 6

STRATEGIES FOR EFFICIENT MANAGEMENT OF WATER RESOURCES

6.1. Equity in Water Distribution

Equity in water distribution is very important factor for the management of water resources. Inequity in water distribution results in frustration, lack of interest in farming and maintenance of watercourses, distrust among water users and disputes over water rights among the users. Inequity in water distribution is the main cause of non-functional water user associations. Dam's authorities should ensure that each and every farmer in the command area gets his due share irrespective of location, size of land and his status in the society.

6.2. Formation of Water User Association (WUA)

A WUA comprising members from head, middle and tail reaches and representative from all sects and casts should be formulated. The WUA should be responsible for the maintenance of watercourses, to resolve the disputes of water, to stop water theft *etc*.

6.3. Proper Maintenance of Canal and Field Channel

Conveyance losses in canals and watercourses are around 25 and 30 percent, respectively. The application losses in fields are around 25-40 percent. The overall irrigation efficiency in the irrigated areas is estimated to be hardly 30%. It is evident that this water could be used for expansion of agriculture. The main causes of these operational losses are: seepage; overflow; thin distorted banks; vegetation; convoluted sections; and rodent holes *etc*. A considerable amount of water is wasted due to distorted, poorly maintained watercourses and field ditches. Under the umbrella of WUA a crash programme of watercourses cleaning and maintenance should be launched. Watercourses should be free from vegetation and silt so that water could reach to the farmers located at the tail end.

6.4 Land Levelling and Proper Farm Layout

The layout of most of the fields is based on traditional flood basin comprising a number of unwanted dikes and ditches. Due to undulated fields, the application efficiency is very low resulting in huge loss of water. The fields should be properly levelled and the farm layout should be properly designed based on the soil type and discharge available. OFWM and WUA could play an important role in the levelling of fields. Precision land levelling (PLL) is a topographic modification of land and involves grading and smoothing of land to an even level, with little or no slope. PLL improves irrigation application efficiency and increases the uniformity of water application with less chance of over and under irrigation. It has been reported that this technology can increase the land use intensity from 8-63% and cropping intensity from 6-70% (Gill, 1994). Therefore, levelled fields not only help reduce the amount of irrigation water required but also help reduce the labour requirements.

6.5. Adoption of High Efficiency Irrigation System

6.5.1 *High Efficiency Surface Irrigation System*

Basin irrigation is the conventional method commonly used in Pakistan. However, application efficiency of basin irrigation is very low. Surface irrigation techniques can be improved by developing crop specific field layouts. Efficient surface irrigation methods such as bed and furrow irrigation system help save water. In the bed and furrow method, water is applied only in furrows. With the passage of time, the furrow beds become relatively hard due to silt deposition. Water then moves laterally and vertical seepage of the water reduces considerably. Since water is applied in furrows, the effect of water born and water transmitted diseases on the crop health is minimal. The weeds, which are transported through canal water, are trapped in the furrows from which these can be removed or controlled easily. Moreover, the same field may be used for inter-cropping.

6.5.2 *Pressurized Irrigation System*

Due to the scarcity of water, merely 25% of total rainfed area is under cultivation. The farmers use obsolete methods of irrigation resulting in poor application and distribution efficiencies. In most of the area, the land is highly undulated and precision land levelling is, therefore, not a feasible option. Under the prevalent topographic conditions, gravity irrigation is also not possible. Therefore, it is of utmost importance that the scarce water resources in the region are utilized most aptly and efficiently with minimum losses. These systems are particularly suited to the command areas of small dams where the watercourse is flowing in the low lying areas and the culturable land is available along the elevated banks of the watercourse. The water could be pumped from the channel and used by pressurized irrigation system.

Highly efficient sprinkler and trickle irrigation techniques have been successfully introduced in Pakistan, and are particularly well suited to the water scarce barani areas. Application efficiencies of these systems can be very high (75 to 85%) thus permitting almost full use of the scarce water supplies. An additional advantage as compared with other methods of surface irrigation is that efficient irrigation can be carried out even where topography is undulated and soil is of light texture, as is the case in much of the barani areas. Rain-gun sprinkler with mobile units and drip irrigation system components have been locally developed which are comparatively less expensive and have proved successful.

6.6 Proper Irrigation Scheduling

Agriculture is the major consumer of water in Pakistan. However, water application and water use efficiencies are very low. The main reason for low efficiency is the over irrigation by the farmers. Farmers normally over irrigate the field due to: (i) lack of proper knowledge about; irrigation scheduling; (ii) with the intention that more water will produce more yield. However, more applications of water may result in low water use efficiency and low net income. Moreover, over irrigation leaches the nutrients out of the root zone and decreases the crop yield (Ashraf *et al*., 2001). Though the year 1999-2000 was a drought year with low river flows and less amount of irrigation water availability, yet about 2.0 million tons of surplus wheat was produced. The high yield of wheat indicates that this could have been the result of greater use of groundwater over which the farmers had greater control. The farmers were able to apply the right amount of irrigation at the right time, thus avoiding over irrigation. Proper irrigation scheduling helps farmers to know when to irrigate and how much to apply? This issue is mostly related to awareness and education of the farmers.

6.7 Adoption of Proper Agronomic Practices

Though water is very important input for agriculture production, however, good quality seed, timely application of fertilizers and pesticides and other cultural practices could increase the crop yield many folds as well as the net income of the farmers.

6.8 Improved Cropping Pattern

The high delta crops such as maize can be substituted with low delta crops of high market value. A strategy can be adopted to introduce low delta crops in the cropping pattern when there is shortage of water. This would help generate some income rather than complete failure of high delta crops. However, the introduction of low delta crops need to be properly evaluated, keeping in view needs of the market and industry.

6.9 Coordination between Various Agencies and Water Users

A well coordinated effort is required by Small Dams Organisation (SDO), On Farm Water Management (OFWM) and Agricultural Extension Department alongwith participation of end users to increase the productivity of available water resources.

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

1. **The studied dams have been partially successful to improve the socio-economic conditions of the local inhabitants. Groundwater (mainly due to recharge from dam) has become easily accessible for pumping due to which number of dugwells has increased many folds after the construction of these dams. This reduced drudgery on the local inhabitants particularly women who have to fetch water from far away for their domestic uses.**

2. **The land use and crop intensities, crop yield have also increased many folds after the construction of these dams. There is a shift of cropping pattern from the traditional cropping towards high valued crops due to the availability of water.**

3. **The designed command area at each dam has not been fully developed so far. However, if properly managed, more area could be irrigated with the same infrastructure/existing facilities and with the same water availability.**

4. **There are several bottlenecks in the full utilization of these dams such as: (i) illegal water diversions; (ii) non-functional water user associations; (iii) poor maintenance of watercourses; (iv) broken/tempered outlets; (v) poorly maintained field channels; and (vi) lack of agricultural support services *etc*.**

5. **Well co-ordinated efforts are required to overcome these issues. An integrated programme should be formulated and implemented in command areas for effective utilization of available water as well as developed infrastructure. In this regard, a pilot programme would be helpful to optimise the implementation process as well as operation and maintenance of efficient land and water management activities in command areas of developed small dams.**

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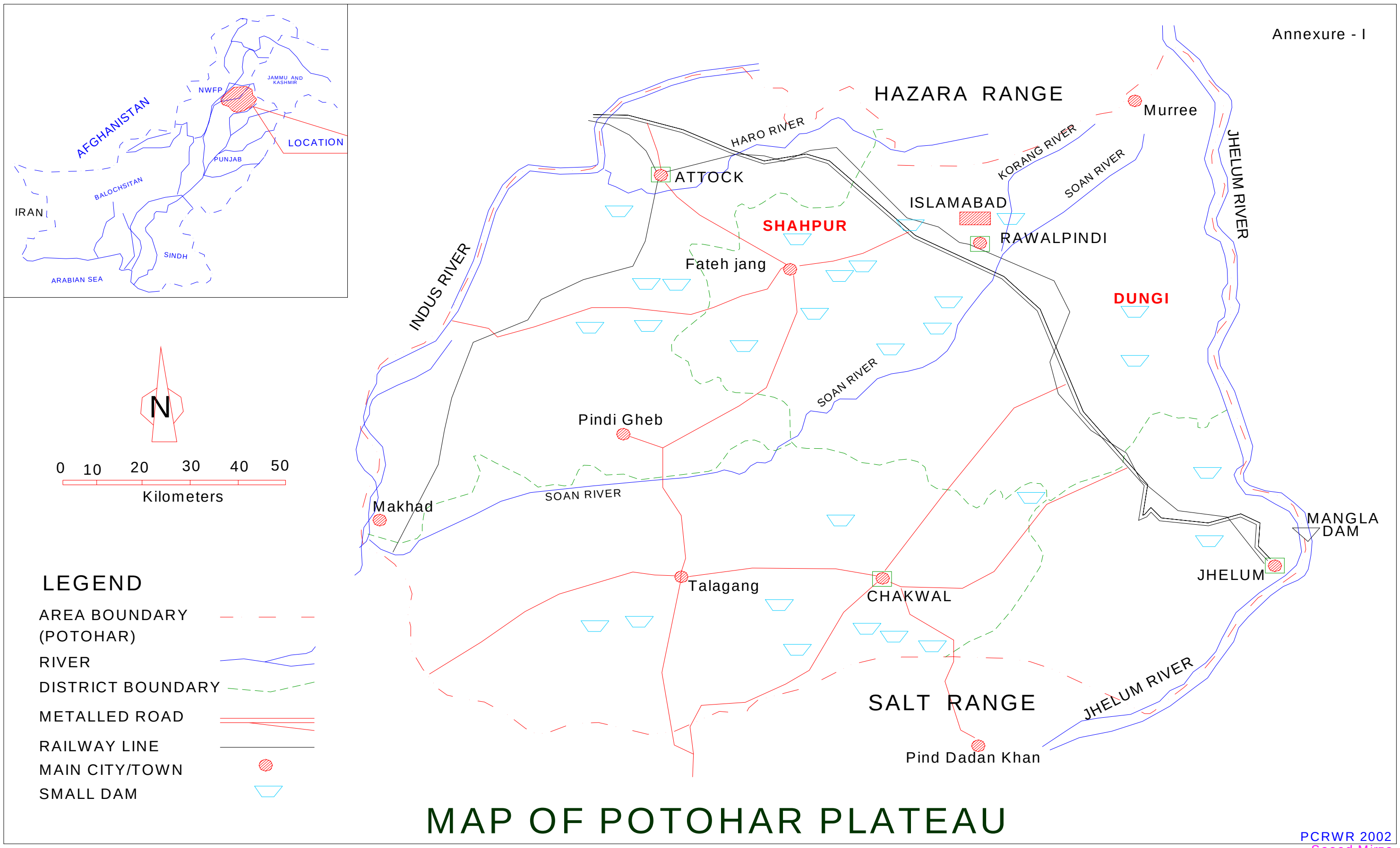
Location Map of Selected Small Dams



Annexure-II

Salient Features of Selected Small Dams

S. No.	Description	Khasala	D. S. Mar	Jawa
1	Type of dam	Masonry	Masonry	EF Zined
2	Location	RWP	RWP	RWP
3	Height of Dam (m)	18.29	19.82	25.13
4	Length of Dam (m)	123.78	561	143.29
5	Gross Reservoir Capacity (MCM)	2.98	0.80	1.94
6	Dead storage capacity (MCM)	1.13	0.16	0.833
7	Live storage capacity (MCM)	1.85	0.64	1.11
8	***Life of project***			
	a. Calculated (years)	175	68	65
	b. Adopted (years)	50	50	50
9	Mean annual run-off (MCM)	4.17	1.84	1.07
10	Spillway crest length (m)	39.60	91.46	109.75
11	Capacity of irrigation sluice (lps)	170	99	141.6
12	Length of irrigation channels (m)	4315	4726	7164.6
13	Gross command area (ha)	647.77	263.15	323.88
14	Culturable command area (ha)	647.77	263.15	449.79
15	Crop intensity	140%	120%	100%
16	Annual irrigation (ha)	906.88	315.72	323.88
17	Total cost of the project (Rs. million)	16.56	19.08	20.13
18	C.C.A (ha)	506	263.15	323.88
19	Catchment area (km^2)	25.38	9.19	9.35
20	Spillway Capacity (m^3/sec)	315.19	189.25	41
21	Pond area at NPL (ha)	42.9	19.83	30.76
22	Completion year	1985	1990	1994
23	Annual operation & maintenance cost (Rs. million)	0.144	0.167	0.24

Source: Approved PC-1s of the Selected Dams.

Annexure-III

Questionnaire for Participatory Rural Appraisal of the Small Dams

Name of farmer _________________________ Village ____________________________

Household System		
	Family Size (No.)	
	Landholding (acres)	
	Livelihood Sources (Rs/Year/Person)	
	Crops	
	Livestock	
	Off-Farm income (labour, service, *etc*.)	
	Education:	
	Literate	
	Under Matric	
	Intermediate	
	Graduate	
	Decision Making:	
	Joint decisions	
	Effect of notable’s	
	Effect of elder’s	
	Women involvement	
		Resource Availability
	Number of households	
	Number of land owners	
	Number of tenants	
	Land tenure system	
	Tenancy rules	
	Cultivated land per household (acres)	
Water availability		
	Size of pond	
	Capacity of pond	
	Year of construction of pond	
	Depth of dugwell (ft)	
	Diameter of dugwell	
	Distance of dugwell from dam	
	Year of construction of dugwell	
	Water table before the construction of dam	
	Type of wells (Tubewells/Deep Tubewells)	
	Depth of wells (ft)	
	Year of tubewell installation	
		Canal water supply
	Rotation	
	Supply hours	
	Area irrigated (acre)	

	Aabiana (cost of water)				
					Agriculture and Rangelands
	Crops Grown				
	- Kharif				
	- Rabi				
	Cropping Patterns				
	Cropping Intensity (%)				
	Vegetation types				
	Area covered (acre)				
	Potential for improvement				
	Water use practices				
	Surface irrigation (acre)				
	Pressurized irrigation (acre)				
	Crop yields (Maunds/acre)				
	(i)				
	(ii)				
	(iii)				
					Livestock
	Type of animals	No.	Source of Fodder	Drinking water availability	Drinking water demand
	Buffalo				
	Cow				
	Goat				
	Bull				
	Camel				
	Donkey				
	Any other				
	Livestock-milk (litre/day)				
	Buffalo				
	Cow				
	Goat				
	Sheep				
	Any other				
					Resource Use
	Water availability				
	Rainwater only				
	Rainwater + tubewell water				
	Tubewell water only				