# LAND TENURE AND WATER RIGHTS IN ISOLATED SPATE IRRIGATION SYSTEMS (*SAILABA* AGRICULTURE) OF BALOCHISTAN, PAKISTAN

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## 1. INTRODUCTION

The area under *sailaba* agriculture (hill-torrent spate irrigation) has expanded to meet the demands of food and fiber of the rural population in the dry mountainous areas of Pakistan. *Sailaba* agriculture entails the management of torrential water flows in time and space. Both biophysical and socio-economic factors determine the performance of the system. Water and vegetation management determines soil erosion rates and flood irrigation can increase and stabilize crop yields; however, this is subject to large variations in water availability in semi-arid environments. The Water Resource Research Institute (WRRI), conducts action research in hill-torrent areas in the four provinces of the country to assess users™ needs in watershed management. Action research in these areas is potentially applicable to 2 million ha in the Divisions of D.G. Khan (Punjab), D.I. Khan (North West Frontier Province), Zhob (Balochistan) and Dadu (Sindh) to reconcile food security with natural resource management. Productive uses of water for vegetable and fruit gardening, livestock operations and domestic uses under extreme conditions of water scarcity in these areas compound the complex water management decisions made by the households.

Land tenure and water rights have been identified as key factors in watershed management both in the command (van Steenbergen, 1997) and the catchment areas (WRRI, 1997). Even though there are rules and regulations to assign water, coordination among farmers to divert water and repair damaged bunds is essential. There is little or no time for verification of water paths or try to divert water according to the agreed water rights. Tribal traditions determine different perceptions and attitudes towards natural resource management. Thus, the water management in *sailaba* agriculture is both technically and socially complex.

### 1.1. System Description

Spate irrigation system of *Sailaba* agriculture provides livelihood for a large number of resource-poor farmers in fragile arid environments of the Balochistan province. The isolated

spate irrigation systems in the study area were built without any support from public-sector programs. In Pakistan there are over 1.45 million hectares under *Sailaba* system (Khan 1987, cited by van Steenbergen 1997), whereas recent estimates indicate that the potential command area is around 2.0 million hectares (PARC 1995).

In small- to large-scale farmers managed spate irrigation systems, seasonal flood flows are diverted from the non-perennial streams. Four isolated spate irrigation systems were selected in the Musa Khel and the Barkhan districts of the Balochistan province and these can be characterized as very small, small, medium and large in size considering number of water users, command area and relevance to non-perennial spate irrigation (Table 1). The existing water rights are well recognized by the community. The water flows are diverted to water channels in proportionate to the command area owned by a farmer in small-scale well defined systems, whereas for medium to large scale systems water diverted to a channel is further allocated in relation to the sequence of land holdings from head to tail. Farmers due to expansion of command area now observe the water shortage during the last two to five decades. There is additional isolated area as micro-catchment in each of the selected systems, which contributes runoff to some of the adjacent fields of the command area.

The two systems of the *Mauza Sirati* selected for study are simple and small. One farmer in each of the selected systems has installed a shallow dugwell and can irrigate around 0.20 hectares of land using Persian wheel operated by a camel. The shallow groundwater at the *Dudar* system is helping the farmer to have more reliability and sustainability for small-scale fruit plants, vegetables and crops. However, the dugwell of the *Sohar Khor* system is not in operation and farmer is presently not using water for irrigation. The *Sham* and *Jhalwani* commands do not have any dugwells.

**1.2. Study Area**

Four small- to large-scale farmers managed isolated *Sailaba* systems were selected in the area of the *Mauzas Sirati, Sham* and *Jhalwani* which are located in the north-eastern side of the Balochistan province and is a part of the districts Musa Khel and Barkhan, Zhoab division. These sites are located at an altitude of 1300 m.a.s.l. D.G. Khan in the east and D.I. Khan in the north surround the district.

Annual rainfall at 50% probability is 320 mm with a bimodal distribution, 62% of it occurs in the summer or *Kharif* season, and the rest occurs in the winter or *Rabi* season

(Kidd et al. 1989)[1]. On the dry side, there is 10% chance that rainfall cannot exceed 53 mm in the *Rabi* season and 85 mm in the *Kharif* season; on the wet side, there is 10% chance that rainfall can exceed 241 mm in the *Rabi* season and 372 mm in the *Kharif* season (Figure 1). More recent time series for Barkhan are not available. Because the Mediterranean nature of the *Rabi* season and the Monsoon nature of the *Kharif* season, the correlation between rainfall in both seasons is weak (r=0.3, Siddiqui, pers. Comm.); thus, a *Kharif* season does not necessarily determine a wet *Rabi* season, or vice-versa.

The command area of the *Dudar* and *Sohar Khor* systems of the *Mauza* Sirati were owned by a *Pakhtoon* family, which belongs to the *Luni* tribe headed by Sardar Hashim Khan, until 1870. In 1917, Garshin tribe came from *Drug* and occupied the land. Sardar Zaman Shah bought this area in 1970 from *Lunis*. The present owners purchased this land from Sardar Zaman Shah at a rate of Rs. 3,300 per hectare in 1975. They actually came to this area in 1937 and started working as tenants; however, they belong to the *Mauza Sirati*. The maps of these spate irrigation systems are presented in Figures 2 and 3.

The command area of the *Sham* spate irrigation system was owned by a *Pakhtoon* tribe, *Luni*, until 1870, headed by Sardar Hashim Khan. In 1905, the population in the *Mauza Rara Sham* was 14 (*Gazetteer* of Balochistan). They cultivated the lands of *Luni's* tribe and pay 1/15th of the produce as a land rent to the head of the tribe. The present owners purchased the land from *Luni* tribe. The *Rara Sham* area was sold in 1975 at a price of Rs. 30,000. The language spoken in the target area is *Saraiki*; however, they can speak *Baluchi* and *Pushto*. The map of the *Sham* spate irrigation system is presented in Figure 4.

The command area of the *Jhalwani* spate irrigation system was owned by a Pakhtoon family, which belongs to the Luni tribe until 1870. The present farmers of the command area are *Hassni*. Their language is *Khetrani*. Before migrating to the command area they lived in Pishin district until 1780, and then they migrated from Pishin to Kohloo. They came to Barkhan in 1820 and lived there for about 40 years. Actually they had a battle with *Marie* tribe in Kohloo. In 1860 they moved to Taghio in Barkhan to avoid their enemies. In 1880, they came to Rarkan. The British Rulers gave the Rarkan area to the Hassni tribe as gift in 1880.

The tribe leader Mr. Alihan (postman) saved the life of wife of the Political Agent from a fire incidence and in return British Rulers gifted the lands of *Mauza Rarkan* to the *Hassni* tribe. Thus Mr. Alihan governed the area. He distributed the land between other

[1] Summer rainfall includes June-September and winter rainfall comprises October to May for the years 1901-1940.

settlers on the basis of their commitment to serve British rulers and their guests. The map of the *Jhalwani* spate irrigation system is presented in Figure 5. Two nullahs namely Garabacha and Khanki command the system area. This system is much more complex compared to the two small-scale systems of the *Mauza Sirati*.

### 1.3. Purpose of the Study

Land tenure and water rights have been identified as key factors in management of *Sailaba* agriculture system. Even though there are rules and regulations to assign water, coordination among farmers to divert water and repair damaged channels is essential. There is little or no time available to the users for verification of waterways or try to divert water according to the agreed rights during the flood period. Tribal traditions determine different perceptions and attitudes towards natural resource management. Thus, the water management in *Sailaba* agriculture is both technically and socially complex even in small and isolated spate irrigation systems. The purpose of this study is to enhance the understanding of interactions of: a) land tenure and water rights with, b) agricultural and resource management practices in *Sailaba* agriculture system. The research builds upon ongoing research of the On-Farm Water Husbandry eco-regional initiative (ICARDA, 1995) and the Pakistan-sponsored Rod-Kohi System Development and Management projects in the Musa Khel and Barkhan districts of the Balochistan province of Pakistan.

**Procedures and methods**

Field visits were conducted during the autumn 1997 and winter 1998 to ascertain the rules and regulations of land and water use in the Musa Khel and Barkhan districts. Two community dialogs were conducted with the farmers belonging to the each of the four systems described here and a team of researchers individually interviewed all the farmers from each system. Crop costs estimates for land preparation, seeding, weeding, harvesting and threshing were estimated from the communal interviews but the crop yields for were individually assessed for each farmer. Thus, crop income is mostly a function of the area cropped, the cropping pattern and the cropping intensity. Livestock income was estimated based on the number of small and large ruminants rather than using a budget analysis for livestock enterprises.

## 2. FINDINGS OF THE STUDY

### 2.1. People and Social System

#### 2.1.1. People and Household

The farmers of the *Dudar* and *Sohar Khor* systems of the study area belong to the *Baloch*

tribe and sub-tribe *Buzdar*. Their mother tongue, customs and traditions are *Balochi*. They are immigrants as they migrated to *Dudar* and *Sohar khor* area of the *Mauza Sirati* in 1937 and then purchased the land in 1975. They remain tenants for about 38 years and then became landowners in 1975. The main language of the area is *Balochi* but they can also speak *Khaitrani*.

The farmers of the *Sham* system belong to the *Garshin* sub-tribe of Syeds. Their mother tongue is *Saraiki*. They are immigrants as they came here in 1880 from Drug. They purchased land in 1970. Their livelihood is mainly dependent on off-farm sources, crops and livestock; each source contributes in order of priority. Mauza *Sham* consists of two settlements, *Khor Chu* and *Khor*. The major part of population is settled in *Khor*.

The farmers of the large system of *Jhalwani* command area belong to *Hassni* and sub-tribe *Jhalwani*. Their mother tongue, customs and traditions are *Khetrani*. The main language of the area is *Khetrani* but they can speak *Baluchi* and *Sarieki*.

The households and population of various settlements of the four-selected spate irrigation systems are presented in Table 2. There are six settlements in the *Jhalwani* command, two settlements in *Sham* command and one settlement each in the other two small-scale systems. In total there are 60 households with a total population of 641.

The distribution of family size in four selected systems indicated that average family size is around 11, whereas about 60% families have a size of less than 10 persons. Only 6.7% families have size of over 20 persons (Table 3).

There is a primary school in the *Sohar Khor* area. There are two primary schools in *Mauza Sham*, each for girls and boys, separately. The nearest high school is in *Rara Sham* located around 3-km distance. There are two primary schools in *Jhalwani Qadeem* and one in *Dada Jhalwani* each for boys and girls. In village *Rarkan*, there is one high school, which is about 3 km from the *Jhalwani* settlement. For basic health facilities, the people have to travel to the nearby town of *Rakhni* located at a distance of around 32-km.

Women are fully responsible to fetch water from ponds and wells for domestic purposes. These ponds are located at a distance of about 2-3 km. They are responsible for collection of fuelwood. They are also involved in making of *Mazry* rope from native vegetation named as *Peach* or *Dohra*. The ropes and mats prepared by women are sold in the local market.

The communication among the people is quite effective. They share their information and experiences at every meeting and termed as *Haal*. This helps to share information regarding weather, production and any happening in the area.

**2.2. Farming Systems**

### 2.2.1. Range-Livestock Production

The number of households, the command area and the number of ruminants with respect to the four systems are presented in Table 4. The average command area is 3.4 ha; the average number of small and large ruminants is 42 and 5, respectively. Cows and bullocks are the predominant large ruminants, but a few donkeys and camels are also present; the small ruminants include sheep and goats. To standardize the numbers of livestock the number of large ruminants were multiplied by 6; hence we will refer to standardized livestock units. The distribution of livestock per family is skewed; in the smallest households, with 5 or less family members the standardized livestock units average 16 while the households with more than 20 family members average 274 livestock units (Table 5). On the average, one family member contributes with 10 livestock units[2].

Similarly, analysis was made for household livestock population considering landholdings. Although, there is no consistent trend compared to family size, however, higher average household livestock population is with larger farmers compared to small farmers (Table 6). The small farmers of 1.0 hectares or less average 24 livestock units, farmers owning between 1.01-4.0 hectares average 50 livestock units, and farmers having landholdings of over 4.0 hectares average 171 animals. There is a weak but significant correlation between landholding and the number of livestock[3], as it will be explained below there is collinearity among the landholding and the number of family members.

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[2] Livestock units = -33.51 + 9.9 family members (no.); t values of the intercept and slope were –1.6 and 6.0,respectively; Adj. $r^2$= 0.375 and n=60.

[3] Livestock units = 18.6 + 15.7 landholding (ha); t values of the intercept and slope were 1.0 and 3.87, respectively; adj. $r^2$=0.192 and n=60.

Farmers supplement animal feed with green harvests from mashbeans, mungbeans, sorghum and wheat. No other fodder is grown in the area. If livestock numbers are more strongly correlated with the number of family members than landholding in the command area suggests that family efforts for livestock husbandry are required and the dependence on fodder from the command area is low. It is often stated that the rangeland condition in highland Balochistan is poor but we are not able to suggest this if the fodder dependence is relatively weak and the livestock population is increasing. Livestock husbandry practices have not been extended to farmers and the provincial government supports only veterinary services. An NGO, Balochistan Rural Support Program (BRSP) is also working in *Sham* and *Jhalwani* areas and provides training to community in veterinary cover. Farmers are trying to protect vegetation for livestock at least for 3-4 months (during??) through a communal agreement for rotational grazing known as *Chor*.

Pastoralists are common in the area and provide services to landowners for production and maintenance of small ruminants. Two systems are commonly practiced:

- *Nim Soodi* --the newly born young sheep and goats are equally divided between the owner and the pastoralist and the livestock owner takes the wool.
- *Zarsar*—small ruminants are given to the pastoralists for a fixed period. After a certain period the herd is sold in the market and the rate fixed initially at the time of agreement which is less than the market rate (15-20% less) is returned to the owner. The profit is divided equally between owner and pastoralist.

### 2.2.2. Crop Production

The total command area of the four-selected spate irrigation systems is around 205 hectares. Farmers grow wheat in the *Rabi* season and mungbeans, mashbeans and sorghum in the *Kharif* season. Three cropping patterns are practiced: a) mixed sorghum, mungbeans/mashbeans-wheat (M-W); b) fallow-wheat (F-W); and c) mixed sorghum, mungbeans/mashbeans-wheat-fallow-fallow (M-W-F-F). In the M-W cropping pattern one half of the landholding (bunded units) is cultivated with the *Kharif* crops and the other half with the *Rabi* crop with 100% cropping intensity (cropped to cultivated area ratio on a yearly basis). In the F-W cropping pattern, the monsoon rainfall and runoff is stored to ensure the wheat monoculture with 100% cropping intensity. The M-W-F-F cropping pattern is different from the M-W cropping pattern in the sense that one-year fallow in both *Rabi* and *Kharif* seasons is required. Thus, the cropping intensity for the cultivated and uncultivated years averages 100% per annum.

About 63% of farmers follow the M-W cropping pattern, 25% follow the F-W

cropping pattern and only 12% of the farmers follow M-W-F-F cropping pattern (Table 7). The majority of head and middle farmers are practicing the M-W cropping pattern, whereas 32% each of middle and tail farmers are practicing the F-W cropping pattern. The one year cropping and one year fallow is normally practiced at the tail command by about 33% farmers. The purpose is conservation of rain and runoff water, in addition to soil fertility. The mix of *Kharif* season crops is commonly grown by farmers located at upstream reaches (head and middle). This is a good indication that more water is available to the head and the middle reaches farmers compared to tail end reaches. The crop evapotranspiration of wheat is low compared to sorghum, mashbeans and mungbeans and thus majority of tail-end farmers practice a pattern based on either wheat only or one year cropping and one year fallow.

The watering intensity per annum is defined as a ratio of the area watered to the cultivated area. Presently, the watering intensity is around 100% per annum. The harvest intensity is defined as a ratio of the crop harvest area to the cropped area per annum, which is about 100%. The watering and harvest intensities have improved in the last 50 years even with the addition of the command area in all the four systems.

The yields are dependent on occurrence and distribution of runoff water. Higher yields are obtained in wetter years. A wet year is defined considering amount of pre-season and in-season runoff storms and not the rainfall. The high intensity rainfall storms produce higher runoff.

### 2.2.3. Integrated Land Use

Without question, the catchment area is used for grazing purposes. The farmers are earning more from livestock and off-farm income compared to crops. Only green wheat is harvested or grazed by animals as a source of green fodder. The mix of sorghum and pulses is basically for grain and not solely for fodder. Fodder of sorghum stalk is too dry and not easily eaten by ruminants. At present, hay of pulses is not used as fodder. In certain cases if animals also do not eat the dry stalk of pulses which has been damaged by rain. Storage of straw from cereals and pulses is not practiced.

## 2.3. Land Tenure

### 2.3.1. Local Institutions and Units

The local institutions prevailing in the area and land units used by the farmers are summarized below:

- *Hashar* is a term referred to joint or community actions. This tradition is institutionalized and any farmer can request to his colleagues in the area to join hands to help him in

operations like ploughing, bunding, digging of well, etc. The farmer has to provide a light lunch and a grand dinner at the end of the day as a token of appreciation.

- *Jirga* is an institution that makes decisions whenever there is any conflict between two farmers or a group of farmers. *Jirga* is composed of three to four *Maliks* and led by a *Sardar*. The two parties having any conflict between them assign powers to the *Jirga* and explain their position on the matter under discussion. The *Jirga* then commissions its proceedings and find appropriate and just solution, which has to be accepted by the two parties. This system is much more just and efficient in decision making compared to the civil courts where poor party could not have any access to justice due to inability to hire a lawyer.
- *Mauza* organization is still prevailing in the area and its meetings held once in a month or whenever necessary. The farmers discuss their agricultural and social problems and try to resolve their problems through mutual dialogues.
- *Jora* is a piece of land cultivated by a pair of bullocks and farmer completes four ploughings within a period of two months (e.g., 20th July to 20th September) and interval between each ploughing is 10 days. This is a normal practice for seedbed preparation for planting of wheat. Farmers use 60 *topas* (360 kg) of seed to plant wheat using bullocks drawn one-row drill and area seeded is also referred as *Jora*. Assuming, a seed rate of 100 kg/ha, the area seeded per *Jora* is around 3.6 hectares.

### 2.3.2. Inheritance System and Fragmentation

According to Islamic rules and Pakistan's law of inheritance, the rights of ownership of male and female have been accepted. However, in the command area and the districts, traditions are strictly followed than the prevailing rules of inheritance. The tradition is that owner can give his land to any member of his family or outsider within his life. But after the death, the land, animals and cash are equally distributed among the sons of the deceased. No share is given to daughters, wife or wives. Thus female members are completely deprived from inheritance. In case the owner has no son, then the brother of the deceased would become owner of the land and widow is also his responsibility.

The distribution of land and animals is based on equal shares which are equal not in quantity but also quality. Therefore, mutual agreements are more important and normally elder son reserves the right to select the share of his choice.

The bride's family is responsible to give dowry to bride at the time of marriage which value to about Rs. 4000 to 5000. Furthermore, women have rights to own poultry flocs and keep the income from sale of chicken and eggs. The ownership right is given to women because men can't raise poultry. The ropes and mats made by women are sold in the local market and income is used to purchase tea and sugar for household consumption. The women are deprived from inheritance and forced to be completely dependent on men.

The inheritance system adds towards fragmentation of land. However, in the district, sufficient lands are available, and if flood water or groundwater is made available, the farmers are trying to develop more lands to overcome problem of fragmentation.

The distribution of landholding in the four selected spate irrigation systems indicated that only 18% farmers have land less than or equal to 1.0 hectare. About 37% farmers have land of less than 2 hectares. Thus about 63% farmers own landholdings of over 2 hectares. About 13% farmers have landholdings of more than 6 hectares. The average land holding is around 3.4 hectares (Table 8). The majority of farmers own landholdings of over 2 ha.

There are around 320 bunded units covering a command area of about 205 hectares in the four selected systems. The number of bunded units per household is a function of landholding. More bunded units are with larger farmers. However, average size of bunded unit is normally small with larger farmers compared to small farmers (Table 9) with an objective to have uniform application of water. The small farmers try to keep the number of bunded units as few as possible to have higher chances of watering because at least one field is allowed to water for equity especially for small farmers in the medium- to large-scale systems.

Out of 60 households, about 20 households (33.4%) own only one bunded unit which constitute about 13% of the command area. About 40% households own 2-5 bunded units. Only 8.3% farmers own more than 20 bunded units but constitute about 24% of the command area (Table 10). Therefore, the handling of water is much flexible with large farmers compared to small farmers.

### 2.3.3. Rules

The rules of land tenure are well established. People and the Land Revenue department recognize individual and communal tenures. The tenures found in the area are:

- Individual tenure of *Sailaba* command area is well established where ownership and proprietary rights are recognized and any owner can get his land registered with the

land revenue department.

- The individual ownership right of mini-catchments adjacent to the command area is well established by the community but proprietary rights are not yet established by the revenue department. The landowner has the right to use runoff coming from mini-catchments called *Abraize*. However owner can't register the *Abraize* with the Land Revenue department.
- The communal tenure of rangelands and mountains is well established and these lands can be used for open grazing by the local community. The farmers can't establish their individual ownership to these tenures.

The tenancy rules are clearly defined with respect to the landlord and tenant shares. Most of the farmers (about 90%) are involved in self cultivation and only 10% farmers have either leased all or part of their land to tenants or working as tenant cum owner. The types of tenancy rules recognized and practiced in the area are:

- Pair of bullocks and seed is provided by the landholder to the tenant, whereas tenant is responsible for all labor-oriented activities. The tenant takes 1/3rd of the share of total marketable produce.
- Tenant is responsible for bullocks or tillage using tractor and labor related operations, whereas owner provides only seed. In this case, tenant takes 50% share of the gross marketable produce.
- Landholder provides seed and tractor, whereas tenant is involved only in labor related operations. The tenant takes 1/4th share of the gross marketable produce.
- Landholder provides well-water, seed and a pair of bullocks, whereas all labor related operations are performed by tenant. One-fourth share of the gross marketable produce is given to the tenant.
- The landholder is responsible for well water, seed, fertilizer, and tractor, whereas tenant is involved in labor related operations. In this rule, only 1/6th share of the gross marketable produce is provided to the tenant (MAP OF RESOURCE SHARING AND REFERNCE TO THE GAZETTER!).

Farmers of the area commonly follow the second and third rules of tenancy. The owner and tenant are both involved in measuring and accounting of marketable produce and therefore no disputes occur on division of produce. The general rules and terms related to land tenure are:

- *Iqrar Nama* refers to transfer of land on mutual basis without charging any amount.
- *Girvi* refers to pledge the land by an owner to anybody against a credit for a

specified duration. After payment of credit, the land is given back to the owner. Hindus businessmen normally provide this service of Girvi.

- *Shufa* refers to the right given to the adjacent farmer on the downstream end to purchase the upstream or adjacent land, if owner plans to sell it. This can be regarded as neighbor's right. This helps to avoid complications due to purchase of land by outsiders but can also create problems in disposal of land by owner because neighbor takes case to the court.
- *Hiba* refers to transfer of land on mutual purposes for long-term basis like maximum of 15 years. The owner can take his land back and it is practiced without any charge or payment.
- *Olgi* is a term refers to service provided by blacksmith to farmers of the area for maintenance of agricultural tools and bullock-drawn implements. From the *Rabi* season production, about 2.5% of the grain are provided to blacksmith. Similar rule is followed during the *Kharif* season. In addition 2.5 kg of grain per hectare is also provided to the blacksmith to account for landholding.

### 2.3.4. Surveillance

The rural communities of the tribal system are still maintaining their traditions and respect rights of each other. The society is well integrated and watches each other's rights. They monitor lands, crops and avoid animals from entering crop fields. They also take care implementation of grazing and tenancy rules strictly.

### 2.3.5. Conflicts and Conflict Resolutions

There is hardly any conflict encountered in small-scale systems compared to medium and large systems. Commonly found conflicts are:

- The breaches in waterway's earthen bunds are common. The prevailing rule is that the downstream farmer would provide the earth to the upstream farmer who encountered a breach. In case the downstream farmer refuses to provide the earth the conflict normally occurs.
- The upstream landholder sometime tries to expand the earthen bund and cover some of the land area of the downstream farmer, which results into a conflict.
- The entry of livestock into cultivated area of any landholder results into a conflict and the affected has a right to take animals into his custody and are returned with assurance of having a control on livestock in the future.

The resolution of conflicts is basically through mutual agreements. If such agreements are not possible a third person participate in conflict resolution. Even if it does not work, then the case is taken to the *Jirga* or ultimately to the Tehsildar office.

### 2.3.6. Adaptations

The farmers are quite versatile and they are trying their best for adaptation to the changes and impacts of such changes. The farmers are trying their best to form fields with the help of bullock for efficient and uniform application of irrigation. Their fields are bunded and to some extent formed.

Tractor is also used for tillage. The adjustments due to introduction of tractor were made in the tenancy rules and shares of landholder and tenants have been defined sharply. Furthermore, tenancy rules have been developed for fields and farms where landholder provides water from dugwells.

The *Abraize*, which provides localized runoff over and above the spate irrigation, is important for *Sailaba* agriculture. Although, it is part of the communal tenure, but community was able to define the ownership for individuals for *Abraize* which are adjacent to the *Sailaba* commanded lands individually owned with proprietary rights. Unfortunately, at this stage it is not possible to provide estimates of the proportion of *Abraize* and catchment area draining to the spate irrigation system in relation to the communal land. In practice, *Abraize* area is much less than the catchment area draining to the spate irrigation system. Water coming through *Abraize* is normally non-channalized and in isolation to the catchment.

## 2.4. Water Rights

### 2.4.1. Local Institutions

*Hashar* is an institution, which plays a vital role in construction, repair and maintenance of the spate irrigation system. The water users' join hands and collect money to maintain the system. At the end of the day, a grand dinner is organized in which everybody participate.

### 2.4.2. Inheritance System and Fragmentation

The water rights were defined centuries ago. These rights are linked with the land. If someone sells the land automatically the rights of water are also sold with the land. However, the landholder has a right to keep proportionate amount of water if he sells part of the land.

The land inheritance system further adds towards fragmentation of land. The water rights are also divided proportionately. The fragmentation of land might result into application of more than one-distribution rules of water. Because, the major share of water

prior to division will be kept same and it will be divided further based on water turn if rule of proportionate discharge is not applicable.

### 2.4.3. Rules

There is a major difference in the water rights of non-perennial and *Kalapani* spate irrigation systems in Pakistan. The water rights of perennial irrigation systems in Balochistan are sharply defined in fixed and even exchangeable proportions of the flow and allowed usage time, water rights in spate irrigation are reactive. They cope not only with the unknown proportions of the next flood, but also with the changes in the waterway morphology, due to scour, siltation and change of waterway course. Water distribution in spate irrigation system is based on allocation rules rather than alienable property (Steenbergen 1997). The rules concerning the *Sailaba* spate irrigation system are:

- Rules for construction of diversion structures and obligations to break them are well established and recognized by the water users of the command area. Regular diversion structures are normally built for small and isolated systems, as few farmers own command area and size of structure is small. For example, two and four farmers own command area of the Dudar and the Sohar Khor systems, respectively.
- The rights of some commands against others to be irrigated are well defined when water flows are small. The farmer at the head of the command has the first right to irrigate the fields until flow is available to the next farmer. This rule is commonly practiced in systems having a channel serving the command area. For example, in the large system of *Jhalwani* command, there is a limit to irrigate a certain number of bunds during storm duration to provide equity to small farmers. Farmers having one bund can irrigate the bund during first storm of the season. Large farmers are allowed to irrigate maximum of 50% of the land area allocated for *Rabi/Kharif* season (i.e. 25% of the command area in a season). These limits vary based on water availability and the size of the command.
- The sequence in which lands are irrigated and the flow proportions to go in different channels are well established in all size systems. The flow is divided in relation to the command area served by each channel. This is followed in all the four selected systems. In small system of *Dudar* command each farmer is owner of a separate channel and thus sequence in which fields are to be irrigated is not required. The sequence is followed when there are more than one farmer on a water channel.
- The normative rules on water usage, like the entitlement to a second turn and

utilization of water within allocated turn are based on type of system and water availability.

- There is no limit on irrigated land within allocated water turn or proportionate flow for small scale isolated systems. However, limits are enforced for larger systems for the first storm of the season to ensure equity especially for small farmers.
- The mutual agreements do exist on disposal of high and unusual floods within or outside the command area.

Unpredictability is inherent to the large-scale spate irrigation systems. The water distribution rules regulate allocation of the unpredictable water supplies. They impose a pattern and reduce uncertainty by at least regulating the relations between the landholders that have access to spate irrigation water. There are several types of rules and it is usual to find that two or three are applied simultaneously. The water distribution rules are summarized as follows:

- The demarcation of command area entitled to irrigation is well established for all systems.
- The proportion of flow allocated to different channels is based on the size of the command area.
- The sequence is well defined for larger systems in which different fields along a channel are watered. The sequence always starts from the head with the beginning of a season.
- The second water turn in larger systems is practiced once all authorized fields of the command area are watered. Water for second irrigation in a season is available in a sequence starting from head to tail and based on limits on maximum number of bunds to be irrigated per turn if any.
- The individually owned waterways provide water to the command area of an individual for isolated systems, e.g. *Dudar* system.

The distribution rules practiced in small-scale systems depend on proportionate flow available to a water user based on his command area. However, for systems where there are more than one water user per water channel a sequence and water allocations are defined in which different fields along a channel are watered.

The division of flow proportionate to the command area is the most critical activity, which requires precision in measurement. The farmers use a stick to allocate proportionate flow to different channels and termed as *Lathi*. The purpose is to assign a channel width in relation to proportionate flow based on command area.

### 2.4.4. Surveillance

The water users monitor the spate irrigation system to have equity in water distribution and maintain the system after every flood season. The joint working is a key for surveillance.

### 2.4.5. Conflicts and Conflict Resolutions

The major conflicts occur on distribution of flow among the farmers and such conflicts are normally resolved on mutual basis. The conflicts commonly occur on water are:

- The most common conflict occurs due to inequity in diversion of proportionate flow to different channels based on command area. The hydraulic characteristics of a channel determine actual flow diverted to the channel. Sometime division of proportionate flow is not only dependent on the width of the channel but also dictated by the gradient of the channel. In such cases conflicts are more obvious. The scouring and erosion of the channel are other causes. The notables also dictate in maintaining inequity with an objective to get more water than proportionate allocation.
- The influential water users sometime divert more water by raising water level through putting stones in the channel.
- The right for borrow pits to repair breaches in channels are well defined. If a farmer refuses to provide earth from borrow-pits the breaches are difficult to repair especially when other farmers are not affected due to the breach. Such conflicts are common in larger systems like *Jhalwani*.
- Farmers are interested to allow silt deposition in their fields, which adds nutrients and increase productivity. Therefore, sometime farmers plough the channel bed to increase gradient of the channel. This also results in diversion of more water to a particular field and disturbs the channel's hydraulic regime. This may cause a breach and disturb equity in proportionate flow diverted to different channels and result into conflicts.

The apparent conflicts on water are normally resolved through mutual agreements. In case of continued conflict, both the parties agree to an arbitrator whose decision is final. In case of violation, the case sometime registered with local administration. In practice, the equity in water availability and distribution is a function of hydraulic regime of the system instead of defined rights. Farmers do not have the capacity to understand the variability caused by hydraulic characteristics of the system.

### 2.4.6. Adaptations

The farmers are performing reasonably in adaptations to changes and impacts due to

water rights and distribution rules. The most interesting situation normally occurs when the flow is too small for effective utilization by the farmers. In this case, they try to exchange water and try to effectively use the available water. Furthermore, they also try to adapt situations due to variability in runoff volume.

The farmers are suffering due to shortage of water and they need help to divert water more efficiently so that they can increase the annual cropping intensity which is around 100% at present.

### 2.5. Resource Management

#### 2.5.1. Predictability

The farmers have developed diversion and delivery system using bullock and tractor power. They try to maintain the delivery system prior to the flood season.

The farmers try to be in the command area during the rainy season. During the rainfall, farmers try to manage runoff water. As the systems are isolated, it is easy for farmers of small-scale systems to predict timings of runoff availability after the occurrence of the rainstorm. They have learnt the predictability of runoff and manage water effectively during day and night times. Efficiency of water application is low at nighttime, as it is difficult to convey and divert water effectively. For small-scale systems, the catchment area is small and thus flow is also small, therefore, farmers can manage the flow effectively. For large-scale systems, predictability of runoff is difficult. Furthermore, for these systems operation and maintenance requirements are high.

#### 2.5.2. Equity

The equity in proportionate water distribution to different channels is maintained at a point of diversion. It is easy in small- to medium-scale systems because of few farmers, compared to large-scale systems where flows are large and difficult to manage. There are more chances of inequity in larger systems.

It is not possible to measure availability of water in volumetric terms because of unpredictability of rainfall and large size of systems. The cropping pattern followed at head, middle and tail of large systems is a good example of inequity in actual water availability to different farmers. The cropping pattern of mixed sorghum, mungbeans-wheat is practiced by farmers who normally have more assured supply of water as the area under this cropping pattern and number of farmers reduced from head to tail (Table 11). The area under cropping pattern of mixed sorghum, mungbeans-wheat-fallow-fallow at the *Sham* command and fallow-wheat at the *Jhalwani* command increased from head to tail which is a good indication that less water is available at tail-end farmers compared to head farmers.

One-year fallow and one year cultivation is a practice normally followed by farmers to conserve moisture and nutrients.

Inequity might increase during low flow season because it becomes difficult to distribute water, as the flow depth is not sufficient. To achieve equity requires the design and construction of channels, which can perform better in both the flow regimes, small and high water flows. The high flows also create problems of channel erosion, which require more maintenance because breaches are common in high flows. In general, equity is reasonable in small-scale systems and it helps to manage natural resources, effectively.

The different cropping patterns with their associated cropping intensities in the head, middle and tail of the command area works in such a way that income from agriculture is equal among farmers. The different cropping patterns like 50% cultivated in each season, 100% cultivated in Rabi season and 50% cultivated in each season and one year fallow also helps to achieve more or less some cropping intensity for different farmers of head, middle and tail. This cropping pattern and notation system is an indirect measure to have equity, to some extent in crop income.

The fuelwood resources are also available to the farmers in an equitable manner. However, they have to bring additional fuelwood to supplement their requirement.

### 2.5.3. Efficiency

The existing cropping intensity of the command area is around 100%, which can be increased to a maximum of 200%, if sufficient water is made available. As water is in short supply, farmers are trying their best to use it efficiently. However, improvements in channel network and field outlets can help to further increase the conveyance efficiency. The efficient water utilization also helps to avoid erosion problems in the area.

### 2.5.4. Sustainability

The reasonable level of predictability, equity and efficiency indicates that there are not serious concerns related to sustainability of the existing level of productivity and production. Farmers have adopted a cropping intensity and crop rotations, which they can sustain on long-term basis within existing levels of management.

The silt-deposition in fields is desirable as farmers are not interested to have sedimentation in channels, therefore, they try that most of the silt is deposited in fields. The silt-deposition in fields also adds towards fertility as silt contains nutrients especially potassium. However, the hydraulic regime has to be adjusted to maintain efficiency of the conveyance system, especially deepening of channel.

The system after a long-term period has resulted into hydrological equilibrium, which

helped to manage resources, effectively. However, grazing in rangelands affected the natural vegetation to an extent where major rehabilitation of rangelands is required.

### 2.6. Productivity

#### 2.6.1. Crops

The weighted average yield of wheat crop in the study area is around 1773 kg per hectare which is 500 kg/ha below the figures reported for fully irrigated wheat in Musa Khel and Barkhan (GOB, 1996) but 600 kg/ha above the corresponding figures for rainfed systems. None of the farmers interviewed is using improved seed or chemical fertilizer because the shortage of capital and the risk of not having enough flood water. The weighted average (BY AREA) yield of grain sorghum and mungbeans/mashbeans is around 479 and 329 kg/ha, respectively. Sorghum yields are 300 kg/ha below the reported yields under rainfed conditions (GOP, 1996). The yields of moongbeans and mashbeans are slighly below the yields reported for rainfed conditions (GOB, 1996). The low performance of the *Kharif* crops is in part because they use some of the green mungbeans/mashbeans and sorghum as fodder. The mungbeans/mashbeans and sorghum are grown as mix crops; therefore average grain yield is 808 kg/ha.

#### 2.6.2. Livestock

The productivity of livestock is low, as farmers are not providing any concentrated feeds or green fodder to their animals. Thus, the weight of animals is low and they fetch low price in the market. The farmers fatten 6-7 lambs per annum to be slaughter and sold during religious holidays.

### 2.7. Household Livelihood and Profitability

#### 2.7.1. Household Livelihood

There is a wide variability in household livelihood earnings as the net household income varies between Rs. 7000 to Rs. 323,050 per annum. The distribution of net annual income per household indicated that 8.3% farmers have an annual income of less than Rs. 25,000. About 57% farmers have an annual net income between Rs. 25,000 to Rs. 75,000 per annum. About 10% farmers have an annual net income of over Rs. 150,000 which is a reasonable level of income for a household in the area (Table 12).

The sources of livelihood in the area are crops, livestock and off-farm income. The off-farm income is from labor, service and selling of rope, etc. The crops in the four selected systems contribute only 18.4% of the total net income. The major sources of livelihood are off-farm income and livestock, which contribute about 43.3 and 38.3%, respectively (Table 13).

The farmers who are dependent on crops only have the lowest annual income, Rs. 32,407. The farmers who are depend on crops plus livestock have an annual income of Rs. 63,052 and those who depend on crops and off-farm income have an annual income of Rs. 67,890. The highest income is earned by farmers who depend on crops, livestock and off-farm income, Rs. 112,959. Agricultural income is a function of the size of the system, command area, number of large and small ruminants[4]. The income of farmers in the very small (Syst1) and the small system (Syst2) was adjusted with dummy variables.

### 2.7.2. Crops

The net income from crops for the farmers in the four selected systems ranges between Rs. 2100 to Rs. 176,350 per annum with an average of Rs. 13,433. The profitability is low, as the average land holding is around 3.42 hectares. Roughly, the average net income per annum is around Rs. 3928 per hectare. Crop income is a function of the size of the system and the command area in 1997[5]. On the average, one ha of command area contributes Rs 9000 to the crop income and farmers who belong to the very small and small systems (Syst1 and Syst2, respectively) have significantly lower income than farmers in the larger systems. This is due to higher reliability of water in larger systems as even in the low-flow season considerable area can be irrigated as the stream size is larger compared to the smaller systems.

### 2.7.3. Livestock

The income from livestock per annum ranges between Rs. 3,250 to Rs. 138,850 for the farmers of the study area. The average annual income is around Rs. 27,950. Livestock income is a function of the number of small and large ruminants, the number of livestock units per household member and the command area[6]. The coefficients for small and large ruminants are not comparable to those figures estimated by Nagy el al. (1989, p. 19) because our figures average all the livestock of different sex, age, reproductive condition and health status. The negative sign in the number of livestock units per household member (LVSTKPER) is because the labor required for animal husbandry activities. The negative sign for the command area is because of the linear structure of the model. If the coefficients of CA97 from the livestock income model is subtracted from the same

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[4] Agric. Income (Rs/year) = 6369 – 24880 Syst1 – 22085 Syst2 + 7207.7 CA97 + 164.4 SR +1884.7LR; t values of the coefficients were 1.83, -2.26, -2.78, 9.76, 3.92, respectively; Adj. $R^2$=0.863 and n=60.

[5] Crop income (Rs/yr) = 4884.8 – 18251.6 Syst1 – 20299 Syst2 + 8932.3 CA97 (ha); t values of the coefficients were respectively 2.39, -2.48, -3.83, and 20.36; Adj. $R^2$=0.879, n=60.

[6] Livestock income (Rs/yr) = 4247.8 + 217.3 SR + 1855.6 LR – 897.7 LVSTKPER – 1855.6 CA97; t values for the coefficients were respectively 1.83, 5.86, 5.64, -2.18, and –3.48; Adj. $R^2$=0.792 and

coefficient of the crop income model the resulting value (7175) is very close the CA97 coefficient for the agriculture income model. Thus the model is adjusting the slope of the command area. It is hypothesized; however, that the income from animals could be higher if there was a stronger interaction with the crop component in the farming system.

## 3. IMPLICATIONS AND CHALLENGES

The implications and challenges related to land tenure and water rights are:

- the increase in population is a driving force to expand the command area which is resulting into thin distribution of water to various fields and ultimately low productivity;
- farmers are facing difficulty in efficient and equitable delivery of water from the diversion as sufficient traction and resources are not available;
- farmers started facing problems due to shortage of water and two farmers have already installed Persian wheels in dugwells but facing difficulty in the use of water;
- managing low and high flows during the cropping season is a major challenge, this appears to be much more critical in the Kharif season when well-below average yields are obtained;
- lack of sufficient quantity and quality of water for livestock;
- expansion of command area is not possible due to shortage of water;
- lack of enforcement of communal rules; and
- degradation of rangelands and thefts of livestock (AGAIN, THIS HAS NOT BEEN PROPERLY DOCUMENTED AND THERE IS NO EVIDENCE FROM THE SURVEY DATA FILE THAT THIS IS THE CASE).

## 4. LOCAL ADJUSTMENTS AND ADAPTATION STRATEGIES

### 4.1. Local Adjustments

The farmers are not getting any help from the public sector programs and this has a positive impact on the activities of farmers. The farmers have realized that they have to manage the spate irrigation system themselves. Therefore, they were actively involved in having local adjustments that are presented as under:

- remodeling of waterways to provide water to newly expanded command area;
- adjusting the flow distribution based on original water rights and the expansion in command area;

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n=60.

- exchange of water turn in case the flow depth is small or insufficient to divide proportionately into different channels;
- improving efficiency of water application through better land forming of bunded fields using bullocks;
- farmers are adjusting their cropping intensity and crops rotation to meet needs of the farming system, especially mix cropping of sorghum and mashbeans is fulfilling the dual purpose of dry fodder and grain;
- joint community actions in larger system to operate and maintain the system;
- mutual agreements for utilization of communal tenures and rights of local farmers in grazing of rangelands.

### 4.2. Adaptation Strategies

#### 4.2.1. Extensification

The farmers were involved in extensification of the command area within existing resources of spate irrigation. Now they have reached to a level where they can't have more than 100% cropping intensity. Therefore, for any further extension of the command area, more floodwater has to be diverted to increase either command area or cropping intensity. The trends in expansion of command area, production and productivity are presented in Table 15 to 18.

#### 4.2.2. Intensification

The farmers are also involved in intensification strategy by increasing productivity. They have also started, although on a very small scale, the use of improved seed and fertilizer. However, their fertilizer use is almost negligible. They only use farmyard manure. There is a scope for intensification through provision of more floodwater and better utilization of organic materials (animal waste and vegetative materials).

## 5. CONCLUSIONS

The size of spate irrigation systems is a function of ratio of catchment area to command area, layout of the water conveyance network and runoff flows. The runoff flow is a function of rainfall storms and catchment characteristics. The property rights of the command area are well established, whereas the catchment is part of the communal tenure except that the community recognizes the rights of localized runoff from the adjacent micro-catchments to the farmers' fields.

The water allocation from main channel to branch channel is based on proportionate flow as a function of the command area. In smaller systems, where an

individual owns a branch channel, the farmer is allowed to use all the proportionate flow diverted to that channel. However, in larger systems, a sequence of water turn is normally defined for different farmers based on the command area having established water rights. In the beginning of the crop season, the water distribution always starts from the head, whereas within season it starts from the next to the last farmer who watered the fields.

Equity in water distribution is a function of several factors: a) location of the water diversion point, b) location of the farm (i.e. head, middle or tail), c) hydraulic regime of the channel, and d) limits imposed on maximum number of bunded units to be irrigated during the first storm. The unit flow and reliability is much higher and assured at the head compared to the tail and it affects the cropping intensity. For example, both *Rabi* and *Kharif* season crops are grown at the head and middle reaches, whereas in tail reaches either both wheat and mungbeans or only wheat are grown in one year but the next year is fallow. Thus, cropping intensity is dependent on location with respect to the source of water, farmer's preferences and integration of crops with livestock.

The expansion in command area is dependent on the adequacy and reliability of water in relation to the higher ratios of catchment to the command area. The expansion is more common in relatively small and newer systems. As there is no control on regulation of flow to different branch channels, farmers always try to expand the area to use all the available flows especially during the wet years. The intensification is a function of farmer's preferences, landholdings, family size, input availability, etc. The livestock numbers are a function of family size and landholding, larger families with without larger landholdings having larger number of ruminants.

The communities in these systems have been traditional in maintaining water rights but they could be willing to change if benefits are demonstrated or reasons for improvements are explained. Once the demonstrations are organized for regulation of flows farmers can certainly make improvements in water distribution rates. This was observed during the construction of the first diversion structure in the Jhalwani command area where the community provided all labor for stone collection, transportation, dressing and construction.

The fundamental difference of spate irrigation system from canal irrigation system is the highly variable flows during and after the storms. Therefore, the hydraulics of open channel flow has to be adjusted to cater the requirements of minimum and maximum flows with *our* objective to optimize the area watered during the dry and the wet years.

The operation and maintenance (O&M) of smaller systems is much easier than

larger systems as the integration between water users is easily possible. Furthermore, farmers can handle smaller flows easily and breaches are much less. The catchments of smaller systems are also better managed than in larger systems because of more cooperation among farmers for control of grazing and cutting trees for fuelwood.

The improvements in spate irrigation systems are possible through the improvement of the hydraulic regime of the channel, regulation of flows to branch channels and distribution rules to achieve equity. The social organization with improved O&M skills could rehabilitate spate irrigation systems and improvements in hydraulic regime of channel flows and regulation of flows could lead towards higher efficiency of water use.

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(CORRECTED TABLES ON 2/5/98)

Table 1. Details of four spate irrigation systems selected in Musa Khel and Barkhan districts of Balochistan province.

| System Name | Mauza | District | Number of Farmers | Command Area (ha) | System Size |
|---|---|---|---|---|---|
| Dudar | Sirati | Musa Khel | 2 | 7.29 | Very Small |
| Sohar Khor | Sirati | Musa Khel | 4 | 13.86 | Small |
| Sham | Rara Sham | Musa Khel | 16 | 34.32 | Medium |
| Jhalwani | Jhalwani | Barkhan | 38 | 149.49 | Large |
| **Total:** | | | **60** | **204.96** | |

**Table 2. Households and population of four selected spate irrigation systems at Musa Khel and Barkhan districts of Balochistan.**

| District | *Mauza* | System Name | Settlements | Number of Households | Population | | |
|---|---|---|---|---|---|---|---|
| | | | | | Male | Female | Total |
| Musa Khel | Sirati | Dudar | Dudar | 2 | 14 | 13 | 27 |
| Musa Khel | Sirati | Sohar Khor | Sohar Khor | 4 | 21 | 22 | 43 |
| Musa Khel | Sham | Walwala Wah | Khor Chu | 4 | 15 | 16 | 31 |
| | | Pelewala Wah | Khor | 12 | 51 | 53 | 104 |
| Barkhan | Jhalwani | Gara Baccha and Khanki | Jhalwani Qadeem | 24 | 148 | 136 | 284 |
| | | | Jhalwani Jadeed | 8 | 26 | 25 | 51 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Dada Jhalwani | 3 | 26 | 27 | 53 |
| | | | Basti Mohabat Jhalwani | 1 | 1 | 3 | 4 |
| | | | Basti H.A.K Jhalwani | 1 | 4 | 8 | 12 |
| | | | Basti Gulshar Silach | 1 | 17 | 15 | 32 |
| **Total:** | | | | **60** | **323** | **318** | **641** |

**Table 3. Distribution of family size in four-selected spate irrigation systems at Musa Khel and Barkhan districts of Balochistan.**

| Family Size (number) | Number of Families | Percent Families |
|---|---|---|
| . 5 | 12 | 20.0 |
| 6-10 | 24 | 40.0 |
| 11-15 | 14 | 23.3 |
| 16-20 | 6 | 10.0 |
| > 20 | 4 | 6.7 |
| **Total:** | **60** | **100.0** |

**Table 4. Number of households, command area and livestock population at four-selected spate irrigation systems settlements in Musa Khel and Barkhan districts of Balochistan.**

| System Name | Number of Households | Command Area (ha) | Livestock | | |
|---|---|---|---|---|---|
| | | | Small Ruminants | Large Ruminants | Total |
| Dudar | 2 | 7.29 | 150 | 20 | 170 |
| Sohar Khor | 4 | 13.86 | 250 | 35 | 285 |
| Sham | 16 | 34.32 | 464 | 33 | 497 |
| Jhalwani | 38 | 149.49 | 1644 | 215 | 1859 |
| **Total** | **60** | **204.96** | **2508** | **303** | **2811** |
| **Average** | | **3.42** | **41.8** | **5.1** | **46.9** |

**Table 5. Livestock population per household as affected by family size at four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Family Size | Number of Families | Number of Livestock | Livestock Per Family |
|---|---|---|---|
| . 5 | 12 | 108 | 9.0 |
| 6-10 | 24 | 746 | 31.1 |
| 11-15 | 14 | 422 | 30.1 |
| 16-20 | 6 | 794 | 132.3 |
| > 20 | 4 | 741 | 185.3 |
| **Total:** | **60** | **2811** | |

**Table 6. Livestock population per household as affected by land holding at four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Landholding Per Household (ha) | Number of Households | Livestock | Livestock Per Family |
|---|---|---|---|
| . 1.0 | 11 | 180 | 16.4 |
| 1.01-2.0 | 11 | 352 | 32.0 |
| 2.01-4.0 | 25 | 827 | 33.1 |
| 4.01-6.0 | 5 | 854 | 170.8 |
| 6.01-8.0 | 5 | 156 | 31.2 |
| > 8.0 | 3 | 442 | 147.3 |
| **Total:** | **60** | **2811** | |

**Table 7. Number of farmers, command area, cropping pattern and farmers practicing a cropping pattern at four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Location | Number of Farmers | Command Area (ha) | Cropping Pattern | Number of Farmers Practicing the Cropping Pattern |
|---|---|---|---|---|
| Head | 20 | 96.10 | M-W | 18 |
| | | | F-W | 2 |
| Middle | 22 | 57.62 | M-W | 13 |
| | | | M-W-F-F | 2 |
| | | | F-W | 7 |
| Tail | 18 | 51.24 | M-W | 8 |
| | | | M-W-F-F | 5 |
| | | | F-W | 5 |
| **Total** | **60** | **204.96** | | |

**Table 8. Distribution of landholding in four selected spate irrigation systems at Musa Khel and Barkhan districts of Balochistan.**

| Landholding Per Household | Number of Households | Command Area (ha) | Percent Households | Percent Command Area |
|---|---|---|---|---|
| . 1.0 | 11 | 9.04 | 18.3 | 4.4 |
| 1.0-2.0 | 11 | 17.13 | 18.3 | 8.4 |
| 2.01-4.0 | 25 | 76.47 | 41.8 | 37.3 |
| 4.01-6.0 | 5 | 26.57 | 8.3 | 13.0 |
| 6.01-8.0 | 5 | 35.67 | 8.3 | 17.4 |
| > 8.0 | 3 | 40.08 | 5.0 | 19.5 |
| **Total:** | **60** | **204.96** | **100.0** | **100.0** |

**Table 9. Distribution of bunded units in four selected spate irrigation systems at Musa Khel and Barkhan districts of Balochistan.**

| Landholding Per Household (ha) | Number of Households | Command Area (ha) | Number of Bunded Units | Average Number of Bunded Units Per Household | Average Size of Bunded Unit (ha) |
|---|---|---|---|---|---|
| . 1.0 | 11 | 9.04 | 11 | 1.0 | 0.8 |
| 1.01-2.0 | 11 | 17.13 | 21 | 1.9 | 0.8 |
| 2.01-4.0 | 25 | 76.47 | 139 | 5.6 | 0.5 |
| 4.01-6.0 | 5 | 26.57 | 43 | 8.6 | 0.6 |
| 6.01-8.0 | 5 | 35.67 | 32 | 6.4 | 1.1 |
| > 8 | 3 | 40.08 | 74 | 24.7 | 0.5 |
| **Total** | **60** | **204.96** | **320** | | |
| **Average** | | **3.42** | | **5.3** | **0.6** |

**Table 10. Distribution of bunded units in four selected spate irrigation systems at Musa Khel and Barkhan districts of Balochistan.**

| Number of Bunded Units | Number of Households | Command Area (ha) | Percent Households | Percent Command Area |
|---|---|---|---|---|
| 1 | 20 | 25.91 | 33.4 | 12.6 |
| 2-3 | 16 | 45.97 | 26.7 | 22.4 |
| 4-5 | 8 | 32.57 | 13.3 | 15.9 |
| 6-9 | 8 | 41.10 | 13.3 | 20.1 |
| 10-20 | 3 | 10.20 | 5.0 | 5.0 |
| > 20 | 5 | 49.21 | 8.3 | 24.0 |
| **Total:** | **60** | **204.96** | **100.0** | **100.0** |

**Table 11. Cropping pattern followed at head, middle and tail commands of *Sham* and *Jhalwani* systems in *Musa Khel* and Barkhan districts of Balochistan.**

| System | Location of Command | Cropping Pattern | Area (ha) | Number of Farmers | Percent Area | Percent Farmers |
|---|---|---|---|---|---|---|
| *Sham* | Head | M-W | 14.79 | 4 | 43.0 | 25.0 |
| | | M-W-F-F | 0.0 | 0 | 0.0 | 0.0 |
| | Middle | M-W | 10.23 | 4 | 30.0 | 25.0 |
| | | M-W-F-F | 0.81 | 1 | 2.0 | 6.0 |
| | Tail | M-W | 4.04 | 2 | 12.0 | 13.0 |
| | | M-W-F-F | 4.45 | 5 | 13.0 | 31.0 |
| *Jhalwani* | Head | M-W | 69.76 | 12 | 47.0 | 32.0 |
| | | F-W | 3.17 | 2 | 2.0 | 5.0 |
| | Middle | M-W | 29.63 | 7 | 20.0 | 18.0 |
| | | *M-W-F-F* | 1.82 | 1 | 1.0 | 3.0 |
| | | F-W | 7.83 | 7 | 5.0 | 18.0 |
| | Tail | M-W | 25.54 | 4 | 17.0 | 11.0 |
| | | F-W | 11.74 | 5 | 8.0 | 13.0 |

**Table 12. Distribution of net annual income per household at four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Net Annual Income Per Household (Rs.) | Number of Households | Percent Household |
|---|---|---|
| < 25,000 | 5 | 8.3 |
| 25,000-50,000 | 22 | 36.7 |
| 50,001-75,000 | 12 | 20.0 |
| 75,001-100,000 | 6 | 10.0 |
| 100,001-150,000 | 9 | 15.0 |
| 150,001-200,000 | 2 | 3.3 |
| > 200,000 | 4 | 6.7 |
| **Total:** | **60** | **100.0** |

**Table 13. Percentage of livelihood of households from various sources at four-selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Sources of Livelihood | Net Income (million Rs.) | Percent of Livelihood |
|---|---|---|
| Crops | 0.806 | 18.4 |
| Livestock | 1.677 | 38.3 |
| Off-farm Sources | 1.892 | 43.3 |
| **Total:** | **4.375** | **100.0** |

**Table 14. Distribution of household net income per annum from various sources at four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Income Sources | Number of Farmers | Percent Farmers | Net Income per Annum (Rs.) | | |
|---|---|---|---|---|---|
| | | | Minimum | Maximum | Average |
| Crops only | 6 | 10.0 | 7,000 | 66,500 | 32,407 |
| Crops + livestock | 7 | 11.7 | 25,500 | 215,100 | 63,052 |
| Crops + off-farm sources | 27 | 45.0 | 21,200 | 208,800 | 67,890 |
| Crops + livestock + off-farm sources | 20 | 33.3 | 18,300 | 323,050 | 112,959 |
| **Total:** | **60** | **100.0** | | | |
| **Average:** | | | | | **72,917** |

**Table 15. Historical trends in command area, productivity and production in the *Dudar* command area, district *Musa Khel*.**

| Parameters | Period | | |
|---|---|---|---|
| | **1947** | **1975** | **1997** |
| Command area (ha) | 0.0 | 2.55 | 7.29 |
| *Sailaba* watered area (ha) | 0.0 | 2.55 | 7.29 |
| Eroded land (ha) | 7.29 | 4.74 | 0 |
| Minor system breaches (No.) | 20 | 15 | 3 |
| Annual Cropping Intensity (%) | 0.0 | 100 | 100 |
| Annual Watering Intensity (%) | 0.0 | 100 | 100 |
| Annual Harvesting Intensity (%) | 0.0 | 100 | 100 |
| Small Ruminants (No.) | 0.0 | 31 | 150 |
| Large Ruminants (No.) | 0.0 | 5 | 20 |
| Price of Small Ruminants (Rs.) | - | - | 650 |
| For weight of (kg) | - | - | - |
| Net income from crops (Rs.) | - | - | 19192 |
| Net income from animals (Rs.) | - | - | 19750 |
| Annual net income (Rs.) (Crops + Livestock) | - | - | 38942 |

**Table 16. Historical trends in command area, productivity and production in the *Sohar Khor* command area, district *Musa Khel*.**

| Parameters | Period | | |
|---|---|---|---|
| | **1947** | **1975** | **1997** |
| Command area (ha) | 3.64 | 7.28 | 13.86 |
| *Sailaba* watered area (ha) | 3.64 | 7.28 | 13.86 |
| Eroded land (ha) | 10.2 | 6.58 | 0 |
| Minor system breaches (No.) | 20 | 15 | 3 |
| Annual Cropping Intensity (%) | 70 | 75 | 100 |
| Annual Watering Intensity (%) | 70 | 75 | 100 |
| Annual Harvesting Intensity (%) | 100 | 100 | 100 |
| Small Ruminants (No.) | 80 | 300 | 250 |
| Large Ruminants (No.) | 25 | 14 | 35 |
| Price of Small Ruminants (Rs.) | 5 | 50 | 650 |
| For weight of (kg) | 7 | 5.5 | 5 |
| Net income from crops (Rs.) | - | 12000 | 15536 |
| Net income from animals (Rs.) | - | 5000 | 20491 |
| Annual net income (Rs.) (Crops + Livestock) | - | 17000 | 36027 |

**Table 17. Historical trends in command area, productivity and production in the *Sham* command area, district Barkhan.**

| Parameters | Period | | |
|---|---|---|---|
| | **1947** | **1965** | **1997** |
| Command Area (ha) | 24.3 | 28.7 | 34.32 |
| Eroded Land (ha) | 10.7 | 6.3 | 0.7 |
| Minor Breaches | 15 | 10 | 4 |
| Annual Cropping Intensity (%) | 70 | 83 | 100 |
| Annual Watering Intensity (%) | 70 | 83 | 100 |
| Annual Harvest Intensity (%) | 100 | 100 | 100 |
| Nos. of Small Ruminants | 2120 | 1735 | 464 |
| Nos. of Large Ruminants | 183 | 123 | 33 |
| Price Per Head of Small Ruminant (Rs.) | 5 | 50 | 800 |
| Price Per Head of Large Animal (Rs.) | 50 | 500 | 8000 |
| Weight of Small Animal (kg) | 11 | 10 | 9 |
| Weight of Large Animal (kg) | - | - | - |
| Annual Income from Crops (Rs.) | 313 | 7800 | 21,294 |
| Annual Income from Crops + Livestock | 63 | 1560 | 7000 |
| Annual Off-farm Income | - | - | 28,294 |

**Table 18. Historical trends in command area, productivity and production in the *Jhalwani* command area, district Barkhan.**

| Parameters | Period | | |
|---|---|---|---|
| | **1947** | **1965** | **1997** |
| Command Area (ha) | 120 | 138.5 | 149.49 |
| Eroded Land (ha) | 29.15 | 10.93 | 0.36 |
| Minor Breaches | 80 | 40 | 15 |
| Annual Cropping Intensity (%) | 80 | 90 | 100 |
| Annual Watering Intensity (%) | 80 | 90 | 100 |
| Annual Harvest Intensity (%) | 90 | 92 | 100 |
| Nos. of Small Ruminants | 1096 | 1370 | 1644 |
| Nos. of Large Ruminants | 1075 | 645 | 215 |
| Price Per Head of Small Ruminant (Rs.) | 5 | 60 | 650 |
| Price Per Head of Large Animal (Rs.) | 40 | 600 | 8000 |
| Weight of Small Animal (kg) | 9 | 8 | 7 |
| Weight of Large Animal (kg) | 180 | 160 | 140 |
| Annual Income from Crops (Rs.) | 436 | 1,105 | 37,618 |
| Annual Income from Crops + Livestock | 452 | 1,421 | 49,860 |
| Annual Off-farm Income | 0 | 395 | 38,981 |

**Annexure I. Measuring units used in the area.**

| | | |
|---|---|---|
| 1 *Jora* | = | 9 acres |
| 1 *Goalagh* | = | 40 *Topa* |
| 1 *Topa* | = | 6 kg |
| 1 *Topa* | = | 4 *Propy* |
| 1 *Propy* | = | 1.5 kg |
| 1 *Goalagh* | = | 6 *Maunds* |
| 1 *Maunds* | = | 40 kg |

**Annex. II. Family size, land holding and livestock at four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Sr. No. | Farmers' Name | Family Size | | | Land holding (ha) | Livestock | | |
|---|---|---|---|---|---|---|---|---|
| | | Male | Female | Total | | Small | Large | Total |
| **I. Dudar Small Scale System, *Mauza* Sirati** | | | | | | | | |
| 1. | Abdullah | 4 | 3 | 7 | 1.82 | 30 | 8 | 38 |
| 2. | Haider | 9 | 11 | 20 | 5.47 | 120 | 12 | 132 |
| **II. Sohar Khor Small Scale System, *Mauza* Sirati** | | | | | | | | |
| 1. | Jan Mohammad | 6 | 8 | 14 | 2.91 | 80 | 12 | 92 |
| 2. | Mohammad Din | 6 | 1 | 7 | 3.65 | 60 | 3 | 63 |
| 3. | Imam Din | 5 | 7 | 12 | 3.65 | 10 | 6 | 16 |
| 4. | Noor Mohammad | 4 | 6 | 10 | 3.65 | 100 | 14 | 114 |
| **III. *Rara Sham* Medium Scale System, *Mauza Rara Sham*** | | | | | | | | |
| **Head** | | | | | | | | |
| 1. | Bangal | 4 | 4 | 8 | 2.43 | 100 | 0 | 100 |
| 2. | Abdur Rehman Shah | 4 | 5 | 9 | 2.94 | 0 | 0 | 0 |
| 3. | Mohsin Shah | 3 | 2 | 5 | 2.94 | 0 | 0 | 0 |
| 4. | Ahmad Shah #2 | 5 | 3 | 8 | 6.48 | 40 | 0 | 40 |
| **Middle** | | | | | | | | |
| 5. | Sahib Shah | 3 | 3 | 6 | 0.81 | 0 | 0 | 0 |
| 6. | Gul Shah | 5 | 3 | 8 | 2.94 | 60 | 2 | 62 |
| 7. | Ishaq Shah | 8 | 8 | 16 | 2.23 | 150 | 16 | 166 |
| 8. | Yousaf Shah | 5 | 6 | 11 | 2.23 | 0 | 3 | 3 |
| 9. | Noor Mohd. Shah | 6 | 6 | 12 | 2.83 | 0 | 0 | 0 |
| **Tail** | | | | | | | | |
| 10. | Yakoob Shah | 5 | 4 | 9 | 2.02 | 60 | 4 | 64 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11. | Mehran Shah | 3 | 5 | 8 | 0.81 | 0 | 0 | 0 |
| 12. | Azeem Shah | 4 | 4 | 8 | 0.81 | 0 | 0 | 0 |
| 13. | Ismaeel Shah | 1 | 2 | 3 | 0.81 | 0 | 0 | 0 |
| 14. | Ahmad Shah #1 | 3 | 2 | 5 | 0.81 | 0 | 5 | 5 |
| 15. | Ehsan Shah | 5 | 4 | 9 | 2.02 | 4 | 0 | 4 |
| 16. | Iqbal Shah | 2 | 8 | 10 | 1.21 | 50 | 3 | 53 |

**Continued Annex. II.**

| Sr. No. | Farmers' Name | Family Size | | | Land holding (ha) | Livestock | | |
|---|---|---|---|---|---|---|---|---|
| | | Male | Female | Total | | Small | Large | Total |
| **IV. Jhalwani Large Scale System, *Mauza* Jhalwani** | | | | | | | | |
| **Head** | | | | | | | | |
| 1. | Gullshar | 17 | 15 | 32 | 18.2 | 200 | 15 | 215 |
| 2. | Khair Mohammad #1 | 4 | 5 | 9 | 3.6 | 0 | 0 | 0 |
| 3. | Nabi Jan | 4 | 3 | 7 | 3.6 | 0 | 2 | 2 |
| 4. | Shah Baig | 6 | 4 | 10 | 2.7 | 16 | 5 | 21 |
| 5. | Ali Baig | 3 | 1 | 4 | 1.82 | 0 | 0 | 0 |
| 6. | Rehman | 7 | 3 | 10 | 3.60 | 2 | 0 | 2 |
| 7. | Master Shair Mohd. | 3 | 2 | 5 | 1.35 | 15 | 2 | 17 |
| 8. | Malik Sardar | 8 | 10 | 18 | 10.94 | 35 | 12 | 47 |
| 9. | Daraie | 7 | 8 | 15 | 1.82 | 150 | 7 | 157 |
| 10. | Azad | 7 | 4 | 11 | 7.30 | 25 | 6 | 31 |
| 11. | Dost Mohd. | 6 | 7 | 13 | 7.30 | 10 | 5 | 15 |
| 12. | Mir Mohammad | 2 | 2 | 4 | 3.6 | 60 | 2 | 62 |
| 13. | Khair Mohammad #2 | 1 | 3 | 4 | 4.6 | 0 | 6 | 6 |
| 14. | Alam Khan | 11 | 6 | 17 | 2.50 | 20 | 2 | 22 |
| **Middle** | | | | | | | | |
| 15. | Sohrab | 3 | 9 | 12 | 3.60 | 0 | 1 | 1 |
| 16. | Jan Baig | 1 | 1 | 2 | 1.82 | 0 | 0 | 0 |
| 17. | Yar Khan | 3 | 5 | 8 | 0.91 | 0 | 0 | 0 |
| 18. | Saeed Gull | 1 | 0 | 1 | 0.73 | 0 | 0 | 0 |
| 19. | Lal Mohammad | 1 | 0 | 1 | 1.35 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 20. | Fateh Mohammad #1 | 7 | 4 | 11 | 1.20 | 4 | 8 | 12 |
| 21. | Piand Khan | 6 | 4 | 10 | 0.91 | 60 | 2 | 62 |
| 22. | Rehan | 13 | 12 | 25 | 5.50 | 300 | 36 | 336 |
| 23. | Din Mohammad | 4 | 1 | 5 | 1.82 | 18 | 1 | 19 |
| 24. | Faiz Mohammad | 7 | 6 | 13 | 3.60 | 4 | 4 | 8 |
| 25. | Haji Gull-a-Mohd. | 8 | 6 | 14 | 3.60 | 3 | 10 | 13 |
| 26. | Lal Jan | 6 | 6 | 12 | 7.30 | 40 | 20 | 60 |
| 27. | Kaka | 3 | 7 | 10 | 0.91 | 3 | 5 | 8 |

**Continued Annex. II.**

| Sr. No. | Farmers' Name | Family Size | | | Land holding (ha) | Livestock | | |
|---|---|---|---|---|---|---|---|---|
| | | Male | Female | Total | | Small | Large | Total |
| 28. | Noorou | 3 | 3 | 6 | 2.73 | 0 | 3 | 3 |
| 29. | Rahim Chacha | 4 | 3 | 7 | 3.30 | 0 | 4 | 4 |
| **Tail** | | | | | | | | |
| 30. | M. Yaqoob | 4 | 8 | 12 | 3.60 | 2 | 3 | 5 |
| 31. | Gull Mohammad | 13 | 16 | 29 | 10.94 | 170 | 10 | 180 |
| 32. | Hassni | 5 | 5 | 10 | 0.91 | 100 | 4 | 104 |
| 33. | Sadan Khan | 8 | 8 | 16 | 5.50 | 350 | 21 | 371 |
| 34. | Fateh Mohammad #2 | 1 | 4 | 5 | 0.62 | 0 | 1 | 1 |
| 35. | Raham Ali | 4 | 3 | 7 | 1.10 | 0 | 0 | 0 |
| 36. | Amir Khan | 13 | 5 | 18 | 1.82 | 50 | 6 | 56 |
| 37. | Haji Sharjan | 14 | 17 | 31 | 7.29 | 0 | 10 | 10 |
| 38. | Master Sharjan | 4 | 8 | 12 | 5.50 | 7 | 2 | 9 |
| **Total:** | | **322** | **319** | **641** | **204.96** | **2508** | **303** | **2811** |

**Annex. III. Landholding, cropped area, cropping pattern and land tenancy of four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Sr. No. | Farmers Name | Landholding (ha) | Cropped Area (ha) | | Cropping Pattern | Land Tenancy |
|---|---|---|---|---|---|---|
| | | | ***Kharif*** | ***Rabi*** | | |
| **I. Dudar Small Scale System, *Mauza* Sirati** | | | | | | |
| 1. | Abdullah | 1.82 | 1.82 | 1.82 | M-W-F-F | S |
| 2. | Haider | 5.47 | 2.735 | 2.735 | M-W | S |
| **II. Sohar Khor Small Scale, *Mauza* Sirati** | | | | | | |
| 1. | Jan Mohammad | 2.91 | 1.455 | 1.455 | M-W | S |
| 2. | Mohammad Din | 3.65 | 1.825 | 1.825 | M-W | S |
| 3. | Imam Din | 3.65 | 1.825 | 1.825 | M-W | S |
| 4. | Noor Mohammad | 3.65 | 1.825 | 1.825 | M-W | S |
| **III. Sham Medium Scale System, *Mauza* Rara Sham** | | | | | | |
| | **Head** | | | | | |
| 1. | Bangol | 2.43 | 1.215 | 1.215 | M-W | S |
| 2. | Abdur Rehman Shah | 2.94 | 1.40 | 1.54 | M-W | S |
| 3. | Mohsin Shah | 2.94 | 1.40 | 1.54 | M-W | S |
| 4. | Ahmad Shah #2 | 6.48 | 3.24 | 3.24 | M-W | S |
| | **Middle** | | | | | |
| 5. | Sahib Shah | 0.81 | 0.81 | 0.81 | M-W-F-F | S |
| 6. | Gul Shah | 2.94 | 1.40 | 1.54 | M-W | S |
| 7. | Ishaq Shah | 2.23 | 1.01 | 1.21 | M-W | S |
| 8. | Yousaf Shah | 2.23 | 1.01 | 1.21 | M-W | S |
| 9. | Noor Mohd. Shah | 2.83 | 1.415 | 1.415 | M-W | S |
| | **Tail** | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10. | Yakoob Shah | 2.02 | 1.01 | 1.01 | M-W | S |
| 11. | Mehran Shah | 0.81 | 0.81 | 0.81 | M-W-F-F | S |
| 12. | Azeem Shah | 0.81 | 0.81 | 0.81 | M-W-F-F | S |
| 13. | Ismaeel Shah | 0.81 | 0.81 | 0.81 | M-W-F-F | S |
| 14. | Ahmad Shah #1 | 0.81 | 0.81 | 0.81 | M-W-F-F | S |
| 15. | Ehsan Shah | 2.02 | 0.81 | 1.21 | **M-W** | S |
| 16. | Iqbal Shah | 1.21 | 1.21 | 1.21 | **M-W-F-F** | S |

**Continued Annex. III.**

| Sr. No. | Farmers Name | Landholding (ha) | Cropped Area (ha) | | Cropping Pattern | Land Tenancy |
|---|---|---|---|---|---|---|
| | | | ***Kharif*** | ***Rabi*** | | |
| **IV. Jhalwani Large Scale System, *Mauza* Jhalwani** | | | | | | |
| **Head** | | | | | | |
| 1. | Gullshar | 18.2 | 9.1 | 9.1 | M-W | S |
| 2. | Khair Mohammad #1 | 3.6 | 1.8 | 1.8 | M-W | S |
| 3. | Nabi Jan | 3.6 | 1.8 | 1.8 | M-W | S |
| 4. | Shah Baig | 2.7 | 0.9 | 1.8 | M-W | S |
| 5. | Ali Baig | 1.82 | 0.91 | 0.91 | M-W | S |
| 6. | Rehman | 3.60 | 1.80 | 1.8 | M-W | S |
| 7. | Master Shair Mohd | 1.35 | 0 | 1.35 | F-W | S |
| 8. | Malik Sardar | 10.94 | 5.47 | 5.47 | M-W | S+L |
| 9. | Daraie | 1.82 | 0 | 1.82 | F-W | S |
| 10. | Azad | 7.30 | 3.65 | 3.65 | M-W | S |
| 11. | Dost Mohammad | 7.30 | 3.65 | 3.65 | M-W | S |
| 12. | Mir Mohammad | 3.60 | 0.90 | 2.70 | M-W | S |
| 13. | Khair Mohammad #2 | 4.60 | 2.30 | 2.30 | M-W | S |
| 14. | Alam Khan | 2.50 | 1.25 | 1.25 | M-W | S |
| **Middle** | | | | | | |
| 15. | Sohrab | 3.60 | 1.8 | 1.80 | M-W | S |
| 16. | Jan Baig | 1.82 | 1.8 | 1.82 | M-W-F-F | S |
| 17. | Yar Khan | 0.91 | 0 | 0.91 | F-W | S |
| 18. | Saeed Gull | 0.73 | 0 | 0.73 | F-W | S |
| 19. | Lal Mohammad | 1.35 | 0 | 1.35 | F-W | S |
| 20. | Fateh Mohammad #1 | 1.20 | 0 | 1.20 | F-W | S+t |
| 21. | Piand Khan | 0.91 | 0 | 0.91 | F-W | S+t |

| | | | | | | |
|---|---|---|---|---|---|---|
| 22. | Rehan | 5.50 | 1.82 | 3.68 | M-W | S |
| 23. | Din Mohammad | 1.82 | 0 | 1.82 | F-W | S |
| 24. | Faiz Mohammad | 3.60 | 1.8 | 1.80 | M-W | S |

**Continued Annex. III.**

| Sr. No. | Farmers Name | Landholding (ha) | Cropped Area (ha) | | Cropping Pattern | Land Tenancy |
|---|---|---|---|---|---|---|
| | | | ***Kharif*** | ***Rabi*** | | |
| 25. | Haji Gull-a-Mohd | 3.60 | 1.8 | 1.80 | M-W | S |
| 26. | Lal Jan | 7.30 | 3.65 | 3.65 | M-W | S+t |
| 27. | Kaka | 0.91 | 0 | 0.91 | F-W | S+L |
| 28. | Noorou | 2.73 | 0.91 | 1.82 | M-W | S |
| 29. | Rahim Chacha | 3.30 | 1.65 | 1.65 | M-W | S |
| **Tail** | | | | | | |
| 30. | M. Yaqoob | 3.60 | 1.8 | 1.8 | **M-W** | S |
| 31. | Gull Mohammad | 10.94 | 5.47 | 5.47 | M-W | S |
| 32. | Hassni | 0.91 | 0 | 0.91 | F-W | S |
| 33. | Sadan Khan | 5.50 | 1.5 | 4.0 | M-W | S |
| 34. | Fateh Mohammad #2 | 0.62 | 0 | 0.62 | F-W | S |
| 35. | Raham Ali | 1.10 | 0 | 1.10 | F-W | S |
| 36. | Amir Khan | 1.82 | 0 | 1.82 | F-W | S |
| 37. | Haji Sharjan | 7.29 | 0 | 7.29 | F-W | L |
| 38. | Master Sharjan | 5.50 | 1.82 | 3.68 | M-W | S |
| **Total:** | | **204.96** | **88.205** | **121.995** | | |

* L - leased to a tenant
t - working as a tenant
S - self cultivation
M-W-F-F - mixed sorghum,mungbeans/mashbeans-wheat-fallow-fallow (one year cropping and one year fallow)

M-W - mixed sorghum,mungbeans/mashbeans-wheat (50% area under mixed and 50% under wheat)

F-W - fallow-wheat (Kharif fallow and 100% area under wheat)

**Annex. IV. Bunded units per household at four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Sr. No. | Farmers' Name | Bunded Units Per Household |
|---|---|---|
| **I. Dudar Small Scale System, *Mauza* Sirati** | | |
| 1. | Abdullah | 7 |
| 2. | Haider | 22 |
| **II. Sohar Khor Small Scale, *Mauza* Sirati** | | |
| 1. | Jan Mohammad | 19 |
| 2. | Mohammad Din | 21 |
| 3. | Imam Din | 13 |
| 4. | Noor Mohammad | 17 |
| **III. Sham Medium Scale System, *Mauza* Rara Sham** | | |
| **Head** | | |
| 1. | Bangol | 4 |
| 2. | Abdur Rehman Shah | 2 |
| 3. | Mohsin Shah | 2 |
| 4. | Ahmad Shah #2 | 8 |
| **Middle** | | |
| 5. | Sahib Shah | 1 |
| 6. | Gul Shah | 4 |
| 7. | Ishaq Shah | 3 |
| 8. | Yousaf Shah | 2 |
| 9. | Noor Mohd. Shah | 3 |
| **Tail** | | |
| 10. | Yakoob Shah | 2 |
| 11. | Mehran Shah | 1 |
| 12. | Azeem Shah | 1 |
| 13. | Ismaeel Shah | 1 |
| 14. | Ahmad Shah #1 | 1 |
| 15. | Ehsan Shah | 1 |
| 16. | Iqbal Shah | 1 |

**Continued Annex. IV.**

| Sr. No. | Farmers' Name | Bunded Units Per Household |
|---|---|---|
| **IV. Jhalwani Large Scale System, *Mauza* Jhalwani** | | |
| **Head** | | |
| 1. | Gullshar | 28 |
| 2. | Khair Mohammad #1 | 8 |
| 3. | Nabi Jan | 2 |
| 4. | Shah Baig | 2 |
| 5. | Ali Baig | 1 |
| 6. | Rehman | 1 |
| 7. | Master Shair Mohd | 1 |
| 8. | Malik Sardar | 24 |
| 9. | Daraie | 2 |
| 10. | Azad | 8 |
| 11. | Dost Mohammad | 9 |
| 12. | Mir Mohammad | 5 |
| 13. | Khair Mohammad #2 | 2 |
| 14. | Alam Khan | 1 |
| **Middle** | | |
| 15. | Sohrab | 8 |
| 16. | Jan Baig | 1 |
| 17. | Yar Khan | 1 |
| 18. | Saeed Gul | 1 |
| 19. | Lal Mohammad | 1 |
| 20. | Fateh Mohammad #1 | 1 |
| 21. | Piand Khan | 1 |
| 22. | Rehan | 8 |
| 23. | Din Mohammad | 2 |
| 24. | Faiz Mohammad | 4 |
| 25. | Haji Gull-a-Mohd | 5 |
| 26. | Lal Jan | 5 |

**Continued Annex. IV.**

| Sr. No. | Farmers Name | Bunded Units Per Household |
|---|---|---|
| 27. | Kaka | 1 |
| 28. | Noorou | 3 |
| 29. | Rahim Chacha | 3 |
| **Tail** | | |
| 30. | M. Yaqoob | 4 |
| 31. | Gull Mohammad | 22 |
| 32. | Hassni | 1 |
| 33. | Sadan Khan | 5 |
| 34. | Fateh Mohammad #2 | 1 |
| 35. | Raham Ali | 2 |
| 36. | Amir Khan | 2 |
| 37. | Haji Sharjan | 2 |
| 38. | Master Sharjan | 6 |
| **Total:** | | **320** |

**Annex. V. Historical trends of land tenure at four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Sr. No. | Farmers' Name | Command Area (ha) | | | Remarks |
|---|---|---|---|---|---|
| | | 1947 | 1965 | 1997 | |
| **I. Dudar Small Scale System, *Mauza* Sirati** | | | | | |
| 1. | Abdullah | - | - | 1.82 | Purchased land in 1975 |
| 2. | Haider | - | - | 5.47 | " |
| **II. Sohar Khor Small Scale, *Mauza* Sirati** | | | | | |
| 1. | Jan Mohammad | - | - | 2.91 | Purchased land in 1975 |
| 2. | Mohammad Din | - | - | 3.65 | " |
| 3. | Imam Din | - | - | 3.65 | " |
| 4. | Noor Mohammad | - | - | 3.65 | " |
| **III. Sham Medium Scale System, *Mauza* Rara Sham** | | | | | |
| **Head** | | | | | |
| 1. | Bangol | 2.43 | 2.43 | 2.43 | No land division |
| 2. | Abdur Rehman Shah | - | - | 2.94 | Land division |
| 3. | Mohsin Shah | - | - | 2.94 | " |
| 4. | Ahmad Shah #2 | - | - | 6.48 | " |
| **Middle** | | | | | |
| 5. | Sahib Shah | 0.81 | 0.81 | 0.81 | No land division |
| 6. | Gull Shah | - | - | 2.94 | Land division |
| 7. | Ishaq Shah | - | - | 2.23 | " |
| 8. | Yousaf Shah | - | - | 2.23 | " |
| 9. | Noor Mohd. Shah | - | - | 2.83 | " |
| **Tail** | | | | | |
| 10. | Yaqoob Shah | 2.02 | 2.02 | 2.02 | No land division |
| 11. | Mehran Shah | 0.81 | 0.81 | 0.81 | No land division |
| 12. | Azeem Shah | - | - | 0.81 | Land division |
| 13. | Ismaeel Shah | - | - | 0.81 | " |
| 14. | Ahmad Shah #1 | - | - | 0.81 | " |

| | | | | | |
|---|---|---|---|---|---|
| 15. | Ehsan Shah | - | - | 2.02 | " |
| 16. | Iqbal Shah | - | - | 1.21 | " |

**Continued Annex. V.**

| Sr. No. | Farmers' Name | Command Area (ha) | | | Remarks |
|---|---|---|---|---|---|
| | | 1947 | 1965 | 1997 | |
| **IV. Jhalwani Large Scale System, *Mauza* Jhalwani** | | | | | |
| **Head** | | | | | |
| 1. | Gullshar | 7.29 | 13.12 | 18.2 | Purchased land gradually |
| 2. | Khair Mohammad #1 | - | - | 3.6 | |
| 3. | Nabi Jan | - | - | 3.6 | |
| 4. | Shah Baig | - | - | 2.7 | |
| 5. | Ali Baig | - | - | 1.82 | |
| 6. | Rehman | - | - | 3.60 | |
| 7. | Master Shair Mohd | - | - | 1.35 | |
| 8. | Malik Sardar | 0.0 | 0.0 | 10.94 | Purchased after 1965 |
| 9. | Daraie | - | - | 1.82 | Purchased the land |
| 10. | Azad | 7.3 | 7.3 | 7.3 | No land fragmentation |
| 11. | Dost Mohammad | 7.3 | 7.3 | 7.3 | No land division |
| 12. | Mir Mohammad | - | - | 3.6 | |
| 13. | Khair Mohammad #2 | - | - | 4.6 | |
| 14. | Alam Khan | - | - | 2.5 | |
| **Middle** | | | | | |
| 15. | Sohrab | 0.0 | 7.3 | 3.6 | Purchased land after 1947 |
| 16. | Jan Baig | - | - | 1.82 | |
| 17. | Yar Khan | - | - | 0.91 | |
| 18. | Saeed Gul | 0.0 | 0.0 | 0.73 | Purchased land after 1965 |
| 19. | Lal Mohammad | - | - | 1.35 | |
| 20. | Fateh Mohammad #1 | - | - | 1.20 | |
| 21. | Piand Khan | - | - | 0.91 | |
| 22. | Rehan | - | - | 5.50 | |
| 23. | Din Mohammad | - | - | 1.82 | |

| | | | | | |
|---|---|---|---|---|---|
| 24. | Faiz Mohammad | 3.6 | 3.6 | 3.60 | No land fragmentation |
| 25. | Haji Gull-a-Mohd | - | - | 3.60 | |
| 26. | Lal Jan | - | - | 7.30 | |

**Continued Annex. V.**

| Sr. No. | Farmers Name | Command Area (ha) | | | Remarks |
|---|---|---|---|---|---|
| | | 1947 | 1965 | 1997 | |
| 27. | Kaka | - | - | 0.91 | |
| 28. | Noorou | - | - | 2.73 | |
| 29. | Rahim Chacha | - | - | 3.30 | |
| **Tail** | | | | | |
| 30. | M. Yaqoob | 3.6 | 3.6 | 3.6 | No land fragmentation |
| 31. | Gull Mohammad | 10.94 | 10.94 | 10.94 | |
| 32. | Hassni | - | - | 0.91 | |
| 33. | Sadan Khan | - | - | 5.50 | |
| 34. | Fateh Mohammad #2 | 0.0 | 0.0 | 0.62 | Purchased land after 1965 |
| 35. | Raham Ali | - | - | 1.10 | |
| 36. | Amir Khan | 1.82 | 1.82 | 1.82 | No land fragmentation |
| 37. | Haji Sharjan | 0.0 | 0.0 | 7.29 | Purchased land after 1965 |
| 38. | Master Sharjan | - | - | 5.50 | |
| **Total:** | | **320** | | **204.96** | |

**Annexure VI. Annual income per household in four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Sr. No. | Farmers' Name | Net Income Per Household (Rs.) | | | Total |
|---|---|---|---|---|---|
| | | Livestock | Crops | Off-farm Sources | |
| **I. Dudar Small Scale System, *Mauza* Sirati** | | | | | |
| 1. | Abdullah | 13,500 | 8,933 | 12,000 | 34,433 |
| 2. | Haider | 26,000 | 29,450 | 0 | 55,450 |
| **II. Sohar Khor Small Scale, *Mauza* Sirati** | | | | | |
| 1. | Jan Mohammad | 25,500 | 12,232 | 12,000 | 49,732 |
| 2. | Mohammad Din | 6,500 | 16,037 | 22,200 | 44,737 |
| 3. | Imam Din | 14,464 | 17,750 | 0 | 32,214 |
| 4. | Noor Mohammad | 35,500 | 16,126 | 1,500 | 53,126 |
| **III. Sham Medium Scale System, *Mauza* Rara Sham** | | | | | |
| **Head** | | | | | |
| 1. | Bangol | 24,000 | 9,000 | 0 | 33,000 |
| 2. | Abdur Rehman Shah | 0 | 40,000 | 20,000 | 60,000 |
| 3. | Mohsin Shah | 0 | 40,000 | 36,000 | 76,000 |
| 4. | Ahmad Shah #2 | 0 | 43,000 | 84,000 | 127,000 |
| **Middle** | | | | | |
| 5. | Sahib Shah | 0 | 6,000 | 20,000 | 26,000 |
| 6. | Gul Shah | 16,000 | 40,000 | 36,000 | 92,000 |
| 7. | Ishaq Shah | 56,000 | 20,400 | 42,000 | 118,400 |
| 8. | Yousaf Shah | 0 | 20,400 | 24,000 | 44,400 |
| 9. | Noor Mohd Shah | 0 | 16,500 | 20,000 | 36,500 |
| **Tail** | | | | | |
| 10. | Yaqoob Shah | 16,000 | 9,400 | 0 | 25,600 |
| 11. | Mehran Shah | 0 | 6,000 | 24,000 | 30,000 |
| 12. | Azeem Shah | 0 | 10,000 | 15,000 | 25,000 |
| 13. | Ismaeel Shah | 0 | 10,000 | 36,000 | 46,000 |
| 14. | Ahmad Shah #1 | 0 | 10,000 | 15,000 | 25,000 |

| | | | | | |
|---|---|---|---|---|---|
| 15. | Ehsan Shah | 0 | 30,000 | 0 | 30,000 |
| 16. | Iqbal Shah | 0 | 30,000 | 42,000 | 72,000 |

**Continued Annex. VI.**

| Sr. No. | Farmers' Name | Net Income Per Household (Rs.) | | | Total |
|---|---|---|---|---|---|
| | | Livestock | Crops | Off-farm Sources | |
| **IV. Jhalwani Large Scale System, *Mauza* Jhalwani** | | | | | |
| **Head** | | | | | |
| 1. | Gullshar | 38,750 | 176,350 | 0 | 215,100 |
| 2. | Khair Mohammad #1 | 0 | 33,600 | 4,800 | 38,400 |
| 3. | Nabi Jan | 0 | 29,400 | 60,000 | 89,400 |
| 4. | Shah Baig | 3,250 | 30,450 | 15,000 | 48,700 |
| 5. | Ali Baig | 0 | 17,500 | 25,000 | 42,500 |
| 6. | Rehman | 0 | 23,041 | 0 | 23,041 |
| 7. | Master Shair Mohd | 3,250 | 14,000 | 67,000 | 84,250 |
| 8. | Malik Sardar | 0 | 93,800 | 115,000 | 208,800 |
| 9. | Daraie | 39,000 | 21,000 | 33,600 | 93,600 |
| 10. | Azad | 0 | 66,500 | 0 | 66,500 |
| 11. | Dost Mohammad | 13,000 | 73,500 | 40,000 | 126,500 |
| 12. | Mir Mohammad | 13,000 | 60,900 | 55,000 | 128,900 |
| 13. | Khair Mohammad #2 | 0 | 50,400 | 0 | 50,400 |
| 14. | Alam Khan | 0 | 22,400 | 115,000 | 137,400 |
| **Middle** | | | | | |
| 15. | Sohrab | 19,500 | 35,000 | 0 | 54,500 |
| 16. | Jan Baig | 0 | 17,500 | 0 | 17,500 |
| 17. | Yar Khan | 14,300 | 11,200 | 0 | 25,500 |
| 18. | Saeed Gul | 0 | 11,200 | 10,000 | 21,200 |
| 19. | Lal Mohammad | 0 | 14,200 | 48,000 | 62,200 |
| 20. | Fateh Mohammad #1 | 0 | 35,000 | 40,000 | 75,000 |
| 21. | Piand Khan | 32,500 | 52,850 | 63,000 | 148,350 |
| 22. | Rehan | 138,850 | 60,200 | 124,000 | 323,050 |
| 23. | Din Mohammad | 7,800 | 2,100 | 8,400 | 18,300 |
| 24. | Faiz Mohammad | 0 | 33,600 | 95,000 | 128,600 |
| 25. | Haji Gull-a-Mohd | 0 | 33,600 | 12,000 | 45,600 |

**Continued Annex. VI.**

| Sr. No. | Farmers Name | Net Income Per Household (Rs.) | | | Total |
|---|---|---|---|---|---|
| | | Livestock | Crops | Off-farm Sources | |
| 26. | Lal Jan | 12,500 | 75,600 | 10,000 | 98,100 |
| 27. | Kaka | 0 | 16,800 | 30,000 | 46,800 |
| 28. | Noorou | 0 | 32,900 | 10,000 | 42,900 |
| 29. | Rahim Chacha | 0 | 31,500 | 25,000 | 56,500 |
| **Tail** | | | | | |
| 30. | M. Yaqoob | 0 | 34,125 | 68,000 | 102,125 |
| 31. | Gull Mohammad | 19,500 | 102,900 | 50,000 | 172,400 |
| 32. | Hassni | 19,500 | 12,600 | 36,000 | 68,100 |
| 33. | Sadan Khan | 51,750 | 54,600 | 84,000 | 190,350 |
| 34. | Fateh Mohammad #2 | 0 | 7,000 | 0 | 7,000 |
| 35. | Raham Ali | 0 | 16,715 | 15,500 | 32,215 |
| 36. | Amir Khan | 13,000 | 22,400 | 22,000 | 57,400 |
| 37. | Haji Sharjan | 25,750 | 63,000 | 140,000 | 228,750 |
| 38. | Master Sharjan | 0 | 75,500 | 60,000 | 135,500 |

**Annex. VII. Yield of crops grown at four selected spate irrigation systems in Musa Khel and Barkhan districts of Balochistan.**

| Sr. No. | Farmers' Name | Yield (kg/ha) | | | |
|---|---|---|---|---|---|
| | | Wheat | Sorghum | Mungbeans | Others |
| **I. Dudar Small Scale System, *Mauza* Sirati** | | | | | |
| 1. | Abdullah | 1186 | 263 | 198 | - |
| 2. | Haider | 1054 | 263 | 263 | - |
| **II. Sohar Khor Small Scale, *Mauza* Sirati** | | | | | |
| 1. | Jan Mohammad | 1317 | 329 | 109 | - |
| 2. | Mohammad Din | 1581 | 131 | 42 | - |
| 3. | Imam Din | 1581 | 131 | 131 | - |
| 4. | Noor Mohammad | 1581 | 264 | 132 | - |
| **III. Sham Medium Scale System, *Mauza* Rara Sham** | | | | | |
| **Head** | | | | | |
| 1. | Bangol | 593 | 198 | 99 | - |
| 2. | Abdur Rehman Shah | 2080 | 430 | 716 | - |
| 3. | Mohsin Shah | 2080 | 430 | 716 | - |
| 4. | Ahmad Shah #2 | 1112 | 185 | 309 | - |
| **Middle** | | | | | |
| 5. | Sahib Shah | 593 | 198 | 99 | - |
| 6. | Gul Shah | 2080 | 430 | 716 | - |
| 7. | Ishaq Shah | 1317 | 198 | 494 | - |
| 8. | Yousaf Shah | 1317 | 198 | 494 | - |
| 9. | Noor Mohd Shah | 988 | 141 | 282 | - |
| **Tail** | | | | | |
| 10. | Yaqoob Shah | 711 | 119 | 277 | - |
| 11. | Mehran Shah | 593 | 197 | 99 | - |
| 12. | Azeem Shah | 988 | 148 | 346 | - |
| 13. | Ismaeel Shah | 988 | 148 | 346 | - |
| 14. | Ahmed Shah #1 | 988 | 148 | 346 | - |
| 15. | Ehsan Shah | 1976 | 329 | 659 | - |
| 16. | Iqbal Shah | 1976 | 329 | 659 | - |

**Continued Annex. VII.**

| Sr. No. | Farmers' Name | Yield (kg/ha) | | | |
|---|---|---|---|---|---|
| | | Wheat | Sorghum | Mungbeans | Others |
| **IV. Jhalwani Large Scale System, *Mauza* Jhalwani** | | | | | |
| **Head** | | | | | |
| 1. | Gullshar | 2503 | 290 | 184 | 66 |
| 2. | Khair Mohammad #1 | 1976 | 527 | 263 | - |
| 3. | Nabi Jan | 1976 | 263 | 263 | - |
| 4. | Shah Baig | 1976 | 790 | 396 | - |
| 5. | Ali Baig | 2108 | 527 | 263 | - |
| 6. | Rehman | 1317 | 527 | 329 | - |
| 7. | Master Shair Mohd | 1756 | - | - | - |
| 8. | Malik Sardar | 2020 | 527 | 263 | - |
| 9. | Daraie | 1976 | - | - | - |
| 10. | Azad | 1647 | 659 | 329 | - |
| 11. | Dost Mohammad | 1976 | 659 | 329 | - |
| 12. | Mir Mohammad | 1976 | 1054 | 790 | - |
| 13. | Khair Mohammad #2 | 1897 | 632 | 632 | - |
| 14. | Alam Khan | 1937 | 581 | 194 | - |
| **Middle** | | | | | |
| 15. | Sohrab | 2108 | 527 | 263 | - |
| 16. | Jan Baig | 2107 | 527 | 263 | - |
| 17. | Yar Khan | 2108 | - | - | - |
| 18. | Saeed Gul | 2635 | - | - | - |
| 19. | Lal Mohammad | 1756 | - | - | - |
| 20. | Fateh Mohammad #1 | 1976 | - | - | - |
| 21. | Piand Khan | 2108 | - | - | - |
| 22. | Rehan | 2042 | 659 | 395 | - |
| 23. | Din Mohammad | 1976 | - | - | - |
| 24. | Faiz Mohammad | 1976 | 527 | 263 | - |
| 25. | Haji Gull-a-Mohd | 1450 | 263 | 395 | - |
| 26. | Lal Jan | 1976 | 922 | 395 | - |

**Continued Annex. VII.**

| Sr. No. | Farmers Name | Yield (kg/ha) | | | |
|---|---|---|---|---|---|
| | | **Wheat** | **Sorghum** | **Mungbeans** | **Others** |
| 27. | Kaka | 2108 | - | - | - |
| 28. | Noorou | 2108 | 1054 | 263 | - |
| 29. | Rahim Chacha | 1756 | 878 | 293 | - |
| **Tail** | | | | | |
| 30. | M. Yaqoob | 1581 | 790 | 296 | - |
| 31. | Gull Mohammad | 1844 | 659 | 263 | - |
| 32. | Hassni | 2371 | - | - | - |
| 33. | Sadan Khan | 1811 | 439 | 439 | - |
| 34. | Fateh Mohammad #2 | 1937 | - | - | - |
| 35. | Raham Ali | 1976 | - | - | - |
| 36. | Amir Khan | 1976 | - | - | - |
| 37. | Haji Sharjan | 1976 | - | - | - |
| 38. | Master Sharjan | 2108 | 1054 | 395 | - |
| **Aggregate Average:** | | **1773** | **479** | **329** | **-** |

* Yield of sorghum grain, mungbeans and other are from a cropping mix, therefore yield of both sorghum and mungbeans together is from the unit area.