Farmers' Irrigation Practices Under Rod Kohi Irrigation System

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ABSTRACT: Farmers' irrigation practices under the Rod Kohi Irrigation System (hill torrents) were studied through socio-economic survey of 22 respondents and field investigations of 5 selected farms. The major problems and constraints of the system included inequity of water availability among users of the commands, construction of excessively large check structures incurring high cost to the farmers, lack of manpower and machinery, low literacy rate, poor economic resources and inefficient use of water.

Data regarding the soil, crop and applied irrigation were gathered through field observations on respondents' farms for performance evaluation of irrigation. An average irrigation application efficiency of 27.7% was found. This was probably the first farmer's field oriented study as 95.5% of the respondents denied of any field survey conducted before the reported study. Approximately 73% of the respondents of the Rod Kohi Irrigation System were uneducated. About 55% of the respondents had the farming experience of 21-40 years.

On average, 64% of the farmers owned a farm size of 12.5 ha. Mostly, the hill torrents occurred twice a year and lasted for 5-10 hrs. About 63% of the respondents expressed that the hill torrent flow was sufficient to satisfy the crop needs. The average yield of sorghum, gram, bajra, oilseed and wheat was found 564.4, 575.6, 519.5, 561.6 and 1229.9 kg/ha, respectively. The water productivity of these crops was 0.067, 0.070, 0.063, 0.075 and 0.161 kg/m^3, respectively. The hill torrent (Rod Kohi Irrigation) water productivity was quite lower than that achieved in irrigated areas.

KEYWORDS: Rod Kohi irrigation, Performance evaluation, Farmer's irrigation practices, Irrigation efficiency and water productivity.

INTRODUCTION

Pakistan covers about 79.61 million hectares of land, of which about 40% is suitable for agriculture and forestry. Out of total cultivated area of about 21.1 Mha, 16.2 Mha are irrigated through canal and groundwater resources, while the remaining 4.9 Mha (about 23.22% of the total cultivated land) are rainfed. The area commanded by hill torrents has been estimated as 2.34 Mha with an estimated total catchments area of about 40.12 Mha. Hill torrents in various parts of the country drain about 55% of the total area of the Pakistan (NESPAK, 1995). There are about 14 hill torrent sites in Pakistan with an average annual run-off of 1.5 Mha-m (12.15 MAF). Currently, the major part of these flows goes wasted because of insufficient hill torrent management facilities. NESPAK (1995) reported that proper management of hill torrents can significantly enhance agricultural production of the country. Rod Kohi irrigation system is practiced in various parts of the world. In Pakistan, it is practiced mainly in Hazara, Bannu, D. I. Khan, Karak, Kohat, D.G. Khan, Kachhi Basin, Khirther Range, Karachi Area, Sehwan and Petaro Area.

Rod Kohi system of irrigation is the least known and the most unattended among the irrigation systems in Pakistan, and therefore, remains undeveloped. The major reasons include poor resources of Rod Kohi farmers, ignorance of farmers to advanced irrigation practices, excessively high flows, non-existence of control structures, lack of scientific investigations about the farmers' irrigation practices and performance evaluation. The prevailing Rod Kohi irrigation practices are traditional in nature and provide subsistence based livelihood to the majority of the farmers in the area. The cultivated crops mostly, included wheat, sorghum, pearl millet, grams and

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oilseed to feed the human beings and their cattle. Production oriented agriculture is not practiced and therefore, crop yields are quite low. Consequently, the average yields per unit area under Rod Kohi irrigation system are far below the national average (Mumtaz, 1989).

The financial condition of the farmers of the Rod Kohi commanded area is generally very poor. They have learnt to live with little basic necessities of life. The Rod Kohi irrigated regions generally lack facilities of roads, schools, hospital, electricity and safe drinking water. The residents usually depend on water storage to meet their domestic water requirements. When a hill torrent comes, its water is stored in deep depressions. The rate of infiltration into the soil is very low because of the presence of hard layer called "Mat" on the soil surface. These kinds of reservoirs are very far from most of the villages and the people have to fetch water daily for drinking and other purposes from these reservoirs. These are open to atmosphere and all the birds and animals such as dogs, donkeys, horses, goats, sheep, cows and buffaloes also drink water from these reservoirs. Now the government has installed pumps for drinking water in some of the villages.

No doubt, the efficient conveyance of flows and development of control structures at the main system is a pre-requisite to achieve the goal of efficiently managing Rod Kohi irrigation at tertiary level, the farmer's irrigation practices at field level play an important role in managing the available water resources at the farm. Water losses, at the farm and field levels due to inefficient irrigation management, result in lower crop yield and water productivity. Unfortunately very little or no significant work has been done to evaluate the farmers' irrigation practices and improve the tertiary component of Rod Kohi system.

Improving management and crop yields under the Rod Kohi irrigation system requires information regarding the existing irrigation practices of the Rod Kohi farmers. Investigations regarding the irrigation practices of Rod Kohi farmers and their consequences on the use of this precious water resource were carried out in the present study. The primary objective of the study was to investigate irrigation practices of the Rod Kohi farmers. The other objectives included identifying the problems and constraints and to suggest improvements in the Rod Kohi Tertiary irrigation system.

MATERIALS AND METHODS

The study was carried out at the Mithawan hill torrent area in D. G. Khan during 2003-4. Figure 1 shows the location of the study area. Data were collected through farmers' interviews as well as through field observations of irrigation practices and determining the agricultural and engineering parameters related to crop productivity and soil-water characteristics. Twenty-two respondent farmers were selected and interviewed regarding their irrigation practices under the Rod Kohi irrigation system. At five of these farms, detailed field investigations, irrigation evaluation and specific farm data collection were carried out. Performance evaluation of the Rod Kohi fields' irrigation comprised determination of moisture deficiency before irrigation application, soil texture, depth of water applied and irrigation application efficiency.

RESULTS AND DISCUSSION

Characteristics of Farms and Farmers

Data in terms of education, farming experience, size of land holding, land use distribution, frequency of hill torrents, adequacy of water resources, cropped area, specification of bunds' embankments used and warabandi were collected to assess the water productivity under the Rod Kohi irrigation system.

Out of the total number of 22 respondents, about 95.5% denied of any investigations carried out pertaining to farmer irrigation practices. The educational status of the respondents as given in Table 1 indicated that 72.9% of the respondents at the Mithawan Hill Torrent system were illiterate, 22.6% had completed primary and only 4.5% had secondary education. Consequently, most of the Rod Kohi farmers were illiterate, which is probably the single important factor impeding the scientific advancement and improvement of the farming under the system.

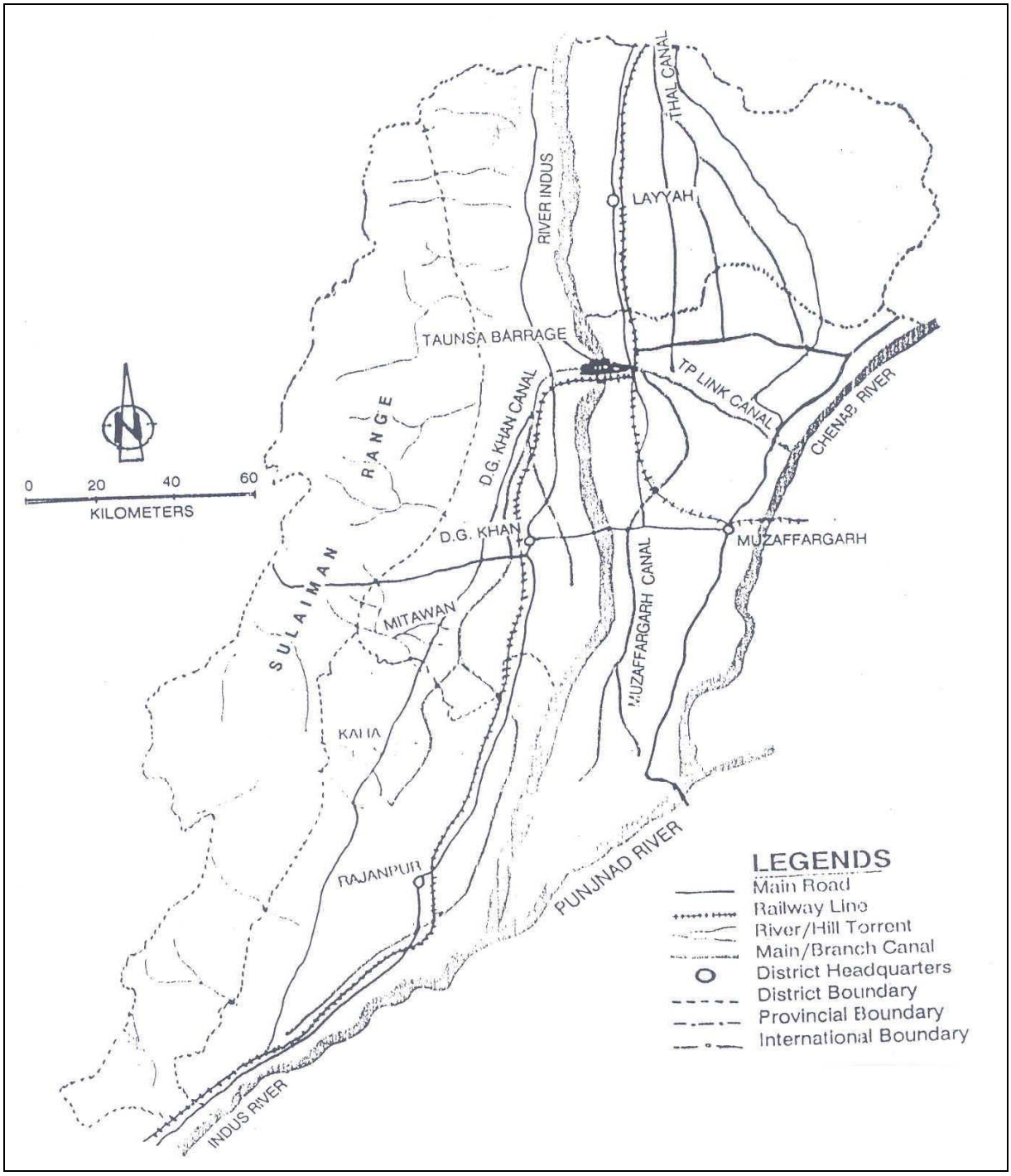

Figure 1: *Location of the Mithawan Hill Torrent System*

Table 1*: Education Level of Respondents*

Educational Level	*No. of Respondents*	*Percent*
Illiterate	16	72.9
Primary	5	22.6
Secondary	1	4.5

The farming experience of the respondents was grouped into 3 ranges of the number of years from 10 to 20, 21 to 40 and above 40 as shown in the Table 2. Eighteen percent of the respondents had the farming experience in the range of 10 to 20 years; about 55% from 21 to 40 years and 27% had farming experience of more than 41 years. Thus, majority of the Rod Kohi farmers had experience range of 21 to 40 years, which indicated that the farming community in the Mithawan Hill Torrent system is highly experienced and has strong professional capabilities to divert and utilize water of hill torrents for agriculture. Probably, inexperienced farmers cannot perform such a skillful job.

Table 2: *Percent Distribution of Farming Experience of the Respondents*

Farming Experience (Years)	*No. of Respondents*	*Percent*
10 to 20	4	18.2
21 to 40	12	54.5
41 and Above	6	27.3

Table 3a presents the frequency distribution of land holding of the Rod Kohi farmers. Accordingly, 36.4% of the farmers had a farm size of 1 to 5 ha, 27.3% farms ranged from 5.01 to 12.5 ha, 9.1% ranged from 12.51 to 25 ha, 9.1% ranged from 25.01 to 50 ha, while 4.5% were grouped in the range of 50.01 to 100 ha and 13.6% of the farmers had above 100 ha of land in the Mithawan Hill Torrent System. The average size of farm in each range was 2.53, 8.26, 15.68, 35.41, 60.7 and 134.9 ha; respectively. Thus, majority of the farms (36.4%) had holding size range of 1 to 5 ha, while about 64% owned a farm size below 12.5 ha and only one seventh of the farms exceeded 100 ha. The corresponding land holding distribution in the irrigated areas of the Pakistan's Punjab is given in Table 3b. A comparison of both the system indicated that the average land holding of the Rod Kohi farmer was about 2.5 times that of the framers of irrigated areas in central Punjab.

Table 3a: Frequency Distribution of Land Holding Under Rod Kohi System

Range of Farm Size (ha)	*Percent of Total Area*	*Mean Farm Size (ha)*
0.01-5	36.4	2.53
5.01-12.5	27.3	8.26
12.51-25	9.1	15.68
25.01-50	9.1	35.41
50.01-100	4.5	60.70
100.01and above	13.6	134.90

Table 3b: *Frequency Distribution of Land Holding Under Irrigated System in the Punjab*

Range of Farm size (ha)	*Percent*
0.01-5	73.66
5.01-10	17.00
10.01-20	7.00
20.01-60	2.00
> 60	0.34

Source: GoP (2003).

The total average land holding of the respondents was 28.97 ha out of which, average gross culturable area was 27.11 ha and irrigated area was 19.24 ha per farm. Out of 22, about 9 farms had an average culturable waste land of 8 ha/farm. The above given land use distribution applies only to the Kharif, while in the winter season, most of the study area remained barren except in a few cases as no hill torrent developed during that period. The results indicated that about 94% of the total land belonging to the respondents was culturable and 6% was wasteland. Out of the culturable land, 66% was irrigated under the Rod Kohi irrigation system and 27% was culturable waste land. On the other hand, in irrigated area, 80% of land commanded by irrigation system.

Results of frequency of the occurrence of the hill torrent per year indicated that about 9% of the respondents expressed that hill torrents occurred once a year while 54.5% showed that hill torrents occurred 2 to 3 times a year. About 13.6% indicated that it occurred 4 times and only 22.8%

showed it occurrence for more than 4 times a year (Table 4).

Table 4: *Frequency of Occurrence of Hill Torrent per Year*

Annual Occurrence	*N**	*Percent*
Once	2	9.1
Twice	7	31.8
Thrice	5	22.7
Four times	3	13.6
More than four times	5	22.8

Note: *Number of Respondents.

The frequency distribution of the duration of hill torrents occurrence is given in Table 5. About 23% respondents indicated that it occurred for 0 to 5 hours, 54.4% expressed that the hill torrent lasted for 5.1 to 10 hours and only 22.8% farmers indicated that hill torrents occurred for more than 10 hours.

Table 5*: Frequency Distribution of Duration of Hill Torrent*

Duration (Hours)	*N**	*Percent*
0 to 5	5	22.8
5.1 to 10	12	54.4
10 and above	5	22.8

Note: *Number of Respondents.

In terms of the adequacy of water availability to meet the crop water demand under the Rod Kohi system, 68.2% respondents of the Mithawan hill torrent system were fully satisfied with the available irrigation water from the Rod Kohi irrigation system while 31.8% of the respondents indicated that the hill torrent water was not sufficient to meet the crop water requirements. Consequently, majority of the Rod Kohi respondents expressed hill torrent water to be sufficiently satisfying the crop needs during the *Kharif* season.

Table 6 summarizes the average crop yields obtained under Rod Kohi and irrigated area. According to the cropping pattern of Rod Kohi system, the commonly grown crops include sorghum, pearl millet, oil seed and wheat. About 79% of the total irrigated area of the respondents was cropped under sorghum while the remaining 21% area had bajra crop. Accordingly, the yield of the sorghum, which is one of the major crops of the area, averaged 564.4 kg/ha. The average yield of gram was found 575.6 kg/ha, pearl millet (bajra) was 519.5 kg/ha and the oilseed yield resulted in an average of 561.6 kg/ha. Similarly, the average yield of wheat crop was 1229.9 kg/ha as given in Table 6.

In order to convey and apply the hill torrent water, heavy embankments are constructed, which is quite costly and labor intensive. Table 7 shows that the height of the different embankments in the study area ranged from 0.91 to 2.29 m, with an average of 1.66 m.

Table 6*: Average Yield of Crops (kg/ha) Under Rod Kohi and Irrigated Systems*

Crop	*Rod Kohi System*	*Irrigated System*
Sorghum	564.4	615
Gram	575.6	606
Bajra	519.5	604
Oilseed	561.6	835
Wheat	1229.9	2384

Source: GoP (2003a)

About 1 to 15 dikes were required to be constructed to accomplish irrigation. Annual repair of embankment by mechanical means was estimated as 34.38 m/hr, while the average rate of constructing new embankment by mechanical means was 4.07 m/hr. Average cost of the bund construction was estimated 222.95 Rs/hr. The change in the elevation of field bed due to silt deposition every year ranged approximately from 0.04 to 0.46 m with an average change of 0.11 m.

Irrigation Turn Under the Rod Kohi System

About 41% of the respondents indicated existence of Warabandi in the Rod Kohi irrigation system, while 59% denied of any warabandi in the system. Out of these, majority of the respondents were of the view that warabandi was self managed. Regarding the season of the occurrence of the Rod Kohi irrigation, about 9.1% of the respondents informed that the Rod Kohi usually occurred in the months of June and July, while 90.9% indicated in the months of July and August.

Consequently, majority of the responding farmers had consented its occurrence during monsoon season.

Table 7*: Specifications of the Embankments Constructed for Rod Kohi Irrigation*

Embankment Specification	*N**	*Range*	*Mean*
Height of Embankment (m)	22	0.91 - 2.29	1.66
No. of bunds constructed	22	1 - 15	3.86
Length of bund repaired mechanically every year (m/hr)	22	6.1 - 60.98	34.38
Length of New bund constructed mechanically, (m/hr)	22	1.52 - 18.29	4.07
Cost of bund construction, (Rs/hr)	22	200 - 250	222.95
Change in the height of bund due to silt every year (m)	22	0.04 - 0.46	0.11

*Number of Respondents Surveyed.

Water Productivity under the Rod Kohi Irrigation System

Table 8 summarizes the water productivity of the different crops sown in the Mithawan Rod Kohi irrigated area. Water productivity as used here accounts for kg of crop yield produced by one cubic meter of water diverted. Accordingly, the mean water productivity has been assessed as 0.067, 0.070, 0.063, 0.075 and 0.161 kg/m^3 for sorghum, grams, bajra, oilseed and wheat, respectively.

The overall average water productivity for all the crops ranged from 0.063 to 0.161 kg/m^3. Consequently, the water productivity of the crops raised in the Rod Kohi irrigated area was very low as compared to that in canal-irrigated area of Pakistan. It was approximately 1.45 kg/m^3 for wheat crop in Rechna Doab as assessed for the *Rabi* 2001-2002 (IWMI, 2002). Although the soil texture was sandy loam to loam, which was appropriate for crop production, yet the productivity was quite low. However, the low water productivity was considered mainly due to inadequacy of water, timely inaccessibility and poor management under the Rod Kohi system. Other factors included the low agricultural inputs such as fertilizer, seed, lack of machinery and other facilities. Unfortunately, these economic factors were not investigated during the reported survey.

Table 8: *Water Productivity under Rod Kohi Irrigation System*

Crop	*Number of Farms*	*Range of Water Productivity (kg/m^3)*	*Mean Water Productivity (kg/m^3)*
Sorghum	5	0.043 - 0.086	0.067
Gram	5	0.056 - 0.094	0.070
Bajra	5	0.049 - 0.086	0.063
Oilseed	5	0.049 - 0.104	0.075
Wheat	5	0.142 - 0.190	0.161

Irrigation System Performance

Performance of the Rod Kohi irrigation system under existing irrigation practices was based on the parameters including soil texture, moisture deficiency and depth of water applied by the farmers as summarized below:

(i) ***Soil Texture***

The soil texture determined from soil samples collected from selected farms was found to range from sandy loam to loam as given in Table 9.

(ii) ***Depth of Water Required***

The soil moisture content determined on volume basis, ranged from 7.58 to 10.99% as shown in Table 9. The observed moisture contents were approximately equal to or less than permanent wilting point. Considering the textural class of the soils, a root-zone depth of 1.35 m, field capacity and observed moisture content, the moisture deficiency was found to range from 14.35 to 21.35% by volume and the depth of water required at the root zone ranged from 19.4 to 28.8 cm as given in Table 9. The moisture at field capacity reported by SCS (1984) was used in the analysis.

(iii) ***Depth of Water Applied and Irrigation Application Efficiency***

Table 10 summarizes the data collected regarding time of application, field size, channel flow rate and the resulting depth of water applied by the farmers on the selected fields. Accordingly, the size of field ranged from 2 to 6.1 ha, which took

13 to 37 minutes to irrigate. The flow velocity varied from 1.3 to 3.5 m/s and channel cross-sectional area from 6.79 to 18.88 m^2, which resulted in channel flow rate of 12 to 61.2 m^3/s. The total volume of water applied to various fields thus estimated ranged from 18751 to 36452 m^3 under the existing farmer practices. The resulting volume of water applied per hectare varied from 7716.5 to 9980.2 m^3. Consequently, the depth of water applied ranged from 77 to 100 cm at different farms as given in Table 10.

Using the depth applied and that required before the irrigation for the selected fields, the application efficiency ranged from 19.4 to 36.5% with an average seasonal application efficiency of 27.7% (Table 11). The application efficiency for sorghum in canal-irrigated area on traditionally farmed land during kharif 1973 at Mona was 10 to 60% with an average of 35% (CSU, 1974). Thus irrigation application efficiency under the Rod Kohi irrigation system was lower than that in irrigated areas, which may be associated with excessive application of hill torrent water.

Table 9: *Assessment of Moisture Deficiency and Depth of Water Required for Irrigation Application*

Field No.	*Soil type*	*Field capacity* (% by vol.)*	*Moisture before irrigation (% by vol.)*	*Moisture deficiency (% by vol.)*	*Depth of water required cm*
1	*Sandy loam*	22	7.58	14.42	19.5
2	Silt loam	32	10.74	21.26	28.7
3	Loam	26	10.99	15.01	20.3
4	*Sandy loam*	22	7.65	14.35	19.4
5	Silt loam	32	10.65	21.35	28.8

*Values reported by SCS (1984).

Table 10: *Depth of Water Applied by the Farmers as Observed in the Field*

Field No.	*Time of App. of Water (Sec)*	*Field Size (ha)*	*Discharge of Channel (m^3/s)*	*Total Volume of Water Applied (m^3)*	*Vol. of Water Applied (m^3 /ha)*	*Depth of Water Applied (cm)*
1	780	2.43	24.04	18751.2	7716.5	77
2	2220	4.25	16.42	36452.4	8577.0	86
3	840	6.07	61.17	51382.8	8465.0	85
4	1680	2.02	12.00	20160.0	9980.2	100
5	780	2.43	24.56	19156.8	7883.5	79

Table 11*: Irrigation Application Efficiency Achieved Under Rod Kohi Irrigation System*

Field No.	*Depth Required (cm)*	*Depth Applied (cm)*	*E_a (percent)*
1	19.5	77	25.3
2	28.7	86	33.4
3	20.3	85	23.9
4	19.4	100	19.4
5	28.8	79	36.5
Average	*23.3*	*85.4*	*27.7*

(iv) ***Use of Hill Torrent water***

The major problems and constraints of the Rod Kohi Irrigation as observed by the farmers in the field are summarized below:

1. Hill torrents are mostly short duration and the upstream farmers have the opportunity of irrigating their lands again and again, depriving the tail end farmers; and
2. Some times, the powerful up stream landowners divert water to their land that has no right of irrigation, thus depriving the tail enders from irrigation water.

Rod Kohi Irrigation Management

Basin irrigation is the most practiced method under Rod Kohi system. Because the hill torrent water has very high velocity, the farmers divert it into the basins in order to minimize its velocity through the dispersion in the basin instead of border. Heavier structures are built, which are made of mud with tractors. The bottom and top width of these embankments are approximately 1.8-2.1 m and 0.76-1.1 m, respectively.

Rod Kohi irrigated commands practice a system of warabandi, which was institutionalized by the British Government before Pakistan came into being. Since that time, the government of Pakistan has not changed the rules regarding the water rights of the hill torrents shareholders. There is one register for every hill torrent system having irrigation rights of the Rod Kohi farmers. This hand written registers are still in use as legal documents. In fact on the ground, there is no implementation of warabandi system in the Rod Kohi irrigated areas. The farmers themselves have fixed rules of irrigation water allocation and there is no interference of the government to this system.

According to the existing warabandi system, the farmer who is at the upstream irrigates, his land first and stores water in his bund as much as he can. This practice tends to allow farmers to over irrigate and cause wastage of water. When the upstream farmer has satisfied his demand of water, he diverts water to the next farmer's land. The diversion of water to the next farmers depends upon their rights. However, practically the upstream farmers generally, don't follow rules in diverting water to farmer's land that has next right. Instead of this, they divert the water to their friends and relatives who have no right of irrigation on that water channel. Mostly, the big and powerful landowners adopt this practice.

Cost of Irrigation Water

The major source of water under the Rod Kohi irrigation is hill torrent water, however ground-water is also used at limited scale. Although Rod Kohi water is free of cost, yet the farmers have to pay heavy charges for reconstruction and maintenance of the Gundh (i.e. the structure to divert the hill torrent water into two "Wah". The maintenance includes repair of cracks, mole holes and erosion of banks. Practically, the farmers repair their bunds every year mechanically and pay cost @ Rs. 250 per hour. The average length of embankment repaired by a 78-hp tractor is approximately 34.5 m per hour, but the average length of newly constructed embankments is approximately 4.1 m per hour.

CONCLUSIONS

- The farming experience of the respondents ranged from 21 to 40 years, which shows that the Mithawan hill torrent (Rod Kohi irrigation) system is being managed and operated by highly experienced farming community;
- The average land holding of the Rod Kohi farmer was about 29 ha. While the majority of the farmers (64%) had the farm sizes below 12.5 ha and about one seventh of the respondents had a land holding exceeding 100 ha;
- Irrigated area of the respondents ranged from 0.2 to 141.6 ha with an average of 19.2 ha/farm. About 41% of the total respondents had the average culturable wasteland of about 20.6 ha/farm, which was much larger than the mean culturable wasteland in irrigated area;
- On the average, the hill torrent occurred twice a year. About 54.4% of the respondents reported that the hill torrents in the Rod Kohi irrigated area lasted for 5.1 to 10 hours during one occurrence;

- The average yield of sorghum, gram, pearl millet (bajra), oilseed, wheat was 564.3, 575.6, 519.5, 561.6 and 1230 kg/ha, respectively;
- With Sorghum and Bajra as the major crops sown during the Kharif 2003, about 79% of the total irrigated area was cropped under sorghum while the remaining 21% area had bajra crop;
- The overall water productivity for sorghum, gram, bajra, oilseed and wheat crops was 0.067, 0.070, 0.063, 0.075 and 0.161 kg/m^3, respectively, which was lower as compared to that in the canal-irrigated area of Pakistan; and
- The average seasonal application efficiency of the study area was as low as 27.7%, which was mainly due to over irrigation of fields.

Suggested Improvements in Rod Kohi Irrigation System:

- Because of high cost of constructing and maintaining of bunds, corporate farming should be introduced to utilize the resources efficiently;
- The existing fields are at much higher elevation than that of Wah, which tends to excessively increase the cost of constructing earthen diversion structures. Concrete diversion structures are recommended to facilitate silt deposition in Wah and consequent reduction in the elevation difference; and
- Improvement of Rod Kohi Irrigation System should be made a part of Flood Control and the OFWM programs for improving the infrastructure.

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