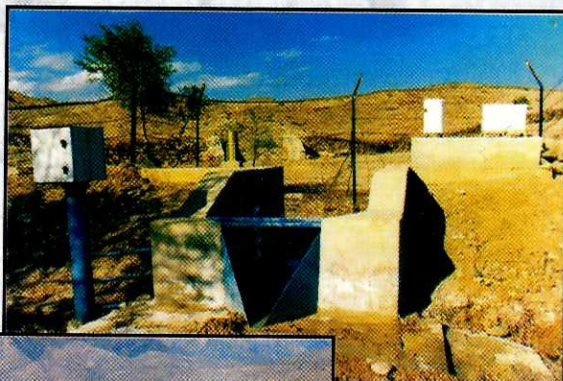


# PERENNIAL ROD-KOHI SYSTEM DEVELOPMENT AND MANAGEMENT IN MITHAWAN WATERSHED



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## 1. Introduction

In Pakistan, Rod Kohi farming system is the second largest system after the Indus basin irrigated agriculture. The potential area under the Rod Kohi system is around 4.0 million ha, out of which around 1.0 million hectares are commanded in an average year. Rod Kohi farming system is dependent on Spate Irrigation, where floodwater from hill torrents is diverted through a system of stream flows duly channelized for commanding the Rod Kohi area. The system is being practiced in piedmont plains of Kohat, D.I.Khan (NWFP), D.G.Khan, Rajanpur (Punjab), Larkana, Dadu (Sindh), Barkhan, Lasbella and Kachhi plains of the province of Balochistan. The largest area under the Rod Kohi farming system is in Balochistan followed by NWFP, Punjab and Sindh.

The Rod-Kohi area in the Punjab province lies in districts of D.G.Khan and Rajanpur. Heavy rains in the catchment areas of the Sulaiman ranges, which extend up to Balochistan and Afghanistan, result in stream flow of floodwater generated from various torrents in the foothills. The Rod Kohi farming system in the province of Punjab is being practiced since centuries but hardly any priority has been assigned by the public-sector. Thus the system is still managed by the communities without any knowledge and financial support from the public sector, except some diversion structures have been built like the Mithanwan watershed at Choti Bala. However, very little or no development support is yet available for Rod-Kohi farming at the secondary and tertiary levels. The infrastructural support is being provided at the primary level.

Spate irrigation based on floodwater is the major source of irrigation for Rod-Kohi farming in the district of D.G.Khan district. More than 52854 hectares of the cultivated area is irrigated by seven major hill torrents which emerge from the adjacent Sulaiman ranges. These torrents are Kaura, Vehowa, Sanghar, Sori Lund, Vidore, Sakhi Sarwar and Mithawan. The area adjacent to the mountainous region is called "Pachadh" which comprises about 498,200 ha out of which 105,310 ha come under the command of these seven hill torrents. The total catchment area of these hill torrents is 10,180 km<sup>2</sup> that receives annual average rainfall of 250 mm with average run off ranging from 17 million m<sup>3</sup> for Sakhi Sarwar to 784 million m<sup>3</sup> for Sanghar. The time and quantity of the torrent floods is unpredictable. They play havoc to the command area as well as to the infrastructure. It is imperative to control and manage these torrents to provide reliable supply of water for Rod-Kohi farming during the low flood season and to ensure safe disposal of the excess water during the high flows season.

In addition to the non-perennial torrent floodwater Spate Irrigation in the district of D.G.Khan, there are perennial Spate Irrigation systems prevailing in areas like the Mithanwan watershed. The perennial Rod-Kohi systems are named as "Kalapani" and are of high potential, as water supply is ensured throughout the year. In fact, these perennial systems are normally fed by the springs originated from the groundwater. Thus these waters are having little or no sediments compared to the non-perennial torrent floodwaters. The project activities were initiated in the Kalapani areas of the Mithanwan watershed.

## 2. The Target Area

The project target area was selected in Dholi, which is a part of the Mithawan watershed in the district of D.G.Khan of the Punjab province, Pakistan. It is located in Sulaiman ranges (Lat.30°00' N and Long.70°07'E) about 70 Kilometers from D.G.Khan city on D.G.Khan-Quetta road near Rakhimunh. Total area of the Mithawan watershed comprises of 993 km<sup>2</sup>.



Major tributaries of Mithawan nullah are: Vershinger, Choti, Nangar, Rakhi, and Siri Nallah. Predominantly, area consists of mountain ranges running in the north-east and south-west directions. Within the mountains there is a valley comprising five Mauzas i.e. Dholi, Kothi, Sohrbun, Khand and Irsind and 16 hamlets. The area is mainly irrigated by perennial water (*Kalapani*) system while the floodwater is available in the downstream area for irrigation. Salient features of Dholi target area are given as:

### Salient Features of Dholi Target Area

➤ Total Area	99,300	(ha)
▪ Catchments Area	72,900	"
▪ Low land area	26,400	"
➤ Project Area	20,277	"
▪ Cultivated Area	845	"
▪ Rangelands	19,432	"
➤ Mauzas	5	"
▪ Settlements	16	"

### 3. Climate

The climate of the Target Area is classified as arid to semi-arid, which is broadly characterized by cold winters and long hot summers. May and June are the hottest months with an average maximum temperature of about 38°C. January and February are the coldest months with average minimum temperature of 10°C. Occasionally in winter, the temperature falls to 0°C due to western cold winds.

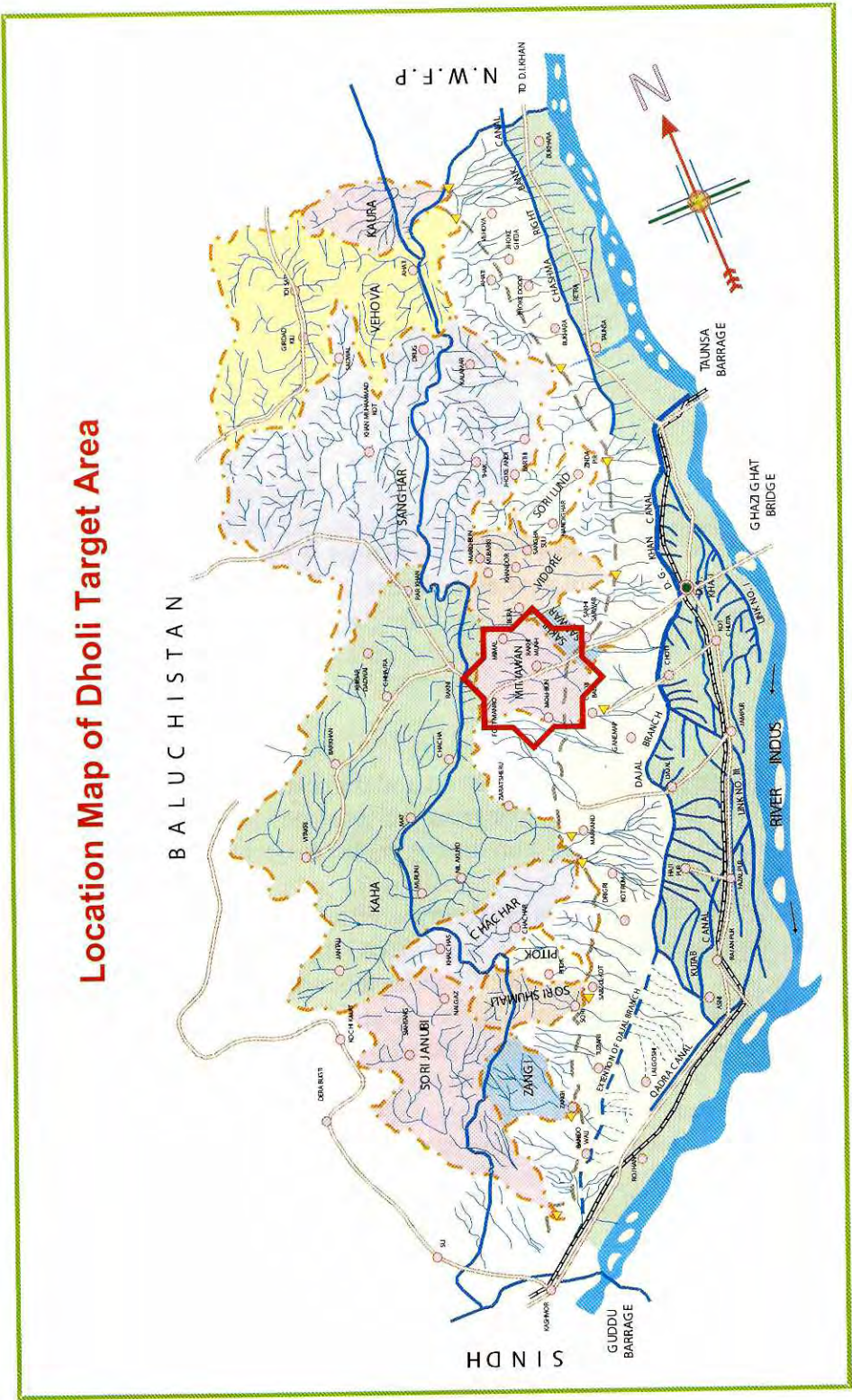
### 4. Rainfall

The area receives very low rainfall most of which is received during monsoon season i.e. July and August. Winter showers are received in December and January. Average annual rainfall varies from 200 to 300mm.

### 5. Vegetation

The vegetation of the area is typical of arid regions and consists of xerophytic species. Low rainfall, deteriorating soil conditions, severe grazing and browsing are the main factors for depletion of vegetation. Place to place occurring lopped trees indicate massive cutting for fodder and fuel wood. Scattered trees of *Salvadora oleoides* are found on the steep slopes while *Prosopis juliflora* and *Tamarix aphylla* are in abundance in the nullah bed. *Acacia nilotica*, *Prosopis cineraria*, *Zizyphus mauritiana*, *Z. nummularia* and *Indigofera oblongifolia* are found on the alluvial fans. Grasses include *Chrysopogon aucheri*, *Cynodon dactylon*, *Cymbopogon jawarancusa*, *Hetropogon contortus*, *Eleusine flagellifera*, *Cenchrus cliaris* and *Cenchrus setigerus*. These trees and grasses provide forage and fodder respectively for livestock when the grazeable species dry out. However, the regeneration of summer grasses starts with the onset of spring season (February- March).

# Location Map of Dholi Target Area





## 6. Land Use

Livestock grazing is the main land use of the Dholi Target Area. Rangelands which occupy 93% of the area are severely deteriorated due to irregular grazing by nomadic and local livestock. According to an estimate, the pressure on grazing lands is more than twice the grazing capacity. Millets and sorghum are sown during the summer (*Kharif*) season on small scale. Wheat is the major winter (*Rabi*) crop. After the ensured supply of Perennial water by the project, the farmers have started growing cash crops like cotton and sunflower as well.

## 7. Water Resources

The Rod Kohi system of Mithawan, Dholi Target Area, is characterized by numerous seasonal and perennial nullahs. The magnitude and time of seasonal and perennial flow is highly dependent on rain. When the hilly regions receive rain the seasonal streams are in Spate. The discharge of perennial flow also increases.

### 7.1. Surface Water

#### Rain water

The Dholi Target Area is traversed by five ephemeral streams which contribute to main Mithawan. The torrent water is not available for irrigation in the area except some patches of land which are irrigated by harnessing water from the adjacent slopes. The command area of torrent water lies outside the hilly region.

#### Perennial water

Perennial flow is the main source for irrigation and domestic use in the area. It emerges from the Sulaiman ranges. Several springs generate the local perennial flow, which finds its way along the dry beds of seasonal streams on its way to the project Target Area.

There are two isolated sources of perennial flows. First one emerges out at a place known as '*Khuldan*' about 5 kms from the Dholi Target Area. It irrigates Mauza Irsind and the areas around it. Due to smaller command area it can be termed as **small-scale irrigation system**. Second and the larger one originates at a place about 8 kms from the project site and emerges out at a place known as '*Bandha*.' Due to larger command area it can be categorized as **large-scale irrigation system**. Mauzas Dholi, Kothi, Khand and Sohrbun are the part of this contiguous system. From '*Bandha*', water is diverted into irrigation channel along the contour of the hills. On its way to command area, few casual springs may add to its flow. The discharge of flow varies from 2.75 to 3.75 ft<sup>3</sup>/sec depending upon the climatic conditions and rainfall.

### 7.2. Groundwater

Groundwater is almost absent in the area. Several attempts have been made by the local community for the exploration of groundwater but in vain.



## 8. Project Achievement

### 8.1. Participatory Rural Appraisal

Before the inception of the Rod-Kohi Project a detailed Participatory Rural Appraisal of the target Area was conducted in June-August, 1995. According to the findings of PRA, water availability, both for irrigation and domestic use, was the foremost priority of the local community. Based on these findings, research and developmental activities were started in the area.



### 8.2. Water Management

According to PRA findings, water was one of the most limiting factors affecting the productivity of the area. More than 50% of water carried by the earthen channels was wasted due to seepage, place to place breaches, overflows and junction losses. The passage of perennial water across the ephemeral streams was hampered by the flash floods during rainy season thus dismantling the supply for irrigation and domestic use. These losses were overcome by constructing masonry watercourse and off take channels. The problem of water conveyance across the torrent bed was handled by constructing siphons and aqueducts (open, pipe etc). Precast water diversion and application structures were installed to overcome junction losses and divert water to the fields efficiently without much consumption of labour and time.

#### 8.2.1 Lining of Main Watercourse

Perennial water is the mainstay of agricultural activities in the Target Area. To overcome the excessive loss rate of this water, lining of the main watercourse was accomplished. To evaluate the comparative performance and cost, following lining materials was tested at different reaches of the main channel during the construction:



- i. stone masonry
- ii. brick masonry
- iii. poly-ethylene plastic lining
- iv. pre-cast parabolic slabs and
- v. RCC pipes

**Length of water channels (in meters) lined by various means.**

Lining Technique	Stone masonry	Brick masonry	Parabolic Slab (Single piece)	R.C.C Pipe	Plastic
Total length (m)	7000	165	253	85	1,900



## 8.2.2 Construction of Water Banks

Along the water channels, several water banks (water storage tanks) were also constructed at different sections to store water when the channel is running so that it could be utilized during the stress periods.

## 8.2.3. Aqueduct Construction

To convey the *Kalapani* across the ephemeral streams thus ensuring the sustainable supply through out the year and to overcome huge conveyance losses, 7 aqueducts of different lengths and cross sections were constructed at different selected places in the target area. The construction of these aqueducts brought a significant change. Not only the already existing area is being cultivated on regular basis but also a great extent of new area has been developed by the farmers and brought under cultivation due to the ensured availability of water. Further expansion of irrigated area is still going on.



### Details of the Aqueducts constructed at Dholi Target Area

Aqueduct Constructed at	Length (m)	Diameter (m)	Discharge Capacity (cfs)	Cost (Rs)
Sohrbun	46	0.203	2.042	20,000
Dongar Khor	18	0.203	2.042	21,000
Siri Nullah	67	0.250	2.784	160,000
Bajhi Wala Open	34	-	3.500	-
Bajhi Wala Pipe	17	0.203	2.042	28,690
Bajhi Wala Slab	7	-	2.512	6,512
Khand	40	0.250	2.135	-

## 8.2.4. Water Diversion Structures

Water diversion to respective Mauzas and fields was a major concern in the area. People were diverting water by constructing temporary earthen or gravel structures due to which junction losses were very high. To overcome these losses easily manageable 'Panal Naccas' were introduced at appropriate locations along the main watercourse and the off-take channels. About 155 panel naccas of 16 inches diameter were installed at different locations. Apart from reducing junction losses, it reduced labour and time.



Similarly more than 100 'Pipe Naccas' of 9-inches/12 inches diameter were installed at appropriate locations at farm level as field inlet structures. By virtue of these structures, water control and diversion to the individual field has become very easy. Farmers having smaller irrigation time (due to smaller landholdings) were particularly benefited by this intervention.



### 8.2.5. Construction of Siphons

To protect the water channel from damaging by Rod Kohi and for safe conveyance of localized runoff across the main water channel, 4 siphons were constructed along the main watercourse. Also to protect the main watercourse from the destruction caused by the passage of carts and tractor trolleys, 6 crossing structures were constructed at various selected points.



### 9. Earthen Water Reservoir Development

Water shortage for human beings as well as livestock is of grave concern in the Dholi Target Area. People have to travel a long way with their livestock to reach the water points. To manage water for domestic and livestock use, replenish the groundwater reserves and to supplement the source of irrigation during the dry spells, small and medium sized earthen water reservoirs were constructed in the Target Area.



Farmers were motivated to participate in the construction of these reservoirs. Proper sites were selected in various Mauzas to harness rainwater. As the terrain is rugged and stony, the construction of massive earthen structures was not possible with ordinary means. So shovel and tractors with dozer blades were arranged for this purpose.



Water stored in these ponds is providing supplemental irrigation as well as being utilized by livestock and domestic sector. As helped by the Project, some of the farmers have also experimented fish farming in the existing reservoirs, and the results were quite encouraging. It indicates step towards poverty alleviation in the area. It is also expected that seepage through these reservoirs will help to create a fresh groundwater resource after some time.

#### Catchment area and storage capacities of major reservoirs in the Target Area

Reservoir	Catchment area (ha)	Ponding area (acres)	Storage capacity (acre-ft)	Embankment specification					
				Length (m)	Height (m)	Top width (m)	Base width (m)	U/S slope	D/S slope
<b>Khand</b>	62.55	5.69	68.37	117.0	4.88	3.66	24.00	2.5:1	2:1
<b>Bhajiwala</b>	38.90	3.25	28.25	55.00	5.00	4.57	23.70	2:1	1.5:1
<b>Kothi</b>	20.34	1.35	7.50	30.50	4.26	2.43	21.64	3:1	1.5:1
<b>Dabra</b>	16.35	1.01	3.12	34.25	1.85	-	-	-	-
<b>Sonawala</b>	3.165	0.741	2.35	-	-	-	-	-	-



## Number of Beneficiaries of the Reservoirs

Settlements	No of Beneficiaries		Area Irrigated (Acres)
	Domestic	Livestock	
Khand	600-700	1000-1250	12-15
Bajhi Wala	300-400	1500-2000	--
Kothi	40-50	400-500	14-18
Dabra	80-100	550-600	4-6
Sona wala	50-60	200-250	--

### 10. Introduction of Trickle Irrigation System

To combat water shortage, a pressurized irrigation system (trickle) was installed at Dabra (Mauza Dholi) which is being operated successfully by the farmer. An orchard of different fruit trees has been established and farmer is getting benefit by selling these fruits.



### 11. Rain Water Harvesting in Arid Areas

Dholi Target Area is the part of Mithawan watershed. It is linked with 'Pachadh' area with the same hydrological system. Four tributaries originating from this area irrigate 23470 hectares of 'Pachadh' area. It is imperative to conserve and manage rain water in the watershed areas to promote vegetation cover, reduce soil erosion, and check bank cutting to attain productive results in the downstream areas. Keeping in account, the management activities were initiated in the area.



More than 1200 eyebrow pits were excavated along the contours in staggered fashion to harvest the runoff water and to detain the silt load which accompany the runoff. Similarly, 40 trenches having the size 10 × 4 × 2.5 ft were excavated along the contours on the upslope steep hilly area of the catchment in an alternate manner to arrest the sediment and gravels coming with runoff.

Thirty loose stone check dams of various sizes were erected across the waterways to reduce the water velocity, control gully formation and trap the silt coming with runoff. *Acacia nilotica* was introduced in these pits for promotion of vegetation. The specie was selected due to its climatic adaptability and capability to withstand harsh climatic conditions and severe grazing. In addition it can provide good economic return. Moreover seeds of palatable grass specie *Cenchrus ciliaris* were also broadcasted in the catchment areas and upstream of the check dams.



## 12. Research Activities

### 12.1. Assessment of Hydrological Parameters

Along with the developmental activities, the research activities were also carried out in the project area. Two paired degraded catchments, with and without various treatments, were selected for this purpose. Automatic water level recorders and 'H' type flumes were installed at the constriction point of both the catchment. The study included the recording of various hydrological parameters like surface runoff, sediment deposition in the local catchments and meteorological investigations that are necessary to determine crop water requirement. The data revealed that no surface runoff was recorded with the rainfall less than 10 mm.



### 12.2. Collection of Meteorological Data

A meteorological station was set up in the Target Area with the beginning of the project. Different climatic parameters like Temperature, Humidity, Sunshine hours, Wind Speed, Evaporation Rate and Rainfall, were continuously recorded and evaluated. The data can help to determine the consumptive use of different crops and ultimately to determine crop water requirement for various crops grown in the area.

## 13. Intervention Impacts

The interventions executed by the project staff have demonstrated following improvements in the study area:

### *i. Reduction in Water Loss Rate*

Due to the lining of watercourse, water loss rate has tremendously reduced at different reaches of the system. As estimated by the project staff, there was an increase of 33% in the discharge as compared to pre-intervention period.

### *ii. Improved Water Conveyance Efficiency*

As the seepage and breaches have been controlled by the lining activity, the water conveyance efficiency was improved by 60 % between Mauza Sohrbun (middle reach) and Khand (tail reach) and 52% between Mauza Sohrbun (middle reach) and Basti Bhajiwala (tail reach).

### *iii. Reduced Water Conveyance Time*

Lining of watercourse has reduced the water conveyance time. For example, it took 180 minutes to reach at the tail of the system i.e., from Mauza Sohrbun to Mauza Khand, before the lining of the watercourse. After the construction of the lined water course it takes only 60 minutes. Thus one of the primary objectives of present project i.e. inducing equitable water distribution system was successfully achieved.



#### iv. *Increased Reliability*

Water supply to the tail reaches has been ensured throughout the year due to the construction of Aqueduct over Sirri Nullah. In addition, construction of lined watercourses and installation of Panal Nakkas have almost eliminated water theft and junction losses. It has increased the reliability of water particularly for the farmers of the lower reaches. They are now taking the risk of growing higher value crops like cotton, wheat, sunflower etc.



#### v. *Expansion in Irrigated Area*

Due to the effective interventions, the extent of irrigated area has been remarkably increased in different Mauzas of the project area. A large chunk of new land has been brought under cultivation particularly at Mauza Sohrbun and Basti Bhajiwala. It will ultimately add to the overall crop yield in the area. The expansion of irrigated area is still going on.



#### **Increase in the cultivable area in different Mauzas from 1995 to 2004.**

<b>Mauza</b>	<b>Dholi</b>	<b>Kothi</b>	<b>Sohrbun</b>	<b>Khand/Bhajiwala</b>	<b>TOTAL</b>
Area in 1995 (acres)	218.074	240.136	52.937	143.507	<b>654.65</b>
Area in 2004 (acres)	249.135	275.076	150.222	215.257	<b>889.69</b>
<b>% Increase</b>	<b>14.2</b>	<b>14.6</b>	<b>183.8</b>	<b>50</b>	<b>35.9</b>

#### vi. *Increase in Crop Yield*

Due to the ensured availability of irrigation water through out the year, the cropping intensity of the area has increased which in turn has increased the overall production of the area. It indicates a step toward poverty reduction.



#### vii. *Socio-Economic Uplift of the Local Community*

The ensured water supply through out the year has significantly changed the socio-economic condition of the local community. Growing and selling of cash crops like wheat, cotton, sun flower, etc has boosted their livelihood. Moreover, crops residues (stubbles and husk) are utilized by the livestock, which is the prime source of their income.



Due to improving economic conditions, the farmers are giving up old bullock farming and turning towards the mechanized agricultural techniques. Now they are purchasing tractors along with cultivators and threshing equipment. Better financial conditions have changed the living style of the people as well. As a result they have started constructing masonry houses instead of mud houses and gradually giving up tent livings. They have also started educating their female children.



#### ***Viii. Increase in Floor Mills***

At the time of inception of the project, there was only one floor mill operating at Mauza Dholi which was sufficient to meet the requirements of local community. Presently the number has been increased up to 7 that indicate the improved cereal production in the Target Area.

#### ***ix. Return of Migrated Families***

Out migration of the community has halted due to ensured water availability. Not only this, already migrated families are also returning to the area to look after and cultivate their lands.

#### **Number of Families back shifted up to the year 2004**

<b>Mauza</b>	<b>Sohrbun</b>	<b>Dholi</b>	<b>Khand</b>	<b>Kothi</b>	<b>TOTAL</b>
Back shifted Families (No)	6	8	4	6	<b>24</b>

### **14. Future Outlook**

Rod Kohi areas are having tremendous potential for development due to land fertility and abundant water which goes into the Indus waste and unutilized. Unfortunately the system is most ignored and least understood. So far, hardly any effort has been made to introduce improved water management techniques as in other arid countries like Yemen and Iran. Following measures are proposed in Rod Kohi areas for productivity enhancement and poverty reduction.

#### **Technical**

- Sulaiman ranges serve as the watershed for hill-torrents. Watershed management programmes/schemes may be initiated in the area with community participation. It may reduce the intensity of floods in the downstream areas as well as the havoc created by them.
- Micro-catchments may be developed along the contours in the sloppy areas to harvest runoff and sediment load.
- Cost-effective earthen water reservoirs/water points may be developed at proper sites to harvest rain water for livestock, domestic use and supplemental irrigation.
- Conserve perennial flow by adopting improved methods of conveyance, diversion and application.
- Improved irrigation methods for various crops should be extended through Water Management/Irrigation departments.



- High efficiency irrigation system (trickle and sprinkler) should be introduced in the area to promote high valued horticultural crops.
- Water user associations may be formed to ensure equity and justice for the use of perennial and rain water.
- Improved varieties of seeds should be introduced.
- Agricultural extension services, which are lacking in the area, should be extended.
- Livestock rearing is the mainstay of the people of Rod Kohi areas in D. G. Khan. Range management programmes/techniques should be introduced in the area to avoid overgrazing of the watersheds.

### **Institutional**

- At present various government agencies like Soil conservation, Irrigation and Power, Forest Department and On- farm Water Management are working in the area on provincial level while NARC, is undertaking research activities under federal government. However, inter-institutional harmony and integrated efforts are direly required for resource conservation and poverty reduction.
- An independent institution like Rod Kohi Development Authority should be established to manage and conserve the hill torrent water.
- Small scale NGOs/CBOs may be encouraged at local level for the uplift of the local community.
- Sulaiman ranges mainly comprise tribal inhabitants with their own social and cultural values. Strong legislation with the involvement of local influential people is required to promote watershed and range management activities in the area.



