Report No. R-33

MANAGING IRRIGATION FOR
ENVIRONMENTALLY SUSTAINABLE AGRICULTURE
IN PAKISTAN

SURFACE IRRIGATION METHODS AND PRACTICES

Farmers' use of Basin, Furrow and Bed - and - Furrow Irrigation Systems and the Possibilities for Traditional Farmers to Adopt the Bed - and - Furrow Irrigation Method

Nanda M. Berkhout
Farhat Yasmeen
Rakhshanda Maqsood
Ineke M. Kalwij

DEPARTMENT OF RURAL SOCIOLOGY
UNIVERSITY OF AGRICULTURE, FAISALABAD

DEPARTMENT OF IRRIGATION, SOIL AND WATER CONSERVATION
WAGENINGEN AGRICULTURAL UNIVERSITY, THE NETHERLANDS

PAKISTAN NATIONAL PROGRAM
INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

SEPTEMBER 1997

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GLOSSARY

Acre	Unit of area the basic agricultural land unit in Pakistan. One acre is 220 **x 198 feet,** or **0.40** ha.
Bandi	Fixation
CCA	Cultivable Command Area; is the area suitable for agriculture with water rights attached **to** it
Chak	Watercourse (w/c) command area
Craw	Tool used for planking purposes
Cusec	Unit of discharge; cubic feet per second
Jundra	Tool used for making bunds
Kachcha	Ordinary; unregulated
Kanal	Unit of area, **1/8** of an acre
Kharif	Summer season
Merra	Clay-loam
Mogha	**Outlet** from distributary into the watercourse
Nakka	Inlet (to farm **or** field)
Pucca/pacca	Official
Punjab	Land of the five rivers
Rabi	Season of the winter crop
RD	Reduced Distance; the distance downstream from **the** starting point of a canal, where 1 **RD = 1000 feet.** For example, W/C Fordwah **14-R** is located at **14320-R,** which means that **the outlet** is situated at **14320** feet downstream of **the** starting point, on the right **(R)** bank of the canal (looking downstream).
Rouni	Name for the pre-sowing irrigation
Sohaga	Tool **used** for leveling
Wara	Turn
Warabandi	Rotation schedule for irrigation

CONVERSION TABLE

Area			***Weight***		
1 acre	=	4047 m^2	1 maund	=	40 kg
1 killa	=	3890 m^2			
1 killa	=	8 kanal			
Distance			***Discharge***		
1 feet	=	30.5 cm	1 cusec	=	28.3 l/s
1 feet	=	12 inches	1 cusec	=	0.0028 m^3/s
1 inch	=	2.54 cm			
1 RD	=	1000 feet			

FOREWORD

Not only farmers express concerns about the future of their land, but also at the national level, the concern about farmers and their agriculture is there. Moreover, Pakistan as a country depends *so* much on its agriculture, and for this, its irrigation system. Due to increasing population, the competition for the water resources between agriculture and industry and urban use continually increases. The awareness that the people must care about the natural resources and that they must not exploit these is there, however, it is a very difficult and long process to bring thoughts into action.

That Pakistan has such a huge irrigation system, which supplies water to at least 80% of the cultivated area, is a blessing. However, the future of this irrigated agriculture lies for a large part in the hands of mankind itself. To find equilibrium between agriculture, human needs and water use is of importance when we want to achieve progress, not only in terms of increasing the standard of living but also in terms of making the irrigated agriculture sustainable. Water can be saved! In fact, the concept of water saving is a worldwide recognized phenomenon, and, therefore should also be applied to irrigated agriculture in Pakistan.

Within the International Irrigation Management Institute (IIMI), in Pakistan, research is being conducted on Irrigation Methods and Practices, which forms part of the Watercourse Management Sub-component under the Netherlands Govt., Grant Project, "Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan". The main objective is developing sustainable improved irrigation management practices at the field and farm level in order to achieve a more efficient use of the irrigation water and to enhance crop production.

Improving on-farm irrigation practices is not only related to developing improved operation and management strategies for the traditional basin irrigation systems, known as small bunded units, but also bed - and - furrow irrigation systems. In the late sixties, farmers became familiar with cultivating certain vegetables and fruits on ridges and beds, which provided the farmers many benefits. However, for more economic crops like cotton, farmers have been using basin irrigation. During the last decade, farmers started cultivating cotton on beds; however, it remained confined to a very small scale due to many reasons. It is a fact that the bed - and – furrow irrigation method has certain advantages above the basin irrigation method, especially when it comes to water savings. However, a coin has two sides, and for making improvements possible and or innovations acceptable to the farmers, the viewpoint and interest of farmers have to be addressed and taken into account. For this reason, this study has been proposed. The emphasis of this study is on farmers' perceptions and viewpoints on the use of basin, furrow and bed – and - furrow irrigation systems; the constraints farmers are facing with these methods and the related practices; and traditional farmers' interest in the furrow and bed - and - furrow irrigation methods.

Three students have conducted the study. One international student (Nanda M. Berkhout) from the Department of Irrigation, Soil and Water Conservation, Wageningen Agricultural University, The Netherlands and two national students (Farhat Yasmeen and Rakhshanda Maqsood) from

the Department of Rural Sociology, University of Agricultural, Faisalabad. They have dons a tremendous job in collecting the field data and analyzing the results, on which this IIMI report has been based. All three learned very well how to do research, and moreover, how to work as a team. For this study, I wanted deliberately a female national student; however, it was not that easy. Two female national students were easier to get for this study and that is why it became three students in total.

Ineke Margôt Kalwij
Associate Expert
Pakistan National Program
International Irrigation Management Institute

EXECUTIVE SUMMARY

Pakistan became an independent state in 1947. With having a arid to semi-arid climate, and an economy which is predominantly agricultural, Pakistan depends heavily on its irrigation system, the largest contiguous irrigation system in the world. Irrigated agriculture accounts for about 90% of Pakistan's agricultural output. However, major problems are arising due to increased water demands resulting from increasing population and other water demands from non-agricultural sectors. Along with this, the cultivated land is limited. The irrigation system of Pakistan has been expanded since Independence, but it still follows the rules and regulations as made by the British. A major contribution to the irrigated agriculture in Punjab comes from the extensive use of groundwater, pumped by public and private tubewells, which has its effect on the groundwater level and environment in terms of salinity and sodicity.

The Fordwah-Eastern Sadiqia irrigation system is one of IIMI's research areas in Pakistan, and is located in the Fordwah and Hakra Division of the Bahawalnagar Circle in the Bahawalpur Irrigation Zone, in South Punjab.

In IIMI, research is being conducted in the lower portion (tail) of the Fordwah Divisions, on Surface Irrigation Methods and Practices. It has its main focus on the development of improved surface irrigation operation and management in order to enhance a more efficient use of the irrigation water and sustainable yield increases. This study deals with farmers' use of basin and furrow and bed – and - furrow irrigation systems and the interest and potential for traditional farmers to adopt the bed – and - furrow irrigation method (for cotton crop). Three topics have been defined within this study:

1. Traditional farmers' perceptions and strategies on the basin irrigation method and applied practices;
2. Perceptions and strategies of progressive farmers on the furrow and bed – and - furrow irrigation methods;
3. Traditional farmers' perceptions on, and the adoptability of, improved surface irrigation methods and practices.

Interviews have been conducted on watercourse command areas of Fordwah and Azim distributaries and some interviews were conducted with farmers located near Khanpur and Lodhran (South Punjab).

The 18 traditional farmers which were interviewed for Topic 1, are ranging from small to large farmers; however, most of the farmers are having a small (5 acres or less) or medium landholding ranging between 5 to 25 acres. Some have their own land, dome lease or work as a tenant, or a combination on the three. Family members are helping in the agriculture, but most of the farmers do also have full-time or part time laborers. The majority have their own tubewell, but most of them do not have their own tractor. External incomes are there for some of the farmers. The farmers are using the basin irrigation method for irrigating their fields. Land is divided into bunded units of which the main motivations as mentioned by these farmers are

- Saving of water (in comparison with having no bunded units);
- Saving of money; not much inputs or labor is needed;

bed - and - furrow irrigation methods, along with advantages and constraints. The traditional basin irrigation method provides a safety for the farmers; they are familiar with this technique and the expenses related to irrigation are limited. Farmers realize that by using furrows or beds - and - furrows, water can be saved and a better yield can be achieved. But farmers pointed out their main constraints related to beds - and - furrows, such as access to labor and machinery. Progressive farmers recognize the constraints, but in a way, learned how to manage these constraints. For them, to achieve advantages carries more weight than the constraints.

The potential is there to have the bed - and - furrow irrigation method more widespread; however, the farming systems have to be considered in a broader context and the constraints have to be addressed. Contributions should also come from other parties which are involved in agriculture in order to make innovations sustainable, such as: (i) providing extension and knowledge to the farmers; (ii) demonstrating to the farmers the impact of bed - and - furrow irrigation; and (iii) strengthening the concept of having common arrangements for using equipment and supplying inputs among farmers.

Keywords: Surface irrigation, basin irrigation system, furrow irrigation system, bed - and - furrow irrigation system, surface, irrigation practices, agricultural practices, irrigation strategies.

CHAPTER 1 INTRODUCTION

IRRIGATED AGRICULTURE IN PAKISTAN

Background

Pakistan came into being as a sovereign independent state on August 14th, **1947.** Pakistan covers an area of about **796,100** km^2 of land, divided into four provinces, Punjab, Sindh, the North-West Frontier Province (NWFP) and Baluchistan. Additionally, Pakistan has Federal Administrative Northern Areas (North of Pakistan), Federal Administrative Tribal Areas (North *of* NWFP) and the people in Kashmir (North East of Pakistan) who have their own legislative body. Pakistan can be divided into five major physical divisions. Figure **1.1** presents the map of Pakistan. One of the five major physical divisions is the Indus Plain. The Indus Plain is a featureless plain, with a gentle general slope towards the **sea** a gradient of 2‰ (Kureshy, K.U., **1995).** The Punjab is located in the Indus plain, which means the land of five rivers. i.e. the Indus, Jhelum, Chenab, Ravi and Sutlej.

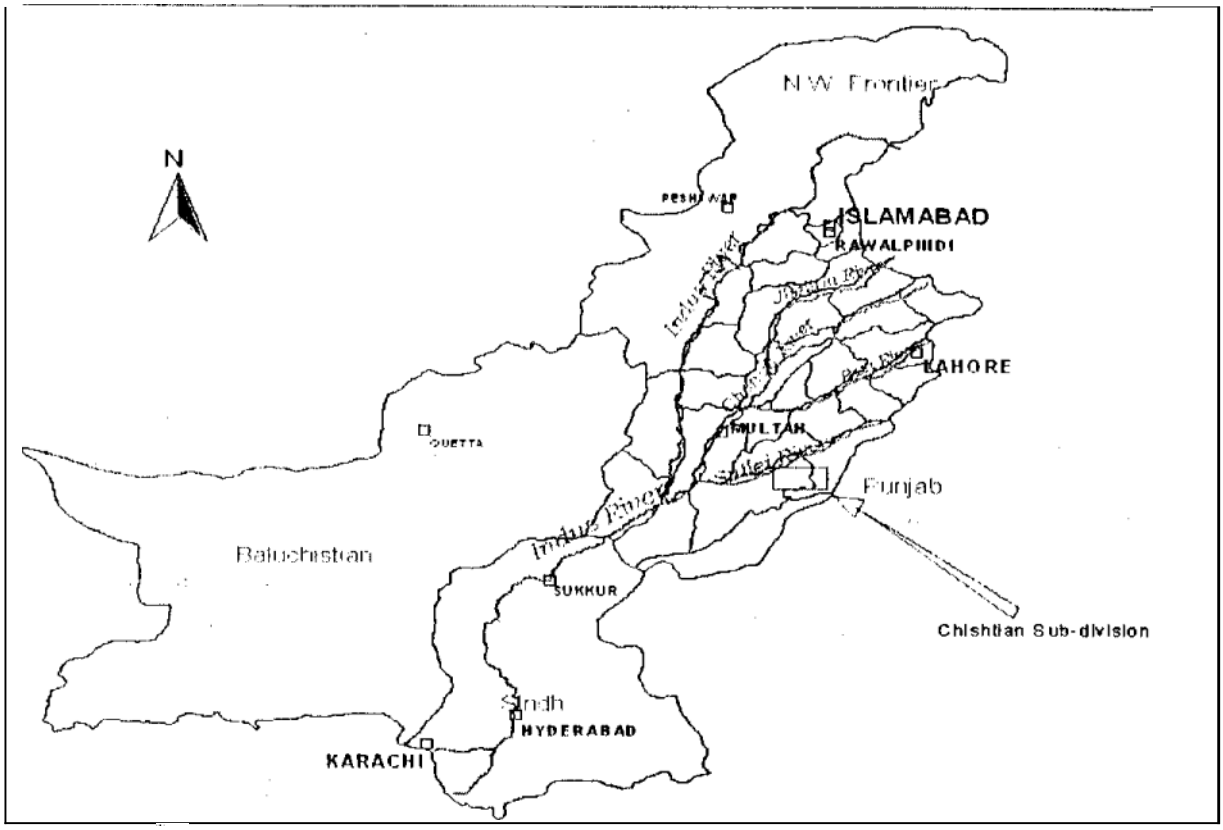


Figure **1.1. Map *of*** Pakistan.

Climate

Pakistan's climate is arid to semi-arid. The temperature in most cultivable areas allows for year-round cultivation. The climate in the Indus Plain is characterized by high summer temperatures, aridity and late summer monsoon rains. The annual range of temperature is high. Annual precipitation over the Indus plain ranges from 150 mm to 500 mm, whereas annual evaporation varies from 1.250 mm to 2.800mm. In Annex 1-1, the year-round figures concerning the climate are given.

The rainfall is insufficient and its usefulness for agriculture is further reduced by its variable nature. Especially in the Indus Plain, when the rainfall takes place in the late summer months, then due to high temperatures, much of it is evaporated. This makes crop production impossible without irrigation (Kureshy, K.U., 1995). Figure 1.2 typified the agriculture in the Punjab.

Figure 1.2. Agriculture in the Punjab.

Economy

The economy of Pakistan is predominantly agricultural. Although of recent years the rate of growth of manufacturing has surpassed that of agriculture, the latter remains the most important single sector of the economy. The total cultivated area of Pakistan was 21 million hectares (26% of the total area) in 1988/89, where 16.2Mha (77% of the cultivable area) were irrigated (World Bank, 1994). Irrigated land supplies more than 90 percent of agricultural production (by value), and agriculture supplies most of the country's food, accounts tor 26 percent of GDP, and employs 54 percent of the labor force (World Bank, 1994).

Some crops, like cotton and sugarcane, play an important role in the industrialization process and the general economic development of the country. But the performance of the sector in terms of efficiency of water use and agricultural productivity is questionable. The yields of the main crops in Pakistan are among the lowest in the world. The production may not answer the demands of the population in the years to come. The cultivated land is limited and the population is increasing. The total population is estimated at 131.63 million as on 1st January, 1996, with an estimated growth rate of 2,82 percent (GOP, 1996).

Irrigation

Rainfall in Pakistan is deficient for agriculture. The country has the largest contiguous irrigation system in the world. The modern system of large perennial canals started to develop at the beginning of the present century. The irrigation system of Pakistan has been greatly expanded since the Independence. Irrigation water stems from canal water supplies, diverted from the main rivers of Pakistan and groundwater supplies, pumped by public and priiate tubewells.

Figure 1.3. An irrigation canal.

The canal command areas together account for 80% of the food crops and virtually all of the cash crops grown in Pakistan (Kureshy, K.U., 1995).

The Indus Basin Irrigation System is a large scale irrigation system and covers some parts of the North West Frontier Province (NWFP), Baluchistan and large parts of Sindh and the Punjab.

Irrigation water allocation is regulated by rules developed by the British more than a century ago. The Irrigation Department delivers a specific amount of water based on a predetermined 'water allowance' and on the size of the cultivable area of the watercourse.

The time duration for each farmer is proportional to the size of the farmer's land holding to be irrigated within the command area below the outlet (called *chak*[1]), regardless of crop water requirements (Bandaragoda, **D.J.** and Saeed ur Rehman, 1995). The present water allocation system, which **is** a continuous rotation of water within the *chaks* is known as warabandi (*wara* means turn and bandifixation). Figure 1.3. shows a distributary canal in the Punjab.

Aside from surface water, a large contribution from groundwater exists to the irrigation water supply. The contribution of groundwater to the total irrigation water supply in the Punjab is estimated at **40%** to 50% (Kuper and van Waijjen, 1993). For more details see Annex 1-2.

[1] **For** the explanation **of** local used terms. the reader **is** referred **to** the **glossary.**

DESCRIPTION OF THE RESEARCH AREA

The research area is within the Fordwah-Eastern Sadiqia (FES) irrigation system. This system lies in the Fordwah and Hakra Divisions of the Bahalwalnagar Circle in the Bahawalpur Irrigation Zone, in the south of the Punjab (see Figure **1.4).**

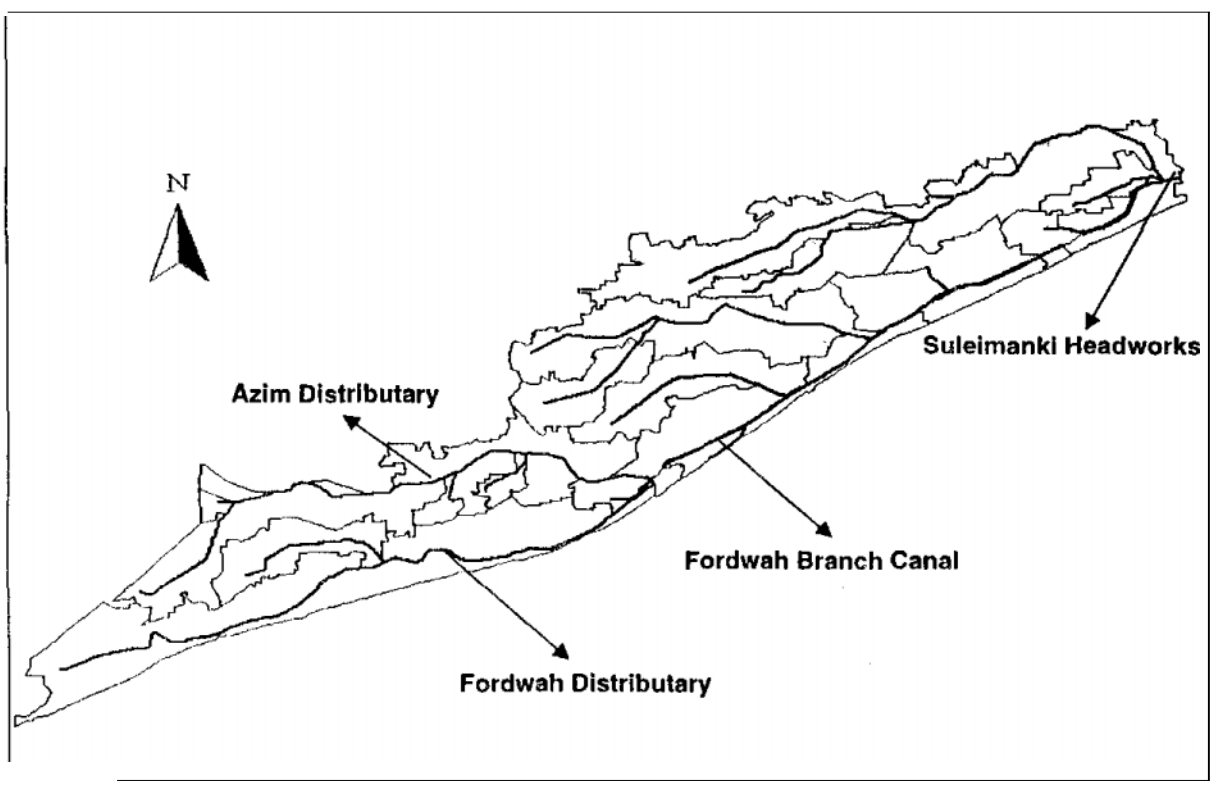


Figure **1.4.** The research area, South Punjab.

From the Sutlej river, the Fordwah Main Canal and the Eastern Sadiqia Canal are diverted at Suleimanki Headworks. At the reduced distance (RD) from the head of the canal (in 1000 feet) **of 44,** Fordwah Branch takes off from Fordwah Main Canal. At RD 371, (i.e. 371.000 feet downstream), three secondary channels (distributaries) follow from Fordwah Branch: Azim, Fordwah and Mahmood (i.e. tail end distributaries).

Figure 1.5 shows the intake of the Fordwah Distributary. The research area for this topic was confined to mostly the W/C Fordwah 14-R, W/C Fordwah **62-R** and W/C Azim 11I-L.

The physical features of the command areas are varying from sandy areas to silt clay areas. Further, quite some areas are suffering from salinity and sodicity. Annex 1-3 provides the soil classification for the interviewed farmers, based on research conducted by the Soil Survey of Pakistan (SSP) in collaboration with IIMI. Annex **1-4** provides a description of the salinity status of some of the interviewed farmers.

THERESEARCH

Background of the research

Research is being conducted in Pakistan within the International Irrigation Management Institute (IIMI) ***on 'Surface Irrigation*** Methods ***and Practices',*** which forms part of the program under the Netherlands Government Grant Project ***'Managing Irrigation*** for ***Environmentally Sustainable Agriculture in Pakistan'.*** The research on ***'Surface Irrigation*** Methods ***and Practices'*** has its main focus on: (i) the application of the surface irrigation simulation technology to small bunded fields; (ii) **the** assessment of irrigation performance at the farm level; and (iii) the development of improved surface irrigation methods and practices for water and salinity management for small landholdings.

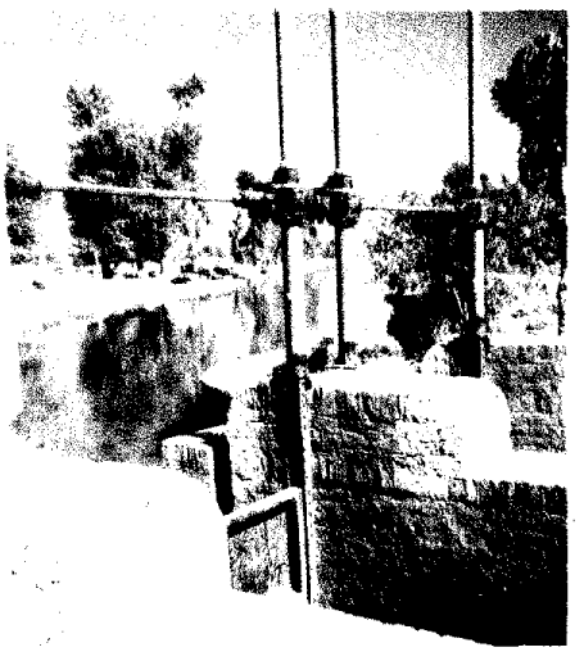


Figure 1.5, The Intake of Fordwah Distributary.

This study is concerned with the last focus, i.e. the development of improved surface irrigation methods and practices which are applicable to small landholdings in the irrigated agriculture of Pakistan. The study has been carried out in order to identify the possibilities for implementation of improved surface irrigation method and practices, mainly consisting of bed - and - furrow irrigation systems for small landholdings. During the Kharif 1997 season, IIMI will implement the bed - and - furrow irrigation method for small landholdings for testing and evaluation purposes. Operation and management options will be proposed in order to achieve a more efficient use of canal water (i.e. reduce the tubewell water use) and to increase the crop productivity through better proposed irrigation management practices at the farm (Kalwij, 1996).

The study entails, on the one hand, farmers' perceptions and strategies on the presently used surface irrigation method and the applied irrigation practices. On the other hand, it contains research for evaluating farmers' interest in implementing the bed - and - furrow irrigation method within **the** current socio-economic environment and physical setting.

Research approach

The main objective can be formulated as follows:

To study the currently used irrigation methods and practices, with an emphasis on formulating the possibilities for implementing bed - and- furrow irrigation systems on small landholdings;

and is segregated into the following sub-objectives (Kalwij, 1996):

- To identify farmers' perspectives and strategies on the presently used basin irrigation method and applied practices, and the related constraints and problems within the present socio-economic environment and physical setting;
- To identify the perceptions on the advantages and disadvantages of improved irrigation methods by the users and non-users within the present socio-economic environment and physical setting:
- To identify the possibilities (along with the constraints) for small farmers of switching from basin to bed - and - furrow irrigation systems;
- To identify farmers in IIMI's sample watercourses along Fordwah and Azim distributaries who are interested in experimenting with improved irrigation methods during Kharif 1997 in collaboration with IIMI.

Based on these objectives, three topics were defined:

1. ***Traditional farmers' perceptions and strategies on the traditional irrigation method and applied practices;***
2. ***The perceptions and strategies of progressive farmers on the furrow and bed – and - furrow irrigation methods;***
3. ***Traditional farmers' perceptions on, and the adaptability of, improved surface irrigation methods and practices.***

The first **topic** entails farmers' perceptions and strategies on the presently used basin irrigation method and applied practices within the current socio-economic environment and physical setting. The basin irrigation method can be viewed as the traditional way of irrigation. **If,** in the text, reference is made to 'traditional farmers', then those farmers are the ones who are using only the basin irrigation method for irrigation and are not using the bed - and - furrow irrigation method. Some of them, might be familiar with the furrow irrigation method for cultivating vegetables. Issues addressed in under this topic are: (i) farmers' motivation for using the basin irrigation method; (ii) related problems and constrains as perceived by the farmers; (iii) followed strategies (i.e. irrigation practices) by the farmers; and (iv) a brief historical description based on farmers' stories. **Also,** in this context, different groups of farmers can be identified related to their socio-economic environment and physical setting.

The second topic deals with farmers' practices and strategies for furrow and bed - and - furrow irrigation methods. These are referred to as improved methods. With improved methods not something new is claimed: in the South of Punjab farmers are using tied – and - furrow irrigation systems for the cotton crop; however, these are confined to a small scale and, in most of the cases, it concerns farmers with a larger landholding. However, some small farmers are using furrows for growing vegetables. The main focus of this topic is on: (i) the motivation of farmers to switch from the traditional irrigation method to bed – and - furrow irrigation systems (i.e. what the driving force has been); (ii) the main constraints they are facing with this method in terms of implementation and additional resources needed; and (iii) the obtained advantages by implementing furrow or bed - and - furrow irrigation methods.

The third topic entails the traditional farmers' interest in, and their possibilities of, using the furrow or bed – and – furrow irrigation method. Different aspects, such as irrigation and cultural practices, input requirements, along with advantages and disadvantages as perceived by the farmers, are discussed in other to identify the possibilities of adopting and using bed - and - furrow irrigation systems for small landholdings for mainly cotton crop.

The results of Topic 1 and Topic 2 are integrated with Topic 3 in order to identify possible options for farmers to adopt the improved technology, taking the constraints for different groups of farmers into consideration. This output will be the main basis for further research on the process of facilitating farmers in adopting new technologies and strategies for improved farm irrigation management.

Research Methodolouy

The field research has been carried out with (semi-) structured interviews, which were taken from selected farmers out of the before mentioned three watercourse command areas. According to the three topics mentioned in the objectives, three different types of interviews were formulated. The interviews were done according to the concept of Participatory Rural Appraisal (PRA), known as type of participatory methods for conducting field interviews. Experience showed that this method worked very well for this study purpose in order to obtain as much feedback from the farmer as possible. Figure 1.6 shows which materials were used while interviewing the farmers.

Figure 1.6. The materials used during the interviews.

For Topic 1, ***'Traditional farmers' perceptions and strategies on the traditional irrigation method and applied practices'*** a semi-structured questionnaire was prepared, which included some PRA methods, like the use of drawings to represent inputs. In total. **18** farmers from three different watercourses were selected. (i.e. **6** farmers were selected from each W/C). Annex **1-5,** Annex **1-6** and Annex **1-7** presents the location of the interviewed farmers in W/C Fordwah 14-R, W/C Fordwah 62-R and W/C Azim 111-L, respectively. Mostly, the farmers were selected according to their location along the watercourse (i.e. head, middle or tail), and type of landownership (i.e. landowner, lessee or tenant) and their willingness to cooperate with IIMI. Furthermore, all of the 18 farmers are using the basin irrigation method to cultivate the main crops. The interviews for Topic 1 were conducted during the months November and December **1996.**

A semi-structured questionnaire was made for Topic 2, ***'The perceptions and strategies of progressive farmers on the bed – and - furrow Irrigation method'.*** Ten farmers were selected, of which two progressive big landowners, one at Tareen Farm nearby Lodhran and another from Bilal Farm nearby Khanpur. The other eight farmers are progressive farmers located in the W/C's of Fordwah and Azim distributaries. The interviews for this topic were conducted during the month of January **1997.**

The research for Topic 3, dealing with ***'traditional farmers' perceptions on, and the adaptability of, improved surface irrigation methods and practices',*** was carried out with participatory methods, along with a semi-structured questionnaire. During this research, the farmers compared the most important factors, (i.e. crops, water, labor, soils, cultural and irrigation practices) for basin and furrow or bed – and – furrow irrigation methods. For this topic, **14** out of the **18** farmers were the same as selected for the first topic. This had a two-fold reason:

1. By having already the information on the farmers basin irrigation practices and perceptions on basin irrigation, it is easier to relate the answers to the farmers socio-economic environment and physical setting; and
2. For the convenience of the farmers, since they are already acquainted with the interviewers.

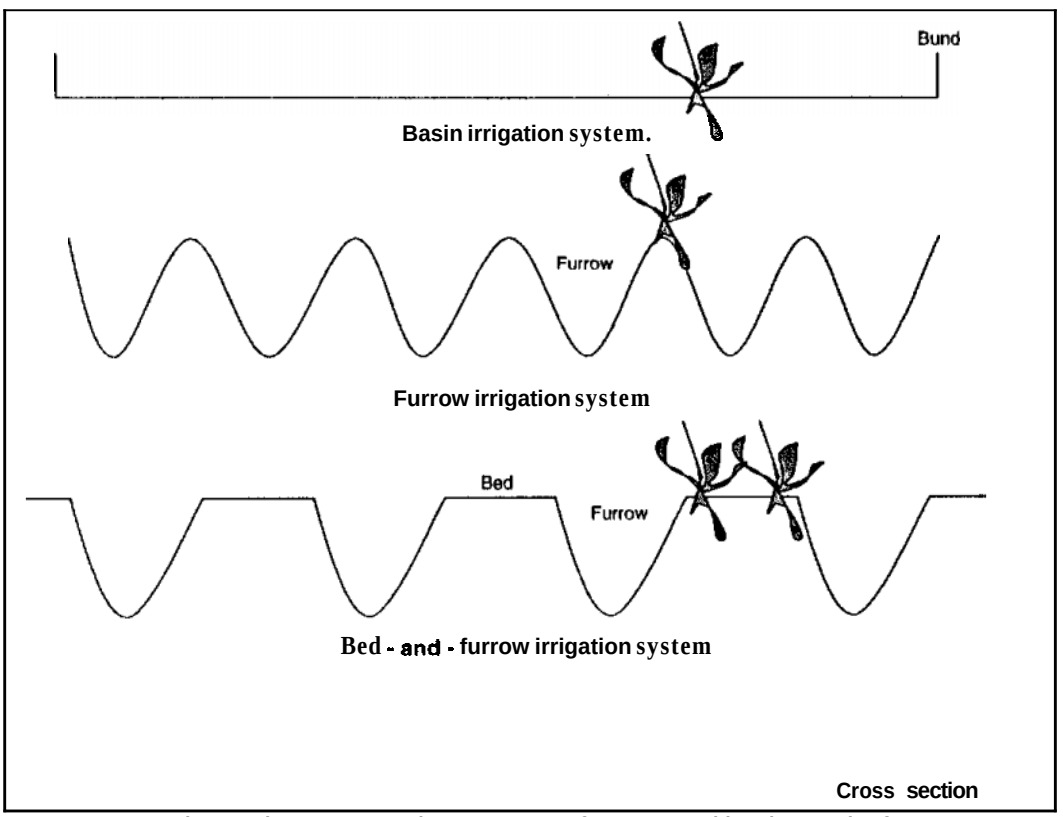
The intention is to make an assessment of the farmers' thinking about furrow or bed – and – furrow irrigation methods and of the possibilities of adopting these kind of methods. While conducting the interviews, it was observed that, generally for traditional farmers, it was quite difficult to discuss furrow and bed – and - furrow irrigation method as two separate methods, since they were not much familiar with this method. Often, farmers considered the furrow and bed – and – furrow irrigation method as the same, or discussed the use of bed – and – furrow irrigation method, based on the exposure to furrow irrigation method for vegetables, either by themselves or by neighbors. Additionally, it was observed that farmers sometimes make statements that are not understandable, which of course made it difficult to rationalize and interpret their responses. The interviews for this topic were conducted during the month of January **1997.** In Annex 1-8 the list of interviewed farmers for this study is presented.

Characteristics of the surface irrigation methods

The basin irrigation method and furrow or bed - and - furrow irrigation methods are classified as surface irrigation methods. This indicates that water is distributed across the field by gravity and that the flow is classified as being open channel flow.

At the time of irrigation, water enters the field through a field inlet and covers the field or furrows within a certain time. The field inlet discharge and the duration of the irrigation determines the total amount of water applied, which should match the crop water requirement in the ideal situation. Figure 1.7 presents a schematic presentation of basin, furrow and bed -and - furrow irrigation systems (cross section).

The main features of the basin irrigation method are that the field is entirely dyked and thus, no runoff of water occurs, and the field has a zero slope (i.e. level basin). The size of the basin can vary, however, in the case of South Punjab, Pakistan, the basins are relative quite small and mostly do not exceed the size of an acre.



igure 1.7. Schematic presentation of basin, furrow and bed – and – furrow Irrigation systems.

The main features of the furrow and bed – and - furrow irrigation methods are that the water flow is confined to the furrows only. Generally, the furrow irrigation method is applied on sloped fields and are open ended (i.e. runoff occurs). In this situation (i.e. South Punjab, Pakistan),

mostly bed – and - furrow irrigation Systems for levelled fields are used which are entirely dyked (i.e. basin - furrow irrigation systems).

The main difference between furrow and bed – and - furrow irrigation systems is the furrow spacing. A furrow spacing figure which is larger than the top width of a furrow implies a bed between two furrows. A bed is created in order to cultivate two rows of crops (i.e. on the left and right side of the bed). The use of furrows or bed – and – furrow irrigation methods has considerable advantages over basin irrigation systems, because they provide better on-farm water management, evaporative losses can be reduced, and higher efficiencies are in general achieved as compared to the basin irrigation method (Walker, W.R. and G.V. Skogerboe, 1987).

Report outline

In Chapter 2, the results of the interviews conducted for Topic 1 are presented, which deals with a detailed description about the basin irrigation method as used by the traditional farmers. Chapter 3 describes the results based on the interviews as conducted with the progressive farmers concerning the use of the furrow and bed – and - furrow irrigation methods (Topic 2). Chapter 4 describes in detail the perception of traditional farmers on the use of furrow irrigation methods (Topic 3). In Chapter 5, all of the results are synthesised and the conclusions are presented.

During the interviewing, a considerable amount of information has been collected, which has all been processed in this report. However, to make the reading of the main text more convenient, a considerable amount of information has been processed in the annexes.

CHAPTER 2 FARMERS' PRACTICES AND STRATEGIES FOR BASIN IRRIGATION SYSTEMS

INTRODUCTION

Traditionally, farmers have always been using basins for irrigation purposes, and still, the basins are the most common irrigation systems in Pakistan. In this Chapter, the focus is entirely on those farmers who have always been using the basin irrigation method. The interest revolves around the motivation of farmers for using basins, their related irrigation practices, and the advantages of this method along with major constraints as perceived by the farmers concerning the basin irrigation method and the associated irrigation practices. Additionally, an inventory is made of the socio-economic setting of the interviewed farmers. Figure 2.1 shows some basins which are used by the farmers.

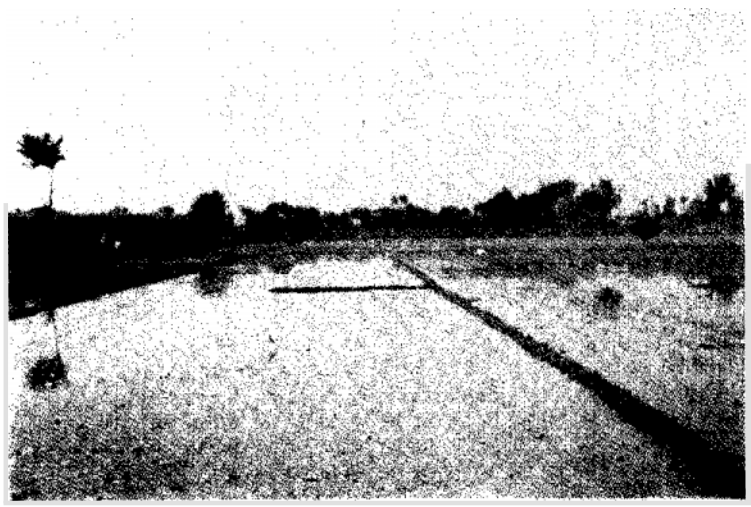


Figure 2.1. Basin irrigation method.

SOCIO-ECONOMIC SETTING

The labor and land access of the interviewed farmers are presented in Table 2.1, while their access to other inputs and location in the watercourse is shown in Table 2.2. Further, the farmers are divided into three categories concerning the size of the landholding and for the location in the watercourse. Annex 2-1 provides more information.

The *size* of the family is either represented by a single family or (most of the time) a combined family system. Family size is therefore variable, 4 up to 20 people are together as a family. Farmers indicated that family members are involved in agriculture, either full-time or part-time, and they hire labor according to the demand. Five farmers mentioned that women are helping in their agriculture, especially during the period of harvesting and picking of cotton. Additional (hired) labor used by the farmers per acre varies widely. One farmer has only 8 percent of labor per acre, while another has 133 percent labor available. Almost all farmers own land, from 2.25 up to 25 acres. Out of the eighteen selected farmers, seventeen farmers were landowners, nine farmers have land on lease (sometimes in addition to their own land) and three farmers were tenants, cultivating land of others on a sharing basis.

Table 2.1. Labor and land access for the farmers.

Farmer No.	Total family Members	Full-time labor	Part-time labor	Own land (acres)	Lease land (acres)	Total land (acres)	Labor per acre %
1	6	1	2	16	17.5	20.5	8
2	9	3	3	3	3	19	18
3	4	4		9	Has tenant	4	100
4	13	3	1	7	16	23	14
5	8	2	4	19.5	has tenant	6	17
6	10	2	4	5.5	---	5.5	50
7	20	3	1	6	---	6	53
8	14	4		25	---	25	16
9	5	7		12.5	---	12.5	56
10	9	1	1	16	has tenant	11	11
11	11	2	6	15	6	20	16
12	8	2	4	2.25	6.75	9	31
13	9	some		22.5	---	22.5	
14	10	4	women	18	8	14	29
15	10	2		8	8	16	13
16	8	3	women	8	4	12	25
17	12	4	women	3	---	3	133
18	4. tenant	2	women	-, 43	11,-	11, 43	18

Table 2.2. Class. access to other inputs and location in the watercourse, for the interviewed farmers.

Farmer No.	Landowner class	Tubewell owner	Tractor owner	External income	Location in W/C
1	Medium	N	N	N	Head
2	Medium	Y, 2	Y	Pension teacher	Tail
3	Small	Y	Y	Irrigation department	Tail
	Medium	Y	N	N	Middle
5	Medium	Y	N	N	Tail
6	Medium	N	N	N	Head
7	Medium	Y	N	hotel	Middle
8	Medium	Y	Y	N	Head
9	Medium	Y	Y	N	Tail
10	Medium	Y	N	N	Middle
11	Medium	Y	Y	Spare-parts shop	Middle
12	Medium	N	N	Teacher and electric shop	Middle
13	Medium	Y	Y	N	Middle
14	Medium	Share	N	Pesticide business	Middle
15	Medium	Y	N	N	Tail
16	Medium	Share	N	IIMI employer	Middle
17	Small	Y	N	N	Tail
18	Medium	Y	Y	N	Head

Based on the classification made in the Province report (Vol.II, Part 3). 1990[2], the following can be stated about the farmers' classification concerning the size of the landholding: The majority are medium landowners (13), ranging between 5.5 – 22.5 acres of land. Two small farmers were interviewed with 4 and 3 acres of land, respectively. One farmer has been classified a large farmer, having 25 acres of land. Thirteen farmers have their own tubewell. Two farmers have a tubewell on share, while three farmers do not have a tubewell. In W/C Azim 111-L, canal water is not available *so* all of the farmers use tubewell water. The majority (eleven out of eighteen) of the farmers do not have a tractor. Farmers indicated that when they need a tractor, they will lease one. Furthermore, one-third of the interviewed farmers have access to other sources of income besides agriculture.

BASIN IRRIGATION METHOD

Historical description

In Box 2.1, the history, as described by a farmer, is presented. This story will give an impression of the history and the developments in the past concerning the basin irrigation method and agricultural practices.

My [illegible] ne is Master [illegible]slam. I am [illegible] t a secondary school living in chak 10 [illegible]ordwah. I [illegible]m 50 [illegible]ears old. My g [illegible] ather [illegible] 19 [illegible] 5 [illegible] d, he di ide [illegible] his la [illegible] ng four [illegible]s. I hav [illegible]nly or brother anc I got 2.25 acres. Canal water [illegible] available i [illegible] the period of my fath [illegible] our t of [illegible] [illegible] d, 30 [illegible] in./a [illegible] I don no have a *tubewell*, I hi [illegible] [illegible] fr [illegible] s Ab [illegible] 40 y [illegible] s ag , [illegible] [illegible] tubewells, we [illegible] water [illegible] the [illegible] lp of oxen, [illegible] connected to a [illegible] out of the [illegible] as very diffi [illegible] lt to [illegible], I had to [illegible] who [illegible] lo [illegible] ig te [illegible] I h [illegible] a pa [illegible] oxer [illegible] were used for ploughing. I used a *craw* to level the land. I also used *sohaga* to make the soil soft. Both instruments are traditional, now they are used with tractor. I have to hire all type of machinery [illegible] drill [illegible] etc. [illegible] official *watercourses* ar still a the same [illegible] The private were di in width because they were made by hands [illegible] t, the soil was very [illegible] and 1 did not use fertilizers. The soil was g [illegible] lor cultivation. The interval of [illegible] month. [illegible] soil does not have this capacity [illegible] no . The [illegible] high due to the pesticides and [illegible] past. the soil was pure [illegible] not anymore, it has become a mixture of so [illegible] es. I made 8 [illegible] per acre due to the [illegible] Then the sl [illegible] si [illegible] the [illegible] were diff [illegible] Thi was due to [illegible] sand dunes. Now, these sand dunes have [illegible] less. [illegible] to the strong winds [illegible] g from [illegible] Sindh side, the air would make the land level. [illegible] ddn'l [illegible] it le [illegible] But now t [illegible] is not like [illegible] any more, the position of the wind has changed. [illegible] dune which [illegible] not h in the past The [illegible] would take these [illegible] articles alo [illegible] g. Now the soil has become hard. A few [illegible] go, I never hired [illegible] r, due [illegible] [illegible] rybody wa [illegible] each [illegible] and got crop like [illegible] dder [illegible] otton B [illegible] now we hire labor and we h [illegible] to pay . In those days I g [illegible] the crops only lor home-consumption, I [illegible] ot grov ing fc [illegible] I was [illegible] cotton, jouwar, [illegible] ijra and vegetables Now we a [illegible] not cultivating vegetables because it needs full attention.

B [illegible] 2.1. Hist [illegible] of a t [illegible] l fi

[2] The following classification is made: small farmer: landholding under **5** acres of land; medium farmer: **5.0** to under **25** acres of land; and large larmer: **25** acres of land and above (from: Census of Agriculture (1990); Province Report, Vol.II, Part –3, Government of Pakistan. Economic Affairs and Statistic Division, Agricultural Census Organization; p. 32.

Mostly, male farmers were interviewed, since they are dealing with the cultural and Irrigation practices. However, in order to obtain insights regarding the extent of the involvement of the women, along with their views and opinions concerning irrigation and agriculture, some women were interviewed. Stories of women are presented in Box 2.2 and Box **2.3.**

A mother in purdah

According to the mother of one of the fanners, agriculture is a very expensive profession. Fertilizers. pesticides, insecticides are too expensive and the cotton rate is very low. The crop rate will be higher when they would sell in the market. Last year there were no taxes, but now there Is a tax on cotton and on pesticides and insecticides.

From the lend she can only get food. but not much profit to buy refreshments. In the past they did not spend much on cultivation and grew crops for home consumption. Due to new techniques. more production and more expenses exists. Machinery should be made available by the government for farmers, without costs. Her 12 acres are barren, her son cannot cultivate these because pesticides and insecticides are too much costly.

She married 20 years ago, but wants to pray in Hadj in Saudi-Arabia. It is her hard wish that she can go. Since her marriage, at the age of 15, she only worked inside the house. She even didn't see her land, because of purdah. After 7 years of marriage, her husband died. He was the only son his parents. Her kids were too young and she had to face problems. At that time, **she** gave land to tenants. Her son started to work in '89. She cannot take care of her land, she does not know how much is produced. She cannot visit the land, otherwise she could judge. She does not know about the way of agriculture, she never went out in the field herself.

Box 2.2. Story of a mother.

Division of land in bunded units

A characteristic of the basin irrigation method is that the land is divided into different parts. By making these different parts, which consists out of land bordered by a bund, i.e. a bunded unit or a so-called basin, farmers reduce the size of the fields which are to be irrigated. Underneath, the general reasons to make bunded units and the motivation to make units of specific sizes are set out. (see also Annex 2.2).

The farmers indicated that the main purpose of creating basins is the savage of water[3]. Answers given concerning this fact are like: *'If I irrigate the* whole field, a// the water *will* spread and the force and *velocity* of water decreases, so *it* will take much time and water'.

Another important reason for creating basins, as mentioned by the respondents, is because land is never entirely smoothly leveled. The disturbance of the undulations can be overcome by making basins. In general, basins are of the same size, especially where the land is flat and not many differences in levelness are to be found. If the land is not properly leveled, farmers indicated that often six basins per acre are made. Otherwise, four basins per acre are found sufficient for cotton and wheat, and about two basins per acre for fodder and sugarcane.

Farmers mentioned that they take the crop and crop water requirements into consideration when they decide on the number of basins in an acre. Especially for fodder and sugarcane, which requires more water, less basins are made. The basins are also related to the soil type, according to the interviewed farmers. Farmers stated that more basins are made on a sandy than on a loamy soil, because they stated that more water is needed on a sandy soil.

[3] By reducing the size of the field, the advancing tront of water will reach earlier the tail of the basin (I.e more water per unit width is applied) and thus, when water reaches more quickly the end of the field, the sooner the required depth of application at the end of the field is achieved (personal communications with I.M. Kalwij).

However, farmers have their limitations in deciding the number of bunded units. They mentioned that if they would make fewer basins per acre, they would not be able to save water and the water will not be sufficient to fill the inaccurately leveled land equally. Farmers mentioned various reasons for not making more basins per acre:

- The tractor will be hindered by the bunds in the fields;
- The water will affect and damage the crop;
- Smaller basins require irrigation after every eight days;
- Water can overflow the basin and irrigation is difficult with smaller basins:
- Irrigation application involves more labor; **and**
- Chance **of** leakage's and failure **of** *nakka's.*

A working daughter

The daughter of one of the farmers told that she harvests the fodder and picks the cotton. She takes care after the cattle and cooks and cleans. Of the farmers with cattle, the ladies have to do a lot of work. Mostly women do a lot of work. She does all the works of the house, but not all the works of the farm. The other works in the field are done by men. She does also hoeing.

Sometimes the yield of a crop is good, sometimes not. She does not know what method and practices are good for agriculture. Daily she comes to the field to help with the fodder. It is compulsory for her that she has to work here. Four years before, she started to work in the field. Before, she was student.

Her sister does not do anything. she is married. She wanted to start her studies, but she could not be able. No girl was left over in her home and her mother is too old to the work alone. For further education she would have to go to Chishtian, but her father doesn't like to let her go to college alone. She wants to do something for country, but she cannot do anything now.

If she was more educated, then she would not have to be a burden. Due to education, we can make a bright future. Now she has decided to study to get the job of teacher. Education is beneficial, when we do something for others. it is good for country.

Box 2.3. Story **of a** daughter.

Motivation for using the basin irrigation method

For farmers, the basin irrigation method is used because this method is considered as the traditional method of irrigation. Some motivations for using basins were mentioned, which were mostly related **to** economic issues **(see** also Annex Annex 2-3):

- Saving of water (in comparison with having no bunded units);
- To save money; not much inputs or labor is needed;
- Irrigation application: water flows automatically over the basin;
- Land topography: basins are very suitable in the

AGRICULTURAL PRACTICES

This section deals with the agricultural activities of the farmers, how farmers prepare the land for cultivation, and what implements they use for land preparation. Three agricultural activities are described: (i) the preparation of the bunds and the inlets; (ii) ploughing and planking; and (iii) land leveling (see also Annex **2-4).**

Preparation of the bunds and the field inlets

In general, farmers indicated that they create the bunds two times, before the *rouni* irrigation and before the first irrigation, after sowing. *Rouni* irrigation is the irrigation which is applied before the sowing of the crop, the so-called pre-sowing irrigation. If farmers apply only one *rouni* irrigation, then usually the bunds are created only once. All of the interviewed farmers mentioned the use of the *jundra* to make the bunds. The *Jundra* is a wooden tool, shown in Figure 2.2.
The inlets from the farm channel into the basins (so-called *nakka's*) may be lined (*pacca*) or earthen (*kachcha*). Farmers prefer to make earthen inlets, due to the following reasons:

- Change in the location of the *nakka* can be desirable for a more optimal water distribution;
- Concrete inlets may be damaged during land preparation, while earthen inlets can be easily repaired;
- Concrete inlets are expensive; and
- The dimension of an earthen inlet can easily be increased when required.

Figure 2.2. Making bunds with the help of the *jundra*.

Ploughing and planking

Ploughing and planking are done during the period of land preparation. All of the farmers indicated they plough the land to make the soil loose and fertile. Ploughing is done either with a tractor or with oxen. Farmers stated that they plough the land 4 to 5 times, while more ploughings are used when the soil surface is hard. The interviewed farmers mentioned that ploughing depends on the time available, the condition of the land, and the soil type. Ploughing with oxen is shown in Figure 2.3.

Figure **2.3.** Ploughing with **oxen.**

Farmers plank before and after sowing. The planking process is to break the bigger soil clods into smaller ones, which gives

the final touch of smoothness to the fields. It is done with a wooden device, the craw, which looks like a beam. Again oxen, but more often tractors, are used for dragging the craw. To improve the planking, farmers plank a field more times, specially when the soil surface has hard clods of earth. Planking is done according to the need of the land and the time available to the farmer. For every crop, in every season, the farmers apply planking.

Land leveling

When the land becomes unleveled after harvesting. it is necessary to level it again for proper irrigation applications. Leveling is done during land preparation, but every farmer has his own timing for leveling. There is a device for leveling, called the sohaga, which is a blade that can cut the soil. All of the farmers use this sohaga. Leveling is done with the tractor. If the farmer has no tractor or no access to a tractor, oxen are used.

Leveling is done by different methods. All farmers **use** their experience and eye-view to know which patches should **be** leveled. In general, farmers observe the flow of the water during irrigation to locate higher and lower patches. Farmers create bunds in the basin, whenever the leveling is too difficult (Figure 2.1). In fact, the small bunded units guide the water to higher patches. Leveling, although costly, is preferably done every season by the farmers.

Generally, the practices of farmers for land preparation are almost the same. Every farmer has his own slight differences in the method he uses for land preparation, according to different conditions like availability of water (own tubewell), availability of tractor, or land holding size.

IRRIGATION PRACTICES

There are two irrigation seasons: kharif, the summer season (from May to October) and *rabi*, the winter season, covering the rest of the year. In kharif, the major crop is cotton, while in rabimainly wheat is cultivated. During the whole year, fodder and sugarcane are grown. Only in W/C Azim 111-L. sugarcane is not a common crop. This section will be dealing with the irrigation practices in the following sequence: (i) the number of basins which are irrigated at once; (ii) the *rouni* irrigation; (iii) the interval between the irrigation events; and (iv) the duration of an irrigation event.

Number of basins simultaneously irrigated

Most of the interviewed farmers in W/C Fordwah 14-R, W/C Fordwah 62-R and W/C Azim 111-L irrigate the basins one-by-one. The main reason mentioned is that farmers can save water (and time) if they irrigate one basin at a time. Further, if they would irrigate more basins at once, the total time to irrigate the basins would increase and less basins could be irrigated in an irrigation turn. Quoting a farmer: 'If I would irrigate two basins at the **same** time, the velocity of wafer

decreases and the basins would **get *more time*** to ***fill. So*** *I* irrigate the basins *one* by one.'. Additional responses are presented in Annex 2-5.

Six farmers prefer to irrigate more basins at once to save time, water and labor. Different situations are given in which it is possible to irrigate more basins at once:

- Lower situated basins with respect to the farm channel;
- High water discharge (mostly mixed tubewell and canal water);
- When the soil has some moisture:
- When the crop is older and roots more developed;
- Two farmers irrigate sugarcane with two to three basins at once because sugarcane needs more water and is not very sensitive to water; and
- In winter, due to higher advance rate according to one farmer.

Rouni irrigation

Rouni irrigation is the pre-sowing irrigation, which is part of the land preparation procedures of the farmers. The purpose of the ***rouni*** irrigation is ***to*** make the soil soft, like one farmer stated: 'How ***could I be*** able *to* ***use the plough*** in ***the land*** without ***rouni irrigation?'***. Moisture is added to the soil, which is used by the seeds for germination. Furthermore, the salts, which are present on the soil surface, will be leached out. Also, a mentioned advantage of the *rouni* irrigation Is that weeds will appear after the rouni irrigation, which can be easily removed at that time (i.e. the crop is very small). The application of rouni irrigation is related to certain factors according to the farmers (see also Annex 2-6). These factors are:

- Crop type (e.g. cotton receives two ***rounis,*** wheat one *rouni*);
- Time a farmer has for application of rouniirrigation:
- Water supply (two rounis are preferred, but due to shortage of water, they are not always applied);
- Weather (evaporation rate is lower in the winter, therefore, one *rouni* would be sufficient): and
- Soil (e.g. hardness due to salinity requires two rounis).

Seventeen out of the eighteen farmers make the same amounts of basins per acre for the rouni irrigation as for the following irrigations. With the rouni irrigation, in general, the duration of application of an irrigation is longer (5 to 10 minutes) than for the other following irrigation events. For a rouni irrigation, it takes longer to irrigate the basin, since the soil is dry and much water infiltrates.

Irriuation interval

The decision when to irrigate a crop is, in general, based on the condition of the crop. Only four farmers stated that they take the condition of the soil into account when deciding whether or not a basin needs to be irrigated. In Annex 2-7, additional details are given for this section. Most of the farmers indicated that their experience helps them in this decision. All farmers check the leaves of

the crops. Either the position of the leave, whether a leaf is turning down, or the color of the leaves (fading, pale) is a criteria used by the farmers to decide when to irrigate. Most of the farmers go to the field in the morning, or in the evening time, to check whether irrigation is necessary. One farmer answered: 'A ***farmer is he who is living in his fields'*** in response ton the question about when he would go to the fields to check the crop water demand.

The intervals, as mentioned by the farmers, are given in the Tables 2.3, 2.4, and 2.5 for W/C Fordwah 14-R, W/C Fordwah 62-R and W/C Azim 111-L, respectively. The most important factors, as perceived by the farmers, which determines the irrigation interval are:

- Crop demand: all farmers mentioned that they keep the interval according to the needs of the crop. Like one farmer said: "***If*** you ***are hungry, then you eat. If the crop needs water, then I irrigate".*** The strategies of farmers, related to agricultural and irrigation practices for the crops, as well as the preferences farmers give to certain crops are provided in Annex 2-8;
- Rooting depth of the crops: cotton roots go deeper in the soil as compared with the roots of fodder;
- Growth stage of the crop: younger crops are irrigated more frequently; at fruiting stage the crop is more sensitive to water;

Table **2.3.** Irrigation schedule and number of irrigation **applications** for different crops **in W/C** Fordwah **14-R.**

W/C	ordwah **14-R**					
Farmer:	1	2	3	4	5	6
Cotton						
1st irr	40	40-50	40-45	30-40	30	60
Next	15	10-15	15	12-15	14-15	8-10
No. of irrigations	6-8	8	7-9	6-7	7-8	5-6
Wheat						
1st irr	18-20	20-25	22-30	25-30	20-21	15
Next	15	15-20	15	15-20	15/20-25	14-15
No. of irrigations	3-4	6	7-8	5-6	5	6-7
Winter fodder						
1st irr	at sowing	---	at sowing	---	at sowing	---
Next	8-15	---	7	---	8-10	---
No. of irrigations	---	---	8-9	---	24	---
Summer fodder						
1st irr	8-10	---	---	20-25	---	20-25
Next	8-15	---	---	7	---	15
No. of irrigations	---	---	---	14-15	---	10
Sugarcane						
1st irr	---	---	---	30	---	---
Next	---	---	---	10-12	---	---
No. of irrigation!	---	15-20	---	22-24	---	---

(intervals are g n in days)

- Previous cultivated crop (when rice is grown as a previous crop, the soil still contains moisture):
- Soil type: the interval is in general shorter on a sandy soil than on a clay-loam soil;
- Weather condition: the irrigation interval increases during cooler weather conditions (evaporation rate and rainfall are less);
- Amount of water available; and
- Occurrence of inter-culture.

When more days are kept between the Irrigation applications, the plants will suffer due to drought and there will be yield losses, according to the interviewed farmers. If less days are kept between the irrigation applications, the crop may suffer from waterlogging and wetness, while seeds will not germinate due to compaction of the soil by the irrigation water. Furthermore, the problem of weed growth will arise according to the farmers when irrigation applications are more frequent. For cotton, the height of cotton also counts, which will increase rapidly with a shorter irrigation interval, but there will not be many flowers and the yield will be less.

The irrigation interval between the different irrigation events, as given by the farmers, is varying between 2 to 4 weeks (see also Annex 2-9).

Table 2.4. Irrigation schedule and number of applied Irrigation applications for different crops in W/C Fordwah62-R.

W/C	'ordwah 62-A					
Farmer:	7	8	9	10	11	12
Cotton						
1st irr	20-22	15-21	40-45	25	30	30-45
Next	15	15	15	22	15	15
No. of irrigations	6	6	6-7	8-10	10-11	10-11
Wheat						
1st irr	20-24	15-21	30	'15	20	15-20
Next	15	15	15	15	15	15
No. of irrigation5	5	6	4-5	5-6	6-7	4-5
Winter fodder						
1st irr	---	15	at sowing	At sowing	at sowing	at sowing
Next	---	8	7	8	---	15
No. of irrigation:	---	24	24	24-25	24-25	24
Summer fodder						
1st irr	7-8	8	20	8-10	---	---
Next	7	---	---	---	---	8
No. of irrigations	5	---	4-5	3-4	5	---
Sugarcane						
1st irr	---	at sowing	at sowing	---	---	---
Next	---	'nd 30, then	7-8	---	---	---
No. of irrigations	---	18	32	---	40-45	---

(intervals are giver days)

Table 25. Irrigation schedule and the total number of Irrigation applications for different crops in W/C Azim 111-L.

W/C	Azim Ill-L					
Farmer:	13	14	15	16	17	18
Cotton						
1st irr	30-40	30-35	60	60	60	30
Next	15-20	10-12	20-25	15	15	15-20
No. of irrigation:	6-7	7-8	4-5	5-6	20	5-6
Wheat						
1st irr	20-25	18	21	18	30	15
Next	20-25/15-20	12	35-40	---	30	15-20
No. of irrigations	5	6	4	5-6	4	4
Winter fodder						
1st irr	---	at sowing	at sowing	---	at sowing	at sowing
Next	---	---	35-40	7	7	---
No. of irrigation:	---	7-8	4	15	25	---
Summer fodder						
1st irr	---	25	30	---	---	15-20
Next	---	---	---	---	---	15-20
No. of irrigation:	---	---	---	---	---	12-14

(intervals are given days)

Irrigation duration

The interviewed farmers mentioned different methods for setting the irrigation duration. During the night, the farmers indicated that they irrigate a basin by approximation, by estimating the time of water application. At daytime, various strategies exist concerning when the water supply to the field is shut off:

- When the water reaches the tail end of the basin;
- When all of the higher spots in a basin are covered with water if land is unleveled;
- When the water reaches to a certain distance (16 feet to 32 feet) from the tail of the basin; and
- When a certain water depth is reached in the basin, e.g. 3 to 4 of water;
- When a certain water depth is reached at the tail end of the basin.

Generally, farmers stated that they prefer to irrigate during daytime, so that they are able to check the irrigation properly, and, of course, so that they can have a proper rest during the night.

In Annex 2-10, the time duration to irrigate an acre is given for canal water, for tubewell water, and for mixed canal and tubewell water, as mentioned by the farmers. Also, some more answers by the farmers are elaborated in Annex 2-10. The average time to irrigate an acre with canal water varies around 60 to 150 minutes, while with tubewell water, figures such as 80 - 120 to 180 - 210 minutes/acre are given. These figures depend on the discharge of the irrigation water, the soil type, the irrigation practices, the climate, and the size and situation of a basin, as mentioned by

the farmers. The amount of acres that can be irrigated per irrigation turn depend, according to the interviewed farmers on:

- Field location: near the watercourse, more fields can be supplied with water as compared with being far away from the watercourse;
- Climate: farmers stated that in the summer less acres could be irrigated than in the winter;
- Water level in the canal: if the canal is full, more acres can be irrigated per turn:
- Irrigation schedule: farmers choose the optimal amount of basins to be irrigated, depending on the water amount available;
- Availability of tubewell water: to supplement the canal water; and
- If only tubewell water is used, the irrigation schedule and number of acres to be irrigated in **one** turn becomes very easy to handle (W/C Azim 111-L).

Arrangement of irrigation water

For W/C Fordwah 14-R and W/C Fordwah 62-R, the warabandi turn of the canal water comes for a farmer after 7 days, which is interrupted by approximately one month during the months December and January for the maintenance of the canals. All of the interviewed farmers are using tubewell water to supplement the canal water for cultivation of their crops. Farmers located in W/C Azim 111-L mentioned that they are not receiving canal water at all and are only irrigating their lands with tubewell water[4]

Three of the interviewed farmers do not have a tubewell, while two farmers have a share in a tubewell. These shared tubewell owners indicated that there is a kind of warabandi, an irrigation rotation for the use of the tubewell water. The farmers without a tubewell mentioned that they pay rent to a tubewell owner for operating the tubewell, and thus, for irrigation purposes (a farmer only does this practice if he has sufficient money available). To decide whether tubewell water should be used as a substitute, or in addition to canal water, the farmers mostly check the water level in the distributary, or pay a visit to the head of the distributary.

There are three situations in W/C Fordwah 14-R and W/C Fordwah 62-R, according to the farmers, related to the arrangement of irrigation water (see also Annex 2-11). In the first situation, there is sufficient canal water available to irrigate all of the fields that are in need of irrigation water. In this case, the farmers only use canal water. The second situation occurs the period that the farmers do not have access to canal water (either their turn is finished or the canal is closed) and there are fields which have to be irrigated: then the farmers make use of only tubewell water. The third scenario concerns the situation in which the farmers make an inventoty of the fields which have to be irrigated, and notice that the coming canal water turn will not be sufficient to irrigate all of these fields. At that moment, most of the farmers indicated that, when it is possible, they will mix the tubewell water in the canal water. One farmer stated: '*I will* not sleep *easily* if the remaining acres, which are demanding wafer, are not irrigated.'

Similar to the situation when the farmer only uses canal water, most of the farmers irrigate the basins one-by-one with tubewell water. Reasons given are e.g. tubewell water is costly, therefore careful application is necessaty for the equal distribution of water. In practice, when only tubewell water is used, it takes a longer time to irrigate a basin, since the discharge for most of the tubewells is lower (i.e. about 1 cusec) than the canal water discharge. One farmer mentioned that the period when he will irrigate with tubewell water depends on 'his pocket', if there is no money he stated '*I* will *leave the* crop for Allah'.

Farmers have no fixed time in which tubewell water is applied to the fields. All depends on the crop demand, the crop type, weather and the availability of canal water. Farmers mentioned that in the summer, they use tubewell every week or even twice a week, while in the winter the tubewell may be used only once in two months.

A mixture of canal and tubewell water is generally preferred for the following reasons:

- Tubewell water is not of good quality;
- They are forced to mix the tubewell and canal water because there is only one watercourse;
- The discharge is higher; fields can be irrigated in less time, and thus, more acres can be irrigated during an irrigation turn. Like one farmer said: '*The* force of *the* wafer increases and one basin *is* irrigated in less time.'

Sometimes, farmers are not able to mix, because tubewell water cannot be arranged or the watercourse is too small. Mentioned problems concerning the arrangement of tubewell water use are also related to the non-availability of a tractor and diesel shortage.

GENERAL CONSTRAINTS EXPERIENCED BY THE FARMERS

Fifteen of the eighteen farmers stated that their major problem was connected with the supply of the canal water. The farmers in W/C Azim Ill-L complained that no water at all was coming[4]. Other farmers stated that not sufficient canal water is available. Four farmers stated that whenever they need water, canal water is not available. And, when irrigation water is not required, the canal water is available

Other problems are related to the availability of pesticides, insecticides and fertilizers. Black marketing, high prices and impure sprays are the most often heard complaints. Six farmers complained about the pesticides, while half of the interviewed farmers mentioned their problems associated with the fertilizers. Four farmers have the perception that electricity, and diesel and

[4] W/C Azim 111-L faces major problems concerning canal water supply. Basically, Azim Ditributary only receives water during kharif season (semi – perennial canal); however, it is claimed by the farmers that the water is taken by the big landowners in the head reach of the distributary. Hardly water can be observed further downstream in the distributary. For this reason, farmers do not follow any warabandi in reality and only rely on tubewell water lor irrigation pusposes (note I.M. Kalwij).

fuel rates are too high, while five stated that loans are hard to get, either high rates or bank personnel have to be bribed before a loan can be taken. Three farmers mentioned the fact that when they sell the crop, the prices are low, while when they have to buy any kind of crop, the prices are high.

Other problems mentioned are the money shortage, problems with transportation, with the sodicity and salinity of the soils, with non-availability of the government announced seeds, non-availability of tractors when the sowing period has come, and the agricultural implements are at that time only available at high rates. Only one farmer indicated that he has no problems, and ***'that when money is available to him, everything is easily available'.***

CHAPTER 3 FARMERS' PERCEPTIONS AND PRACTICES ON FURROW AND BED – AND – FURROW IRRIGATION METHODS

INTRODUCTION

This chapter deals with Topic 2, as described in Chapter 1, which concerns the perceptions and irrigation practices of farmers who are using the furrow and bed – and – furrow irrigation methods. During the late sixties, the furrow irrigation method was introduced to the farmers in Pakistan for the cultivation of vegetables and fruits. Throughout the counttyside this type of cultivation can be observed.

During the last years quite some large farmers have switch from basin to bed – and - furrow irrigation method for cultivating cotton crop. Additionally, more farmers have started using the furrow irrigation method for other crops, such as maize, sunflower and potato. However, farmers with small land holdings, or less financial resources remained, confined to the basin irrigation method for many reasons as discussed in Chapter 2. The farmers who are using the furrow or bed - and - furrow irrigation methods have identified the many advantages of the irrigation method. It makes water saving possible, which is crucial for irrigated agriculture, especially with the growing demand on agricultural production due to the increasing population.

In fact, many advantages can be ascribed to the furrow and bed - and - furrow irrigation methods. As described in Walker, **W.R** and **G.V.** Skogerboe, **1987:** ' *furrows provide better on-farm wafer management capabilities under most surface irrigation conditions. Flow rate per unit width can be substantially reduced and topographical conditions can be more severe and variable. A smaller wetted area can reduce evaporative losses on widely spaced crops. Furrows provide operational flexibility important for achieving high efficiencies for each irrigation throughout a season. It is a simple (although labor intensive) matter to adjust the furrow stream size to changing intake characteristics by simply changing the number of simultaneously supplied furrows*'.

In this chapter, different issues are discussed based on the interview held with the farmers who are using the furrow and bed – and - furrow irrigation methods. This chapter addresses the socio - economic background of the farmers, facets about the furrow and bed – and – furrow irrigation methods and the related irrigation practices, the motivation for shifting from basin to the furrow and bed – and - furrow irrigation methods, along with advantages and disadvantages of these irrigation methods.

Eight farmers have been interviewed in the command areas of Fordwah and Azim distributaries, while two farmers were located outside these areas. Additional to these farmers, some information from four farmers, which were interviewed Topic 1, is included in this chapter, since it turned out that these traditional farmers were using the furrow irrigation method for certain crops.

SOCIO-ECONOMIC SETTING

As indicated in the introduction, most of the farmers using the furrow and bed – and - furrow irrigation methods are larger farmers with a considerable amount of land and resources for purchasing agricultural inputs. Table 3.1 shows the farmers' land holding-size and labor availability, while Table 3.2 indicates which main inputs are available to the farmers. Out of the ten interviewed farmers, nine farmers belong to the large landowner class. One farmer has a medium size landholding.

Table 3.1. Farmers' land holding-size and labor availability.

Farmer no.	Total family Members	Full-lime labor	Part-time Labor	Own land (acres)	.ease land (acres)	Total land (acres)	Class
I	10-27	162	Hired	1200	500	1700	Large
II	7	16	Hired	150	150	300	Large
III	11	3 & 7 tenant	Hired	21	100	121	Large
IV	4	3	Hired	9	24	33	Large
V	12	9	Hired	12.5	72.5	85	Large
VI	9	6	Hired	20	80	100	Large
VII	9	5	Hired		57	57	Large
VIII	10	5	Hired	2	40	42	Large
IX	20	2	Hired	12.5	25	37.5	Large
X	9	2	Hired	20		20	Medium

Contract labor, tenants and full time labor is hired by these farmers needed in irrigation and agricultural practices. The part –time labor is hired for sowing, thinning, fertilization, spraying,

Table 3.2. Farmers' access to farm inputs.

Farmer No.	Tractor Owner	Ridger	furrow shaper	Tubewell owner	Other Income	Hire labor	Canal water
I	9			8	Y	Y	Y
II	1			1	N	Y	Y
III	2			3	N	Y	Y
IV	1			1	N	Y	N
V	1	Y	Y	share	Y	Y	N
VI	2	Y	N	2	N	Y	N
VII	1	Y	N	1	N	Y	Y
VIII	1			landowner	N	Y	Y
IX	1	Y	N	1	N	Y	Y
X	1	Y		1	N	Y	N

hoeing, picking and harvesting. At the biggest farm (Tareen Farm), about 162 full – time labors are working, and farmer no. 2 has about 16 full –time labors. The remaining eight farmers have full –time labor between 2 to 9 people.

All the ten interviewed farmers either own or have easily access to the required equipment, having their own tractors and one or even more tubewells (Table **3.2)**. The two farmers with the largest landholding, have also their own agricultural implements (i.e. bed and furrow shaper, hoeing machine, etc.). Most, of the remaining eight farmers have their own ridger.

THE FURROW AND BED – AND – FURROW IRRIGATION METHODS

Introduction

Going back to the past, some farmers mentioned the old practice for making furrows and ridges and the changes that occurred over the years. One old farmer, a father of a respondent, knew about the old method of creating furrows. They made the furrows by hand with the help of *jundra*. Afterwards, the potatoes were planted by hand in the soil and covered by hand with the help of laborers to get enough soil above the potatoes. According to him, labor is not available these days. Another farmer said that the ridger was not *so* sophisticated in the past and furrows were not so stable. In the past, they had to make different units by creating units surrounded by bunds containing a number of furrows to irrigate them. At that time, furrows were not so deep and stable and they were afraid that the water would overflow the crop. But now, there is no danger of overflowing the water, because now the furrows are made by the ridger with the help of a tractor and are more stable. Nowadays, due to the water shortages, they create small units and irrigate these units of furrows one – by - one.

Preparation practices for the furrows

The practices for the furrow and bed – and – furrow irrigation methods are quite different as compared to the basin irrigation method. Farmers have been experimenting with size, length and direction of the bed or ridges and furrows. Figure 3.1 shows a farmer creating ridges and furrows.

Plot size

The sizes of beds/ridges and furrows as found in the fields and mentioned by the farmers are mainly related to the crop type and the limitations set by the tractor use. For cotton, the bed width and the furrow width are of 2.5 feet. Cotton plants should not be close to each other, because the bolls need aeration. One furrow and one bed consists of 5 feet. In general 44 beds and furrows per acre are made (an acre has a length of 220 feet and a width of 198 feet). Cotton is sown in summer. Maximum heat and space is available, since it is sown on both sides of the beds.

Many vegetables are grown on bed – and - furrows, because after germination they require space for proper growth. If their leaves dip in the water, they will be damaged. Other crops, like maize, melon, potatoes or sunflowers are in general planted on ridges. The ridges and furrows are of 2.2 to 2.5 feet in total, which gives about 90 to 100 ridges and furrows per acre. These crops grow straight in the air and need little space for their canopy, so more ridges and furrows can be made.

Furrow length

Farmers make in general, the length of a furrow equal to the width of one acre, **198** feet. A couple of large landowners create furrows longer than 198 feet. They relate the length to the size of the plots and blocks of different acres, which exist on their farms. Two farmers create units for irrigation, which consist of ***2 kanals*** of width, which is ***55*** feet. In this unit, ridges and furrows are created of 55 feet length and **6** feet width in total. Sometimes, farmers create units of 1 *kanal* width, ***27.5*** feet. These units are made for crops which are sensitive to water, for unlevel land, and for the first irrigation events when furrows are not yet stable.

Figure 3.1. Farmer creating ridges and furrows.

The furrow length depends on the levelness of the land. If land is not accurately level, units can be created. Especially, when furrows are newly made, there can be a problem for water to flow smoohly through the furrows. All furrows are made along a straight line, because the land is level (i.e. a zero slope) and the contour lines are straight.

Furrow direction

Some farmers indicated that they change the direction of furrows with respect to the season. The direction can either be perpendicular to sun (from north to south) or in line with the sun (in east to west direction). In the winter most of the furrows are perpendicular to the sun. In this way, onion is grown on the shady side (i.e. in the west direction) which can do with **less** sun. On the sun-side (i.e. in the east direction) other crops, which require more heat for the germination of the seeds, are planted. With more sun heat, these seeds will germinate after one week otherwise it will take one month for their germination.

In summer, the beds and furrows (for cotton crop) are made along the direction of the sun (i.e. in east to west direction). In this way, both sides of the bed are receiving an equal amount of the sun heat and e.g. cotton can be sown **oh** both sides of the bed. Another advantage of maintaining this bed and furrow direction, **as** mentioned by the farmers, is that in summer the wind blows in a north-south direction. This Wind is very hot and can harm the cotton. But by maintaining the east – west direction for the beds and furrows, the crop is protected from the wind.

Motivation for the shift from basins to the furrow irrigation methods

Prior to using the furrow and bed – and – furrow irrigation method, all the farmers indicated that they were using the traditional basin irrigation method. Although, for the last many years, the furrow irrigation method has been used by most of the interviewed farmer, they came in contact with the bed –and – furrow irrigation method, especially for cotton' crop, during the last few years, through certain sources. The most common sources as mentioned by the farmers were (see also Annex 3-1):

- Informal contact with neighbors or relatives; and
- Information from research centers and institutes;

The Farmers mentioned several reasons for their shift from basin to the furrow and bed – and - furrow irrigation method. These reasons were mostly related to economic issues. The main reasons as mentioned by the respondents are briefly stated below (see also Annex 3-2).

- The profit of a crop. When the furrow and bed – and – furrow irrigation method are used, some of the farmers indicated that the provid (i.e. net income) is much higher as compared with the basin irrigation method.

- Acting upon advice of others. A couple of farmers have shifted due to changes in the physical circumstances. Increasing salinity is one of the major reason to shift. Farmers know that a crop cannot grow in basins on salt affected soils. But they know that a crop can be grown on saline land when the furrow or bed – and – furrow irrigation method is used.

- Saving of crops. The crop can be saved from damage with the furrow and bed – and – furrow irrigation methods, when rain falls within a few days after sowing. One farmer was taught by his father about the furrow irrigation method. He did not change his irrigation method, but only expanded the area under furrow irrigation method.

AGRICULTURAL PRACTICES AND STRATEGIES

The following section explains the practices of the interviewed farmers who are using the furrow and bed – and – furrow irrigation methods for cultivation. Land preparation, sowing, hoeing and harvesting are briefly discussed and further elaborated in Annex 3-3.

In general, similar practices for land preparation for the basin or the furrow and bed – and – furrow irrigation methods are carried out. Some farmers indicated that the land preparation needs to be done more intensely when using furrows, since most of the farmers have to sow by hand on the ridges or beds. For leveling, the traditional method is used by nine farmers, while only at one farm

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(Tareen Farm) is the laser leveling technique being used. Most of the farmers create ridges or beds and furrows with a tractor and ridger, a few are using a bed – and – furrow shaper for making the beds and furrows.

Most farmers sow seeds by hand on the left and right sides of the beds, at about ¾ of the depth. Farmers stated that if the seeds are sown on the top of the beds, the crop will suffer from drought. Some crops, like maize and melon in winter, are deliberately sown on only one side of the beds, otherwise, there will not be enough sun for germination. Other crops, like onion, which is planted as a seedling, can be sown on the shady side according to the farmers. Two farmers use a drill machine (i.e. planter) to sow cotton or potatoes. If cotton is sown by drill, thinning needs to be done according to one farmer. Thinning, which involves the removal of the plants which are too close to each other, is done to maintain a certain plant – to – plant distance.

Generally, farmers perform spraying by hand when the plants are small. Furthermore, almost all interviewed farmers hoe by hand with the furrow and bed –and –furrow irrigation method. Only at the two largest farms, special implements are used for hoeing purposes. Most of the farmers hire labor for hoeing, which is very costly. The majority of the farmers indicated that only limited weed growth occurs with the bed – and - furrow irrigation method. The beds will remain dry and weeds can only appear in the furrows. The interviewed farmers stated that harvesting is not difficult for the crops they sow on beds or ridges. The harvesting is done manually, which often involves for cotton several pickings at the end of the season. Generally, it is the women who are picking the cotton.

IRRIGATION PRACTICES AND STRATEGIES

Strategy of water allocation

The strategy for water allocation deals with how water is applied to the field (see also Annex 3-4). One objective of the farmers is to irrigate furrows as quickly as possible with the amount of water available. Another objective is to keep the furrows in shape and not to overflow the beds or ridges. Sometimes, the water overtops the bunds, then, the farmer closes the field inlet temporarily. In general, 7 to 20 furrows are irrigated at once, which form a unit together.

In Figure 3.2 such a unit is presented. In a basin, the beds – and - furrows are constructed. Mostly, the field has a zero slope and the lower end of the field or unit boundary is closed–end, and thus, tailwater runoff does not occur. Often, this type of irrigation system is referred to as a basin – furrow irrigation system.

According to the farmers, several factors have to be taken into account in order to decide how many furrows or units to be irrigated at the same time. These factors are:

- Discharge available at the farm or field inlet;
- Soil type;
- Furrow condition in terms of roughness (soil particles and weeds in the furrows);
- Slope of the furrows (however, mostly in this area the fields have a zero-slope); and
- Size of the unit (i.e. number of furrows).

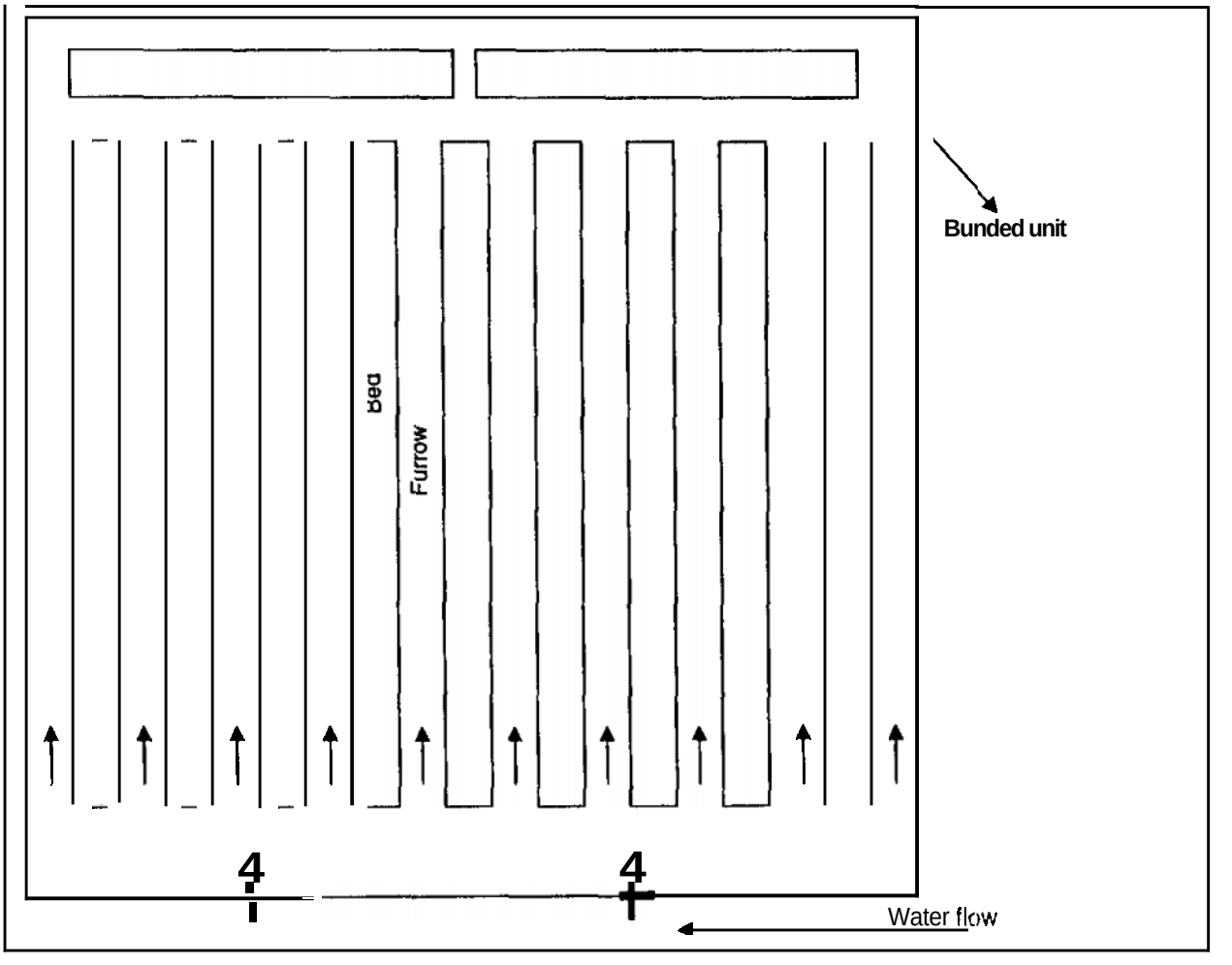

Figure 3.2. A bed-and-furrow irrigation unit.

Irrigation interval

Farmers have different strategies for irrigation application with the furrow and bed – and – furrow irrigation methods. Table 3.3 gives the intervals and duration of application as given by the farmers (see also Annex 3-5). In general, the interval depends on crop demands (Annex 3-6 shows the agricultural and irrigation practices described for different crops). Most farmers estimate crop water requirements by looking at the crop, but one farmer uses a neutron probe to determine when a crop needs water. Furthermore, the farmers indicated that the climate is on influence on the interval (e.g. an increase in irrigation interval when rainfall occurs).

In general, farmers stated that they have no problem with irrigation application for the furrow and bed – and – furrow irrigation methods. They said that the water moves quickly and irrigation can be done in a short time. They stated that to irrigate furrows, a carefully controlled irrigation is needed and mostly one person is involved full-time to open and close ***nakkas*** and to repair the furrows wherever necessary.

Overall, no *rouni* irrigation is applied by the farmers when using the furrow and bed - and – furrow irrigation methods. The absence of *rouni* irrigation is a great benefit according to the farmers. The first irrigation for the crop sown on beds or ridges is at the time of sowing. The farmers said that the seeds need this moisture to germinate. Out of the ten farmers, three farmers indicated that the first irrigation given to the furrows is a bit difficult.

Table 3.3. Irrigation applications for the furrow irrigation methods.

Farmer No.	crop	Duration (min./acre)	Irrigation interval First irrigation (days)	Later irrigations (days)	Number of irrigation events
I	Cotton	60		10-12	6-7
II	Cotton	40	--		8
III	Cotton	150	--		12-15
	Maize	--	12-15	6-8(hot)-15(cold)	15-16
IV	Cotton	45	at sowing	2nd 4, next 7-10-15	15-20
V	Cotton	75		7 days	15-18
	Maize	--		8 * 7, next 8 * 4	24
VI	Cotton	40		10-15 for all crops	5-7
VII	Potato	53		15-Ocl	7
VIII	/egetables	--	at sowing	2nd 15, next 7	--
IX	Cotton	--		7 days	14-15
X	Cotton	90	at sowing	4 * 7, next 15	16

Six farmers indicated that they keep for cotton, sown on beds an interval of 7 days in the early stages of the crop, while when the crop gets older, an interval of 10-15 days can be kept. Concerning cotton, the variety in total irrigation applications is very larger, 5 to 6 times to 25 to 30 irrigation applications, are mentioned by the farmers.

Irrigation duration

The duration of irrigation to the furrow units changed considerably among the interviewed farmers, ranging between 40 to 150 minutes.

The objectives of the farmers for the duration of irrigation are to keep the seeds of the crops dry, to take care that the furrows remain intact, and to irrigate all of the furrows. Three different strategies are followed by the farmers in order to decide the irrigation duration for a certain

number of furrows or units. The main strategies regarding irrigation duration are as follows (see also Annex 3-7):

Figure 3.3. A farmer irrigating beds - and – furrows.

1. When water reaches the tail of all furrows (used by ***50%*** of the interviewed farmers);
2. When water reaches a certain distance from the tail of a furrow (used by a few farmers); and
3. When water reaches to a certain level in all of the irrigated furrows (two farmers).

In most of the cases, the farmers use a combination of the strategies, depending upon the topography or number of irrigation events (e.g. one farmer applies for

INPUTS

An inquiry has been made about the inputs needed for the furrow and bed – and - furrow irrigation methods in comparison with the basin irrigation method. These inputs concern labor and machinery. Also, soil is considered as an input in this context (see also Annex 3-8).

Figure 3.4. Machiney at a farm in Khanpur.

In general, the interviewed farmers mentioned that labor is a very important input. In fact, more labor is required with the furrow and bed – and furrow irrigation methods as compared with the basin irrigation method. The amount of labor needed by the farmers varies from about twice as much, to ten times as much, as they would use with the basin irrigation method.

The farmers mentioned that, in the past, they have been making the furrows with jundra. Nowadays, ridgers are used with a tractor. Machinery is often rented or borrowed. Some have bought their own equipment. One farmer has his own workshop where he fabricates different farm machinery for himself and for others (Figure 3.4).

All interviewed farmers are of the opinion that a clay-loam soil, (merra soil) is most suitable for the furrow irrigation method. On a soft merra soil, farmers give preference to furrow irrigation, and on a hard (pacca *merra)* soil, the use of furrows is a must for cultivation. The farmers explained that if the basin irrigation method is used, the water will pond after rainfall and, also, when the soil **is** saline and crust formation occurs, in both of the cases the crop will be damaged.

The majority of the interviewed farmers mentioned that the furrow and bed - and- furrows irrigation methods can be used on semi-sandy land, but according to them it is impossible when the soil is sandy only. Some farmers indicated that if the furrow irrigation method is used on a sandy soil, then they will be destroyed due to the force of the flowing water. One said: "Furrows on *a* sandy soil can be broken, they cannot survive. When irrigation fakes place, the ***soil*** is *very* soft and *the* beds and furrows are damaged.

The furrow and bed – and – furrow irrigation methods are preferred by the interviewed farmers above the basin irrigation method on saline land. They mentioned that a crop can only germinate if it is sown on beds or ridges.

ADVANTAGES AND DISADVANTAGES **OF** USING THE **FURROW** AND BED - AND - **FURROW** IRRIGATION METHODS

Based on the experiences of this group of farmers, an inquiry has been made about what they consider as advantages and disadvantages of using the furrow and bed – and - furrow irrigation methods.

The advantages are categorized as follows (see also Annex **3-9):**

1. A *rouni* irrigation is not required; sowing can be done just prior to the first irrigation; The process of germination is better on beds or ridges, a farmer stated: "there is a vigorous ***start of*** the *crop':*
2. No crop losses when rainfall occurs within 2 or 3 days after sowing. Furthermore, continuous rain cannot harm the crop, because the water can collect in the furrows without damaging the crop.
3. No burning of a crop sown on beds or ridges. Moisture stays longer in the soil and it prevents the crop from burning if the temperature is extremely high.
4. Early crop maturity is achieved. The crop is ready sooner for harvesting. Furrows are especially preferred by farmers when the harvest of the previous crop is late.

5. Water is saved. The farmers mentioned that they can save water with the furrow and bed – and - furrow irrigation methods, from 30% up to 50%, while one farmer could even save ***75%.***
6. Fertilizers do not leach. Fertilizers are concentrated in furrows and the distribution **of** fertilizers can be very well controlled.
7. Seeds are better conserved (i.e. not washed out).
8. Furrows provide better crop germination when the soil is saline.
9. Some farmers mentioned that not much weeding is needed. Weeds are either removed by spraying, or hoeing by hand, or hoeing implement.
10. Higher yield and more profit is obtained with the furrow irrigation method.

The disadvantages are categorized as follows (see also Annex 3-10):

1. Labor requirement. A lot of labor is required and **thus** the expenditures do increase.
2. Sowing is difficult when it has to be done manually.
3. Access to implements, such as bed - and -furrow shaper and hoeing machine, is often difficult and, foremost, expensive to buy.
4. Weeding is considered as a problem for some farmers, since the weeds are removed manually. According to these farmers, more weeds do occur due to the frequent irrigations.

CHAPTER 4 PERCEPTIONS OF TRADITIONAL FARMERS ON THE FURROW AND BED - AND - FURROW IRRIGATION METHODS

INTRODUCTION

Chapters 2 and 3 provided insights into the traditional basin irrigation method and the furrow and bed - and - furrow irrigation methods with respect to farmers' perceptions, agricultural and irrigation practices, along with advantages and disadvantages of these methods. One important aspect remains the perceptions and interests of traditional farmers concerning the furrow and bed - and - furrow irrigation methods. This information is crucial if the potential for implementing furrow irrigation methods on small landholding is to be addressed. Next, any possible constraints need to be recognized so that appropriate solutions can be developed that are sustainable and can be successfully adopted by the farmers.

Already, some disadvantages have been addressed by some of the farmers who are a furrow irrigation method. Although, these disadvantages do not count in the same measure for each farmer, mostly they. are related to access to labor and machinery, restricted knowledge, and available soil type.

In this chapter, exclusively the opinions and answers as given by the traditional farmers are elaborated. First, the interest of the farmers in a furrow irrigation method is addressed, followed by farmers' perceptions on the furrow and bed - and - furrow irrigation methods. When was asked: ***"Are*** you ***interested in the furrow and bed – and – furrow irrigation methods?',*** the farmers often mentioned the benefits and problems they expected if they would be using a furrow irrigation method. Farmers' expressed their thinking through discussing the expected advantages and constraints concerning agricultural practices, labor, water demand and irrigation scheduling, and soil type.

For this part of the study, fourteen farmers were interviewed. They were the same farmers interviewed for Topic 1.

TRADITIONAL FARMERS' INTEREST IN THE FURROW IRRIGATION METHODS

W/C Fordwah 14-R

In W/C Fordwah 14-R, five out of the six interviewed farmers showed much interest in the furrow irrigation methods. They would prefer to use the furrow irrigation methods and mentioned (some of) the advantages, like saving of water and higher yields. Only one farmer is not interested, he

told: ***"Furrow irrigation method is not a trend here,.it depends upon the land that I use basins. My land is unleveled, due to this I need to make basins. I have used this method for so many years':*** All of the interviewed farmers of W/C Fordwah 14-R mentioned that they are not able to use the furrow irrigation method at the moment. They stated that more labor, varying from two extra laborers per acre to 10 **to 15** laborers full-time are needed for the furrow irrigation method. Four of them indicated that they also need machinery, like a tractor, rotavator and ridger for agricultural practices.

W/C Fordwah 62-R

Two out of the six interviewed farmers in W/C Fordwah **62-R** are interested in using the bed – and - furrow irrigation method. These farmers see more profit, but for various reasons including soil type (i.e. having lighter soils), water shortage and lack of agricultural tools they are not able **to** use furrows at the moment. One farmer mentioned that his water supply could not match with the demand of the crop on furrows. For this farmer the soil is too light, so there is not enough compaction to obtain stable furrows. Another farmer lacks the agricultural **tools** that he assumes to ***be*** required for the furrow irrigation methods. Without these constraints, the farmers are interested in furrow irrigation methods.

An old farmer said he does not like furrows and has no interest. Basins are ***so*** much easier for him **to** use and, even if all machinery is provided, he would prefer the basin irrigation method because it is ***so*** familiar **to** him. Another farmer agreed that irrigation is easier with basins. His main argument was that a tractor can be use on basins, but not with the furrow irrigation method. Two farmers in W/C Fordwah **62-R** have tried to use the furrow irrigation method but have had bad experiences and are therefore not interested anymore. One stated that his crop suffered from drought due to the sandy soil. He explained: ***"Due to furrows in a sandy soil, the wafer cannot reach the roofs of the crop. The water infiltrates quickly and the crop stands dry.".*** The other farmer indicated that too many weeds occur when furrow irrigation methods are used; also, due to his fixed warabandi turn, he will not able **to** supply the required water at the right time.

W/C Azim 111-L

In W/C Azim 111-L, two farmers who are not using a furrow irrigation method at the moment are showing interest. One **of** them indicated that he has no constraints for using a furrow irrigation method and is going to use bed - and - furrows for the coming cotton season. The other farmer, who is a tenant, would use the furrow irrigation method if the landowner tells him **to,** since the landowner decides which irrigation method is to be used. He indicated that he has no constraints regarding any of these irrigation methods. **He** also stated, ***"Allah knows better".*** Some farmers in these areas already have bed - and -furrows.

THE PERCEPTIONS OF TRADITIONAL FARMERS ON THE FURROW IRRIGATION METHODS

The perceptions of the farmers are noted according to the following topics: crops, agricultural practices, labour demand, water demand and irrigation scheduling, and soil type.

Suitability of furrows for different crops

Nowadays, farmers cultivate cotton with the basin irrigation method. In general, the method is used which is described in Annex 2-8. However, the respondents clearly defined advantages of furrows, such as:

- Cottonyield is higher;
- Water is saved;
- Water will not overflow cotton sown on beds;
- Irrigation can be better controlled;
- Rainfall within two or three days after sowing will have no adverse effects on germination;
- Growing conditions (moisture, sunshine and air) are beneficial for cotton; and
- The roots can easily extract the moisture from the soil, since the soil remains soft.

A disadvantage as mentioned by a farmer is that due to the loose soil, the cotton seeds can go too deep into the soil and therefore not germinate. Two other farmers mentioned that the soil texture and quality have an impact on the use of the furrow irrigation method and, thus, have to be taken into account when the suitability of furrows is investigated.

Concerning the suitability of the cultivation of sugarcane on furrows, different farmers commented as follows:

- With more soil around the roots, more roots can appear and sugarcane gets support;
- Roots will be provided with good fertile soil, moisture and air; and
- Not enough soil is above the seeds, therefore, sugarcane cannot germinate on beds.

Due to the last factor, it is not possible to grow sugarcane with the furrow irrigation method, according to all of the interviewed farmers.

With respect to vegetables, most of the vegetables are already grown on beds, however, on very small plots. The farmers explained that vegetables should not be soaked in water, since vegetables are very sensitive to water. Other types of vegetables, like carrots, are grown often in basins. Farmers indicated that with the furrow irrigation method water can be much better controlled. Another reason given by a farmer is that the germination takes place in the sub-soil, therefore furrows with loose soil are better for germination. One farmer explained: "I use furrows, because vegetables grow under the ground, not on the surface. Potatoes and radishes are roots

of the ***plants, so it can grow beffer in more soil on furrows.",*** According to the farmers, there is a higher yield of vegetables when grown on beds and irrigated with furrows. Additionally, vegetables, growing on beds, ripen more quickly and, thus, can be sold earlier sold at the market.

For wheat, as well as fodder, the farmers do not consider furrows suitable.

According to the farmers, the yield is good for cotton and vegetables when the seeds are sown on beds. With the bed - and - furrow irrigation method, two crops can be grown at the same time, like sugarcane or cotton with onion. But wheat and fodder give better yield in basins. According to four farmers, the yield is not affected by the irrigation method. Different replies were given related to the yield, such as: ***"basinsgive good yield and are suitable for all crops: "if the soil is good, basins are good for yield"*** and ***"the yield depends upon Allah':*** One farmer raised the issue of experience. He mentioned that an increase of yield is related to the experience that a farmer has.

Agricultural practices

Land preparation

All of the farmers who are using basins indicated that the two irrigation methods require a similar type of land preparation. This procedure for land preparation is described in Chapter 2. Farmers mentioned the related constraints that are expected with respect to land preparation for furrow irrigation:

- After creating beds or ridges and furrows, planking, ploughing or ridging cannot be done;
- No machinery is available for land preparation;
- A tractor cannot move in between the beds or ridges and furrows:
- A rotavator is needed after harvesting a crop; and
- Much work is involved if beds or ridges and furrows are made with the *jundra.*

Sowing

All of the interviewed farmers expected that with a furrow irrigation method, they would have to sow every seed separately by hand. Farmers think that hard work and more expenses for hiring laborers are required for sowing on beds or ridges. Furthermore, three farmers assumed that fertilizers and seeds are more effective with bed and furrows as compared with basins. It was mentioned that when using bed and furrows, the fertilizers are concentrated in the furrows where the water is flowing. In basins, the seeds can be wasted according to the farmers, but on beds they are carefully sown by hand and are not washed away.

Hoeing

In general, farmers are of the opinion that hoeing will be problematic with the bed - and - furrow irrigation method. They expect that the hoeing will be difficult due to the beds or ridges and furrows and more laborers, money and hard work are required to remove the weeds. According to some of the farmers, weeds will grow quicker due to more frequent irrigation.

Harvesting

Farmers expect that harvesting will be similar for bed - and - furrow as for the basin irrigation method, since for both methods harvesting is done by hand. Several farmers mentioned that harvesting on beds or ridges must be difficult due to unleveled land created by the beds or ridges and furrows.

Labor demand

The labor requirements are difficult to predict for the farmer. The following figures give only a rough indication. The difference in labor demand for furrows and basins depends on the type of agricultural practice. For land preparation, equal time and labor is generally assumed to be needed for furrows and for basins. Some farmers indicated they need more labor for bed – and - furrows because more ploughings will be required according *to* them. The lime needed to make furrows depend strongly on the availability of a ridger. A farmer, who would have to make the furrows by hand, indicates that 36 times more labor is needed to make the furrows compared to making basins. Other farmers think that 3.5 to 10 times more labor is required for making the furrows.

For sowing, 2.5 to 10 times as much labor is assumed to be required for sowing on beds as compared with basins. The farmers mentioned the high labor input for sowing on the furrow irrigation method as a constraint to apply furrow irrigation. The farmers differ widely in their opinion about the labor demand what would be required for hoeing. Some farmers expect that the same amount of labor would be needed, while others think that about 3 times as much labor is required on furrows as compared to basins. For harvesting. the same labor is required for furrows and basin irrigation.

Overall, the major labor demand which are expected by farmers are for hoeing, sowing and creating furrows, in case they are made by hand. In this case, additional labor has to be hired.

Water demand and irriqation scheduling

With respect to the irrigation application and water demand, all farmers expect that the application of irrigation water is not more difficult with the furrow irrigation method. Some issues raised were:

- Better control over the water supplied:
- Same amount of labor is needed to irrigate as with basins;
- Water flows quickly, furrows can be irrigated in a shorter period;
- If required, the higher frequency of irrigation can be problematic due to the availability of irrigation water; and
- Irrigation will be easier with furrows, because the water flows only in the furrow and is more leveled as compared to basins.

Table 4.1. Farmers' expectations towards Irrigation application practices for furrows and basins.

Fanner No.	Irrigation Furrow (hour/acre)	basin (hour/acre)	rrigation interval furrow (days)	Basin (days)	No. of Irrigations	No. of rrigations
1	1	2	20	15	3	4
2	3	3	15	10		
3	1,5	2	7	15		
4	1	2	14	14		
5	1	2	15	15	7-8	7-8
6	1	2	7	15	8-10	6
7	1,5	2	7	15		
8	1	2	7	15		
9	1	2	15	15	4-5	5-6
10	1	0,5	15	15		
11	1	2	?	?		
12	1-1.75	2	?	?		
13	1.5-2	4	7	15	10-12	4-5
18	2	3	4 * 5, then 15	15-20		

Table 4.1 shows the irrigation timing, interval and number of irrigation for the furrow and basin irrigation methods as mentioned by the farmers. The majority of the farmers (eight out of the fourteen) expect that with the furrow and bed – and – furrow irrigation methods, the duration of water application per acre is about half as long as on basins. One farmer mentioned that he would irrigate furrows as long as basins: otherwise the water will not reach the roots in a sufficient manner.

Two of the interviewed farmers would apply water to basins more frequently as compared with bed - and - furrow or furrow irrigation methods, while four farmers expect the same interval with the furrow and basin irrigation methods. However, five farmers would apply water with a smaller interval for those crops irrigated by beds - and - furrows as compared with basins. On average, it is expected that - when using beds – and - furrows or furrows - an interval of 7 days should be kept, while with basins, an interval of 10 to 15 days can be applied. So, more irrigation applications are expected when the furrow and bed – and – furrows irrigation methods are used. However, a few farmers had no idea about how long to irrigate furrows.

Eight farmers have the expectation that with the furrow irrigation methods, about 50% of the water amount is needed as compared with the basin irrigation method. Other farmers think that the water use is about 20% to 33% less on furrows as compared to basins. Water can be saved because with the furrow irrigation method water is used more efficiently. Due to furrows, the soil is loose and absorbs more water. It takes more time before the soil dries out; the moisture is better conserved in the soil and more moisture is available to the plant.
Only one farmer believes that an equal amount of water is used with basins and with furrows. And, two farmers were of the opinion that more water, up to twice as much, is used with the furrow irrigation method.

Soil type

Three different soil types, which are common in the command areas of Fordwah and Azim distributaries are discussed: (i) a clay-loam soil (so-called merra soil); (ii) a sandy soil; and (iii) a salt affected soil. In general, farmers mentioned that both irrigation methods can be used on a merra soil. A few farmers mentioned that they would prefer to use the bed – and - furrow irrigation method on a merra soil, especially when it concerns a hard merra soil. This, because the iinfiltration rate is low for a hard soil and when the crop is planted on the bed, the crop will not be inundated by water. Most farmers mentioned that the crop choice will determine which method to use.

When it comes to sandy soils, different opinions were given by the farmers. Eight farmers prefer basins, especially in a pure sandy soil for the following reasons:

- The formation of beds or ridges and furrows is problematic;
- Water will infiltrate and evaporate quickly and will not be able to reach the roots of the plant properly: and
- The soil will be heated due to less water; and due to this heat, the crop will burn.

Two farmers assumed that on a sandy soil (but not a pure sandy soil), the furrow irrigation method should be used. Two other farmers were of the opinion that both of the irrigation methods are suitable on sandy soils since it is the crop choice that is determining which irrigation method to select.

The interviewed traditional farmers are of the opinion that for the case of saline land, only the furrow irrigation method is suitable. Different reasons were given such as:

- Due to frequent irrigation, the soil will become soft and water can infiltrate;
- Moisture remains longer in furrows;
- The roots are able to extract water;
- The infiltration rate is low on a saline soil; the ponded water will damage the crop in basins, but not when the crop grows on the beds:
- Gasses will appear from the saline soil due to hot weather; when crops are growing on beds, they will not be damaged and
- A crust will appear on the soil surface when basins are used, which will disturb the crop germination.

However, three farmers stated they prefer basin above the furrow irrigation method for saline land. According to these farmers, the salinity will come up to the surface if the furrow irrigation method is used and the seeds will not germinate. Most of the interviewed farmers are of the opinion that the salinity problem is not related to any kind of irrigation method, and, thus, salinity will not increase nor decrease by selecting one or the other method. A reduction of salinity can only be achieved by using canal water for irrigation.

CHAPTER 5 SYNTHESIS AND CONCLUSIONS

INTRODUCTION

In Chapters 2, 3, and **4,** all of the findings have been presented concerning the interviews conducted with respect to the different aspects pertaining to the (i) traditional basin irrigation systems; (ii) furrow and bed - and -furrow irrigation systems; and (iii) traditional farmers' interest in furrow and bed – and - furrow irrigation systems.

In the following section, the perceptions of traditional farmer and progressive farmers has been highlighted. This has been based on interviews conducted with both groups of farmers through a special exercise whereby the focus was on comparing the irrigation, cultural practices, crop choices and inputs for the basin as well as furrow and bed - and - furrow irrigation systems. In the last section, the conclusions are presented, built around the question on what the possibilities are for the farmers to use furrow irrigation methods.

SYNTHESIS

Irrigation method

Box **5.1** shows the comparison of the opinions by the farmers for the irrigation method that is applied. The progressive farmers mentioned more factors which they consider as important for the creation of beds or ridges and furrows, like sunshine and wind direction. The requirement or access to machinery (implements) should also be taken into account in creating furrows according to the progressive farmers, which are mostly not available to the traditional farmer with small landholdings. This is also considered as a main constraint for the small farmers.

The strategies on deciding the number of basins, or number of furrows per basin, do not differ much between the two methods. Soil type and quality, crop choice, topography, water availability, and machinery availability. It appeared that for having good-shaped bed - and – furrows, and for its maintenance, access or possession of good machinery is an asset. Additionally, more labor is required. The amount of labor becomes even more when the preparation of bed – and - furrows, sowing and weeding is done manually. Labor is the main aspect mentioned by the farmers using bed – and - furrow but who are not so well equipped with machinery. Traditional farmers foresee this as a main constraint for their farming system.

Box 5.1. Comparison of Irrigation methods.

Traditional farmers about the basin irrigation method	**Progressive farmers about the** furrow Irrigation methods	**Traditional** farmers about the furrow Irrigation methods
Farmers' strategies for making bunds, once or twice, are set according to their ways of land preparation and whether the farmers apply one *rouni* irrigation or two. Bunds are made with *jundra*. Farmers make bunds the first time before *rouni* irrigation and the second time they make the bunds after sowing. In general, farmers make 4 to 6 basins in one acre. If the land is leveled, 1 or 2 basins/acre can be sufficient. Basins are made to save water, according to the crop, the levelness and roughness of the land, and the labor requirement.	In general, farmers first make furrows along the total length of the field. For some crops, the field is divided into units by making small feeder canals. The number of bed or ridges and furrows depends on tractor tires, slope of land, crop type, sun and wind direction. For cotton, in general, 40 - 44 beds and furrows per acre are made. For sunflower, melon, potatoes 90 to 100 furrows per acre. Some farmers change the direction of furrows with respect to season In summer, along with the sun direction, but in winter perpendicular to the sun direction.	There is no information on whether the farmers think that the division on land for furrows is difficult or what their strategy would be to divide the land in furrows.

Crops

Eight of the progressive farmers indicated that wheat, fodder and sugarcane cannot be grown with the furrow irrigation method. The traditional farmers also expect that the production of wheat and fodder will not be high if they are sown on beds. Whether furrows are suitable for irrigation depends mainly on the crop. According to the farmers, certain crops are not suitable to cultivate with the furrow irrigation method, due to their rooting system, canopy, and air, water and sun requirements. The interviewed farmers indicated that of the crops grown nowadays in the research area, only cotton and vegetables can be grown on beds and wheat and fodder should be grown on basins. (see also box 5.2).

Agricultural practices

In Box 5.3, a comparison of the agricultural practices is given. According to almost all of the interviewed farmers, the land preparation activities, like ploughing, planking and leveling, are similar for the basins as for beds or ridges and furrows.

Box 5.2. Comparison of **crops.**

Traditional farmers about the basin irrigation method	,Progressive farmers about the furrow Irrigation methods	**Traditional farmers about the** furrow irrigation methods
Main crops are cotton, wheat, sugarcane and fodder. These crops are all cultivated in basins, of which for conon and for sugarcane, corrugations are made. These small furrows provide support to plants and cover bare roots again. This method is good for crops like fodder and wheat, which require much water and are dense in nature.	The main crops grown are cotton, maize, sunflower and vegetables, but these farmers cultivate wheat, rice, sugarcane, and fodder on basins. Farmers think the required density of wheat, fodder and rice does not make these crops suitable for furrows. Only a few farmers would like to sow wheat and fodder on beds. For cotton, in general, there is a higher yield on furrows, like vegetables, maize and sunflower.	Farmers think that the growing conditioris on beds or ridges are good, as plants gets more support, the roots of the plants can extract water from more subsoil and the yield is good for cotton and vegetables when sown on beds. Farmers stated that the furrow irrigation methods are not suitable for wheat and sugarcane. And the yield of wheat and fodder is not good if grown on beds or ridges.

Only four farmers, of which some are using the furrow irrigation method and some not, indicated that the land needs to be prepared better for the furrows irrigation methods. Three traditional farmers expect that a tractor will not be able to move in between the beds or ridges and furrows. According to the farmers who do use the furrow irrigation method, this is not the case. They are able to use a tractor for agricultural practices, especially if furrows are made over the entire length of the acre.

Concerning sowing, all farmers mention that on basins the sowing can be done by the broadcasting or drilling method. But the traditional farmers expect that the sowing on beds needs to be done by hand. This is not according to the practices of three farmers who use beds - and - furrows. They are able to use a special drill to sow the seeds of cotton or potato. About hoeing, the farmers have very different opinions. Some farmers who are using the furrow irrigation method mentioned that more hoeing needs to be done on beds – and - furrows, while others mentioned that there is no need of hoeing. One farmer has his own hoeing machine, while all other farmers are hoeing by hand. The traditional farmers are, in general, expecting more weeds when using bed - and - furrow or furrows and expect to have to hire labor for hoeing by hand.

Concerning the harvesting, all farmers indicated that harvesting is done by hand and that the practices will be similar for both irrigation methods.

Box 5.3. Comparison of agricultural practices.

Traditional farmers about the basin irrigation method	Progressive farmers about the furrow irrigation methods	Traditional farmers about the furrow irrigation methods
For cotton, farmers apply kachi *rouni,* use the rotavator to remove weeds, plank and plough. After the second rouni, they again plough and plank the land and then sowing takes place. The rouni for wheat is the last irrigation of cotton. With the basin irrigation method, the modern drilling method or traditional broadcasting method for sowing can be used easily. For weeding, spray is used or a ridger. Harvesting is done by hand	Farmers plough, level and plank their land before they create the furrows and beds or ridges. There is no rouni irrigation. One farmer said that he uses a rotavator many times in order to soften the soil so no hands will be injured during sowing. Generally, sowing is done by hand except a few farmers who use a drilling machine for sowing cotton and potato seeds. Cotton seeds are sown on both sides of the beds, while other crops (melon and maize) are sown on the sunrise side and onion on the shade side of the beds. In general, labor is hired for hoeing. Harvesting is done by hand.	Farmers practice similar land preparation on two methods. A tractor cannot move in between the beds or ridges and furrows. Farmers can make furrows by tractor or by hand. With jundra. much work is involved. All expect sowing is done by hand on beds. A few farmers assumed that fertilizers and seeds are better used with the furrow as with the basin irrigation method. Many farmers fear that hoeing will be a problem with furrow irrigation. More labor, money and hard work is needed for sowing and hoeing. Harvesting is similar and done by hand. Some think that the furrows make the harvesting difficult

Irrigation practices

Box 5.4 shows the opinions of the traditional and progressive farmers about their irrigation practices. According to all farmers, the irrigation application is not more difficult for the furrow irrigation methods. The strategy to select a number of furrows or basins to irrigate at the same time is similar. The area to irrigate at once is determined in a way that irrigation application is done quickly and that basins or furrows will be damaged by the flowing water.

Farmers who are, or who are not, the using the furrow or bed – and – furrow irrigation methods mentioned the same strategy to determine the irrigation duration for all the methods. Irrigation to a certain area is stopped when either all of the irrigated land is filled (up to some depth) with water, or the tail of the area will be reached by the water in some time. All the farmers, except one, keep the same strategy for determining the Irrigation frequency and interval. They will irrigate furrows or basins, according to the crop water demand. They observe the condition of the crop. When the leaves of the plants are going to wither, the farmers decide to irrigate this crop. Farmers hereby take the weather, soil type, crop stage and other factors into account.

Box 5.4. Comparison of **irrigation** practices.

Traditional farmers about the basin irrigation method	**Progressive farmers about the** furrow irrigation methods	**Traditional farmers about the** furrow irrigation methods
In general, one basin is irrigated at a time, to save water and to irrigate as quickly as possible. The criteria to stop irrigating is when the water has reached the tail of the basin, or when all of the high spots are covered with water. Water is applied when the leaves of the crops are going to wither. *Rouni* irrigation is necessary. The irrigation interval and total number of times depends on the crop type and crop stage, soil type, water available, weather and growth of weeds.	In general, farmers irrigate 7 - 20 furrows at the same time, depending on the discharge of the water. According to one fanner, an acre can be irrigated at a same time if the land is level. Criteria to stop is when water either reaches the tail or a certain distance of the tail. Two farmers stop when the water fills to a certain level on all furrows. Farmers irrigate when the crop needs the water. Only one farmer used a neutron probe to determine the water requirement. Non apply *rouni* irrigation for furrows. The first irrigation for all of the crops is at the time of sowing. The irrigation interval and total number of irrigation events depend on the crop and climate.	Ail think that irrigation is not more difficult on furrows, and the same amount of labor is needed to irrigate. They said that irrigation on furrows can be much better controlled. Majority of farmers think that with furrows, the duration of application is about half as long as on basins. Farmers think the higher frequency of irrigation for furrow irrigation can be problematic due to the fixed water supply. Four farmers expect the same interval, while five farmers would keep an interval of 7 days for furrows and 10 - 15 days for basins. Most farmers would give in total more irrigations to furrows.

But the practices of the farmers are not corresponding among the progressive farmers. Different irrigation intervals are kept and, further, the traditional farmers do also differ in opinion about the interval which should be kept when using the furrow irrigation methods. Most of the traditional farmers expect that the interval for furrows must be 7 days, which, in fact, is kept by some progressive farmers. However, some other progressive farmers keep an interval of 10 - 15 days when using furrows. A major difference between basins and furrows is the timing of the first irrigation. With basins, the first irrigation is given after 7 to 40 days of sowing, depending on crop choice and weather conditions. But with the furrow irrigation methods, the first irrigation is applied at the time of sowing because there is no rouniirrigation and the seeds need water to germinate.

Inputs

In Box 5.5, the comparison of the inputs used by the farmers is given. Water, labor, machinery and other inputs are discussed separately.

Box 5.5. Comparison of inputs

Traditional farmers about the basin irrigation method	Progressive farmers about the furrow irrigation methods	Traditional farmers about the furrow irrigation methods
Water The farmers use canal and tubewell water. The tubewell is operated when the crop demands water and the farmers have no warabandi turn. Labor This method requires, according to the farmers, not much labor. Machinery Most of the farmers use a tractor, either their own or rented. But quite a few farmers are still using oxen for agricultural practices. Other implements used are the craw, the sohaga and the *jundra* and a ridger. Other inputs Fertilizers and seeds are used in high quantities.	Water Farmers stated that water savings with furrow irrigation, is from 30% up to 75%. if rain falls just 2 or 3 days after sowing, no losses occur. The soil is softer and rainwater can either infiltrate or stand in the furrows without damaging the crop. Labor This method requires much labor. Those farmers without machinery have to hire labor for weeding and for sowing. Machinery To use machinery for this method is very profitable. Furrows are created with a ridger and the tractor is used for sowing, ploughing, planking, leveling and hoeing. Other inputs Fertilizers do not leach as readily if furrows are used and can be saved up to 50% as well on seeds. The profit is higher as compared with basins.	Water Water can be saved (20 - 50%) by using furrows, generally. A few farmers think more water is used with furrows. Water will not overflow the crop on beds and when rain falls within two or three days of sowing on beds, it will have no adverse effect. Labor Farmers expect to need more time and labor (4 times as much) for furrow irrigation. The major labor demand which are expected by farmers are for hoeing, sowing and making furrows, in case they are made by hand. Machinery Most of the farmers require machinery like rotavator or dril for cultivation for bed – and - furrow irrigation, which they dc not have at the moment. *Other inputs* Some farmers expect to savf fertilizer and seeds.

Water

The traditional farmers are using canal and tubewell water during the entire year. Progressive farmers indicated that water is saved when the furrow irrigation methods are used. Most of the traditional farmers expect that water is used more efficiently with beds or ridges and furrows and less water is used. Some traditional farmers are not aware of this and think that more water is used with the furrow irrigation method. Beds or ridges and furrows have, according to all farmers, the benefit that the crop is not damaged during rainfall just after sowing or by continuous rain.

Labor

The traditional farmers indicated that, at the moment, when using the basin irrigation method, two or three laborers per acre are needed for cultivation. Most of the progressive farmers are requiring

more laborers for the furrow irrigation methods as compared with the basin irrigation method. Only the progressive farmers who have access to machinery indicate that less labor is required. The main labor demands, as told by the progressive and the traditional farmers, are for sowing on beds and for hoeing. Some traditional farmers expect that labor for making the furrows will be a major restriction.

Machinery

The traditional farmers use either oxen or a (hired) tractor for agricultural practices. When using the furrow irrigation methods, the progressive farmers indicated that at least a ridger is required for cultivation. The traditional farmers expect that more machinery is needed as compared with the basin irrigation method, while they are at the moment mostly using wooden devices.

Other inputs

Most of the farmers stated that due to the basin irrigation method most of the seeds and fertilizers are wasted. With using bed – and - furrows, fertilizers and seeds can be used more optimally. Most of the traditional farmers expect that farming becomes more expensive when using the furrow irrigation methods, mainly because they would have to hire labor for the cultural practices. But the progressive farmers indicated that although the expenses are higher, the profit is higher as well by using the furrow irrigation methods.

Soils

According to the interviewed farmers, and listed in Box 5.6, a clay-loam or so-called *merra* soil is suitable for both irrigation methods. Most of the farmers prefer the furrow irrigation methods on a merra soil. However, on a sandy soil, basins are preferred by the majority of progressive, as well as traditional, farmers. Some progressive and some traditional farmers think it is possible to use furrows on a sandy soil.

On a saline soil, the furrow irrigation methods are most suitable according to almost all of the farmers. A few traditional farmers are of the opinion that the use of basins is better for salt-affected land. However, all progressive farmers prefer to use bed – and - furrow despite the quality of the soil. Only two farmers, of which one is progressive and one is traditional, stated that the salinity can be reduced by using the furrow irrigation method, but according to all the others this is not the case.

Box 5.6. Comparison of **soils.**

Traditional farmers about the basin irrigation method	Progressive farmers about the furrow Irrigation methods	Traditional farmers about the furrow irrigation methods
Some farmers have a hard soil type, and they have to plough many times. Some farmers mentioned that their soil is affected by salinity. Others have a sandy soil with a high infiltration rate. Due to salinity, farmers get less germination and a low yield, while more water should be used with the basin irrigation method.	All of the farmers mentioned that a *merra* soil is most suitable for furrow irrigation but that basins are also suitable. Most farmers think that furrows can be made on semi-sandy land, but is impossible on pure sand. Almost all farmers think that salinity cannot be increased or decreased by using furrow irrigation, while one farmer thinks salinity is reduced very slowly by using bed- and -furrows. Furrow irrigation is preferred for saline land. One farmer stated that due to the sand, the land cannot be continuously used for furrow irrigation, otherwise the crop will be burnt.	In general, both irrigation methods can be applied on rnerra soil. Most prefer basins on sand, especially in a pure sandy soil. A few farmers thought that both methods are suitable on sandy soils. Some believe that furrow irrigation is better on sandy soils. Most farmers think that only furrows are suitable on saline soil, a few prefer basins. All farmers, except one, mentioned that salinity will not increase or decrease by basins or furrows.

CONCLUSIONS

Traditional farmers: expectations and familiarity

The traditional farmers have always been using basins for cultivating major crops, however, many farmers do cultivate vegetables on beds and irrigate through furrows. But this latter mostly occurs for very small units. Using basins for irrigation purposes is a familiar practice to them, often based on many years of experience. The farmers are limited when it comes to on-farm investments, and, therefore, the traditional basin irrigation method provides them the opportunity to limit expenses

related to irrigation. With basins, a farmer knows how the crop grows, how the irrigation takes place and the associated constraints, and what can be the expected yield.

The traditional farmers expect certain advantages when the bed - and - furrow irrigation method is used for growing cotton, such as water savings, a better environment for the crop is created, and thus, better yields can be expected. Additionally, for saline soils, bed - and - furrow is better because the crop germination will not be hindered then. But more weight is put on the expected constraints, such as the additional required implements for creating good bed – and - furrows, planting the seeds, and for hoeing. Additionally, it is expected that more labor is required, especially when they cannot afford the implements and, thus, the agricultural practices have to be done manually. It is expected that the irrigation frequency will increase, which will be difficult to handle, especially when they receive waster on a rotational basis. Further. farmers feel uncertain, because they have no experience with the furrow and bed – and - furrow irrigation methods, and moreover, how to handle the involved agricultural and cultural practices and how to manage the constraints.

Most of the farmers realize the advantages of the furrow irrigation methods, but yet they feel they cannot use it at the moment because of their limitations. They pointed out that if constraints were not there, they would have considered the bed - and - furrow irrigation method for their major crops (cotton).

Proaressive farmers: motivation and attitude

Among the progressive farmers, most of them do not own all of the required implements or have many laborers at their disposal, but these farmers mentioned that they managed to be successful by using "simpler" implements. More labor is required, along with harder work, but, then, the payoff comes with the increased yield.

The progressive farmers do recognize most of the constraints, but they have been able to manage these constraints in one way or the other. More important is that overall their attitude is different towards their farming. They are very much interested to improve their on-farm irrigation in terms of water savings and to obtain better crop yields. They are able to compromise between the constraints and the benefits. For them, the achieved advantages have more weight than the constraints. For most of the traditional farmers, they feel being at risk when something is changed which is, in a way, unfamiliar territory to them. Moreover, although farmers have their savings, they do not want to invest everything for one purpose only, because farming is a risky job and many factors have an impact on the yield (i.e. crop diseases, climate, drought, etc).

Possibilities and solutions

The possibility, or more the potential, is there to have furrow or bed - and - furrow irrigation systems more widely spread among farmers for cultivating cotton. But it would not be a responsible action when under the current situation, in which the farmers are to implement this kind of improvements without considering the farming system in a broader context, and without addressing the constraints. In general, a farmer likes nothing more than gaining profit out of his farming. For this, a small farmer in Pakistan does not differ much from a big farmer in the United States of America. The question is. how willing is the farmer to adopt, and experience new technology. To facilitate the implementation of furrow or bed – and – furrow irrigation systems, the following possibilities should be considered.

I. 'Providing extension and knowledge to the farmers

Farmers are limited when it comes to testing something new, because of the involved financial risk and lack of knowledge. Extension is a powerful tool, when done in an appropriate manner. Extension services are there, but their capacity is also limited. For farmers, it is not easy to go elsewhere to obtain information and a one-time interaction does not yield much of an advantage. However, extension services could focus on the on-farm related irrigation activities, and on grouping farmers for providing sessions on irrigation in order to provide knowledge and moreover, an awareness among farmers about the importance of having good irrigation water management at the farm. It should not be just once, but a continuous process should be there.

II. Demonstration plots

A farmer is somewhat conservative by nature and will only believe that some innovation is really beneficial for him when he actually sees the impact and benefit himself. By showing farmers results through demonstration plots in their area, farmers are able to observe. Moreover, a farmer is inclined to believe something only if it is possible in his area under the conditions he is living, and not, when something is beneficial for a farmer *50* miles further south.

For this reason, IIMI's irrigation methods and practices research team has identified four traditional farmers who are very much interested in implementing and evaluating the bed – and - furrow irrigation systems on their farm. For this purpose, the proper equipment has been provided through a farmer who makes the implements himself. The sample plots are being closely monitored for each irrigation event during the Kharif **1997** irrigation season. During this implementation stage for the bed - and - furrow method, many farmers have shown an interest and borrowed the bed - and - furrow shaper for their own farm. Additionally, the On Farm Water Management Directorate has implemented bed - and - furrow demonstration plots scattered throughout much of the Punjab, which are being closely monitored by its field staff in order to compare the results with basin irrigation systems.

III. Strengthening common arrangements

Constraints have been identified. However, how can these constraints be solved, *so* that the average farmer can indeed use the furrow or bed – and – furrow methods, improve their irrigation practices, and moreover, obtain better crop yields? The concept of having common properties among farmers will facilitate this change process by eliminating many of the constraints. Farmers can rent equipment, but having farmers owning common farm machinery will create a responsibility among farmers, and moreover a feeling of not being dependent on others (some farmers addressed that when equipment is needed, they are borrowed out). This is just an example, but of course many other common arrangements can be made to facilitate the farmers. But, for now, the emphasis should be on how to activate this process. Organizing farmers will contribute to this concept.

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ANNEX 1-1 CLIMATIC DATA

Salient features:

Mean annual rainfall	150 mm to 179 mm
Mean summer maximum temperature	40.7 ºC
Mean winter minimum temperature	6.2 ºC
Summer maximum temperature	***51.7*** ºC
Winter minimum temperature	4.4 ºC

Months	Mean Maximum	Temperatures Minimum	(ºC) mean	Evapotrans-piration mm	Rainfall mm
January	**21.4**	5.0	13.2	63.4	4
February	**25.1**	7.6	16.4	78.7	5
March	**26.7**	13.2	20.0	96.0	14
April	**37.9**	19.6	28.8	138.2	4
May	**43.0**	26.2	34.6	166.1	10
June	**43.4**	29.6	36.5	175.2	11
July	**40.2**	28.9	34.6	166.1	59
August	**38.5**	27.7	33.1	158.9	41
September	**38.3**	25.5	31.9	153.1	23
October	**36.5**	18.3	27.4	131.5	1
November	**30.5**	12.2	21.4	102.7	2
December	**23.9**	5.9	14.9	71.5	5
Annual	**33.8**	18.3	26.1	1501.4	179

Temperature data available for the Fort Abbas station based on 24 years of data.
Rainfall data available for the Chishtian station based on 20 years of data.

ANNEX 1-2 IRRIGATION IN PAKISTAN

The Indus Basin Irrigation System is a large-scale irrigation system and covers some parts of the North West Frontier Province (NWFP), Balochistan and large parts of Sindh and the Punjab. Construction of the system was initiated by the British in 1859 with the Upper Bari Doab Channel in the north of the Punjab. The system comprises 3 major storage reservoirs, 19 barrages and headworks, **43** canal commands and about 63,000 kilometres of canals and distributaries, carrying water to about 90,000 watercourse command areas (so-called chaks) (Bhatti and Kijne, 1990). Water flows continuously from canals into distributaries, through concrete outlets (*moghas*) into watercourses and finally through the field inlet (nakka) into the water users' ditches and fields (Merrey, 1986).

Irrigation water allocation is regulated by rules developed by the British more than a century ago. The Irrigation Department delivers a specific amount of water based on a predetermined 'water allowance' and on the size of the cultivable area of the watercourse. The tirne duration for each farmer is proportional to the size of the farmer's land holding to be irrigated within the *chak,* regardless of crop water requirements (Bandaragoda, D.J. and Saeed ur Rehman, **1995).** The present water allocation system within the *chaks* is known as warabandi (*wara* means turn and bandi fixation). The warabandi is a continuous rotation of water in which one complete cycle **of** rotation lasts most of the time seven days and each farmer in the watercourse receives water during one turn in this cycle for an already fixed length of time. The cycle begins at the head and proceeds to the tail of the watercourse, and during each time turn, the farmer has the right to use all of the water flowing in the watercourse. Each year, preferably at the canal closure, the warabandi cycle or roster is rotated by twelve hours to give relief to those farmers who had their turns during the night in the preceding year's schedule. Today, two types of warabandi are common in Pakistan. The warabandi, decided by farmers solely on their mutual agreement, without formal involvement of a government agency is known as 'kachcha' (unregulated) warabandi. The opposite is the '*pucca*' (official) warabandi, which is decided after field investigation and inquiry by the Irrigation Department when disputes occurred (Bandaragoda, D.J. and Saeed ur Rehman, 1995). Modifications of warabandi schedules occur in the form of water trading, by borrowing and selling or buying of water (Pintus, F. 1995). Aside from surface water, a large contribution from groundwater exists to the irrigation water supply. Due to severe waterlogging and salinity problems in the Punjab and Sindh provinces, public tubewells were introduced. The first large-scale Salinity Control and Reclamation Project (SCARP) was completed in 1963. In the last 30 years, large-scale vertical drainage schemes were **set** up. About 20.000 public tubewells were installed in the Punjab and even more recent is the creation of more than 300.000 private tubewells (Pintus, F. 1995). The contribution of groundwater to the total irrigation water supply in the Punjab **is** estimated at **40% to** 50% (Kuper, 1993).

ANNEX 1-3 DESCRIPTION OF THE SOIL TYPES ACCORDING TO THE SSP

Table A2. Soil description.

·armer Jo.	Soil types	Slop	Drainage	Texture	Permeability
	W/C Fordwah 14-R				
·1	0.5 Rs 2/W1, 1 Hr 4/W1 1 Jg 2/DLX, 3.5 Rs 4/W1 12 Rs 4p/W1	1-	imperfect	fine sandy loams to loamy sands	Moderately rapid to Rapid
2	9 Hr 4/W1, 3 Rs 2-DLX, 3 Mt 4	1- 2-	imperfect to moderate	fine sandy loams sand & silty clay	Moderately rapid to slow
3	3 Rs 4p/W1, 7 Rs 4/3C 9 Hr 4/W1, 3 Hr 6/W1	1-	imperfect	fine sandy loarns to loams	Moderately
4	1.5 Mt 4, 2 Rs 4p/W1 3 Rs 4/W1, 3.5 Hr 4p	1-	imperfect well	fine sandy loams	Moderately
5	9 Rs 4p/W1, 6 Rs 4/W1 2 Hr 4p, 1.5 Mt 4, 1 Gb	1-	imperfect	fine sandy loams	Moderately Rapid
6	2.5 Hr 6/W1, 2.5 Hr 4/W1	1-	imperfect	fine sandy loams to loams	Moderately
	W/C Fordwah 62-R				
7	4.5 Rs 4, 1 Hr 6	1-	well	(fine sandy) loam!:	Moderately
8	13 Jg 2, 12 Rs 6	1-	excessive	loamy sands	Rapid
9	6 Hr 6, 2 Hr 6p, 2 Rs 4(av)	1-	well	loarns	Moderately
10	2 Hr 6, 10 Jg 2,5 Rs 4	1-	well-	(fine sandy) loams	moderate-
11	1.5 Jg 2-DLX, 2 Hr 6 12.5 Rs 4	2- 1-	moderately to excessive	loamy sands fine sandy loams	Moderately Rapid
12	7 Jg 2,3 Rs 4	1-	excessive	loamy fine sands fine sandy loams	(moderately) Rapid
	W/C Azim 111-L				
13	2 Jk 6, 4 Su 6, 6 Nb 6p 8 Su 6p	1-	well	loams to silt loam!	Moderate
14	2.5 Jk 6, 3.5 Su6, 6.5 Nb	1-	well	loams to silt loam	Moderate
15	4.5 Nb 6/3C	1-	well	loams	Moderate
16	1 Nb 6p, 1 Su 6/3C, 8 Jk 6	1-	well	loamslsilt loams	Moderate
17	0.5 Ad6-Jk6X(b), 1 Jk 6 1.5 Su 6/3C	1-	well	loamslsilt loams	Moderate
18	3 Jk 6. 6 Su 6p, 21 Su 6	1-	well	loams/silt loams	Moderate

ANNEX 1-4 DESCRIPTION OF THE SALINITY FOR THE INTERVIEWED FARMERS

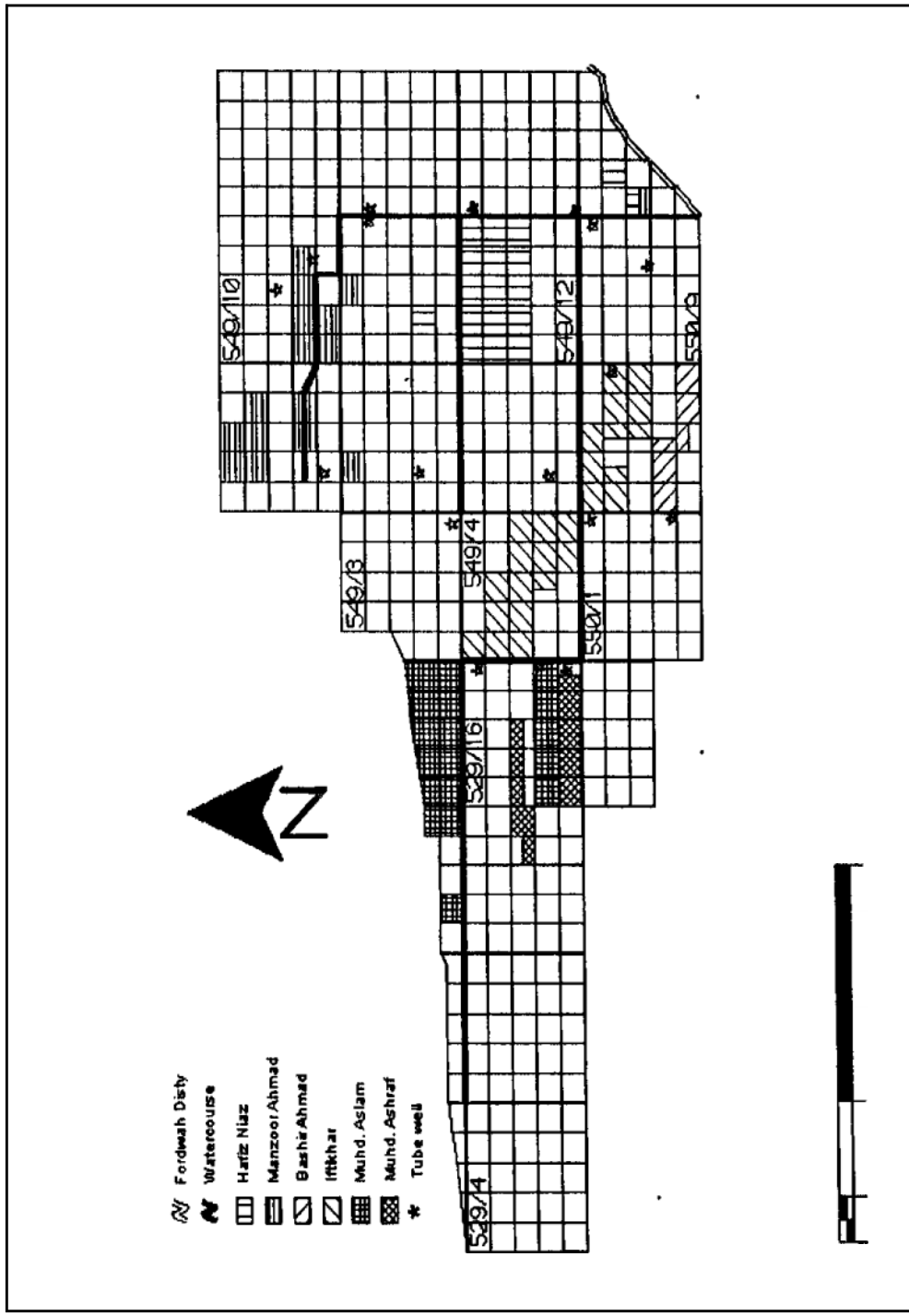
The degree of salinity is given (i) according to the farmers, (ii) according to the soil map of SSOP and (iii) according to the research of Neeltje Kielen, 1996.

Table A3. Salinity description.

According to:	Farmers	Soil map	Neeltje Kielen
W/C Fordwah 14-R			
Farmer ID			
1	Normal with some salts	2/3 crust	Some white
2	merra	nil	no salinity
3	hulky merra	1/7 crust	(some) white and black
4	Normal, not merra or hulky	1/2 crust	(some) white and black
5	Some hulky merra, some pacci with salts	1/2 crust	white and black
6	Normal with chitta kalar	nil	White salinity
W/C Fordwah 62-R			
Farmer ID			
7	Sandy loam, no kalar	nil	----
8	Merra, no kalar	nil	----
9	Sand & merra, some chitta	1/5 crust, 1/5 profile	----
10	Sand & merra. no kalar	nil	----
11	Sand & merra. no kalar	nil	----
12	sandy	nil	----
W/C Azim 111-L			
Farmer ID			
13	Hard loamy soil, no kalar	4/5 crust, 1/5 profile	Increasing hardness
14	Some very small chitta kalar	1/3 profile, 2/3 crust	Increasing hardness
15	Pacci soil, some chitta	nil	Hardness
16	Pacci soil with kalar	1/7 crust, 6/7 profile	Hardness
17	Hulky merra, no kalar	1/2 profile	Hardness
18	Kachi, no kalar	1/10 profile, 1/5 crust	Increasing hardness

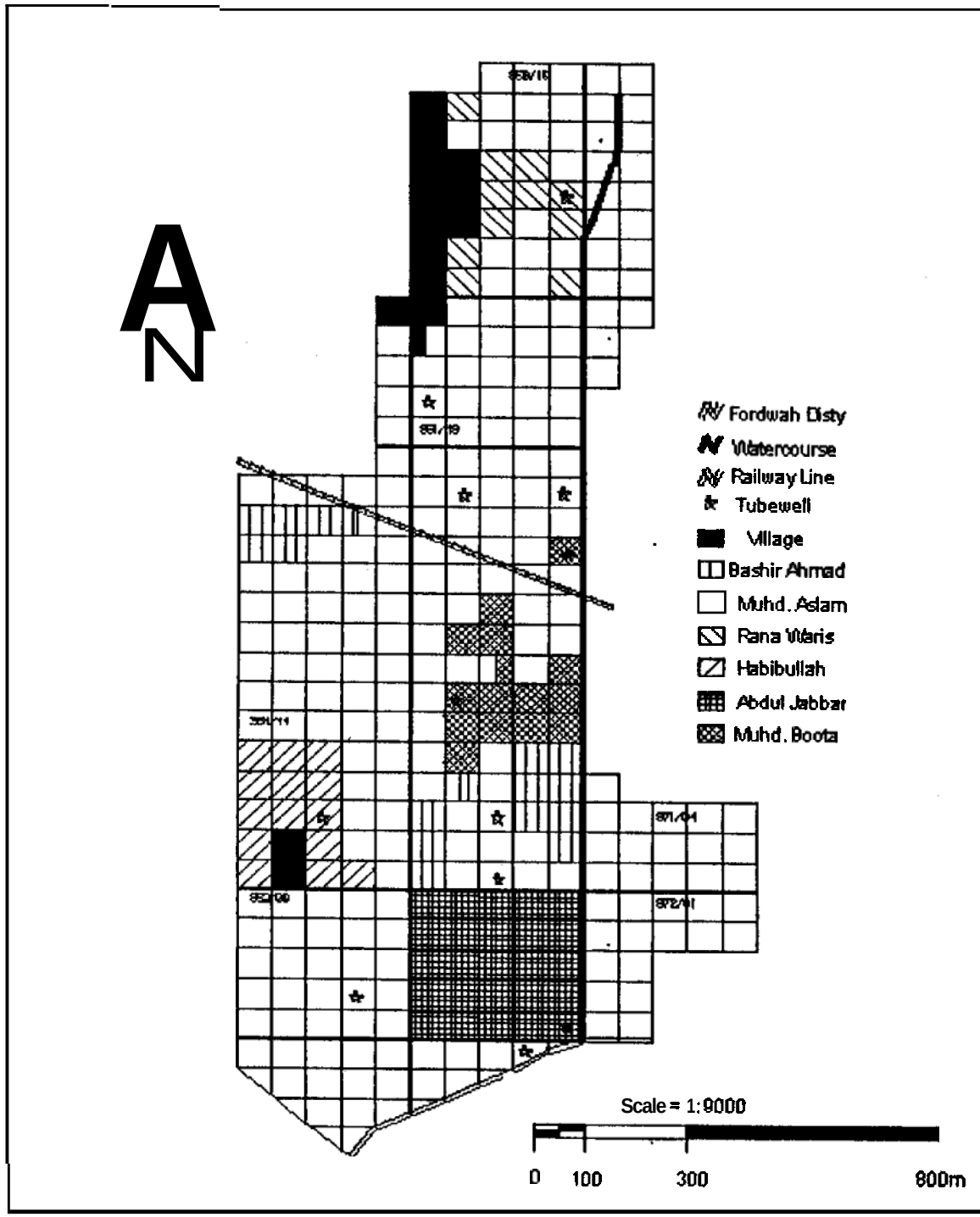
Hulky is light merra
Kachi is soft
Pacci is hard
Merra is sandy-clay loam
Kalar is salinity
*Chitta is **white** salinity*

ANNEX 1-5 MAP OF WATERCOURSE FORDWAH 14-R



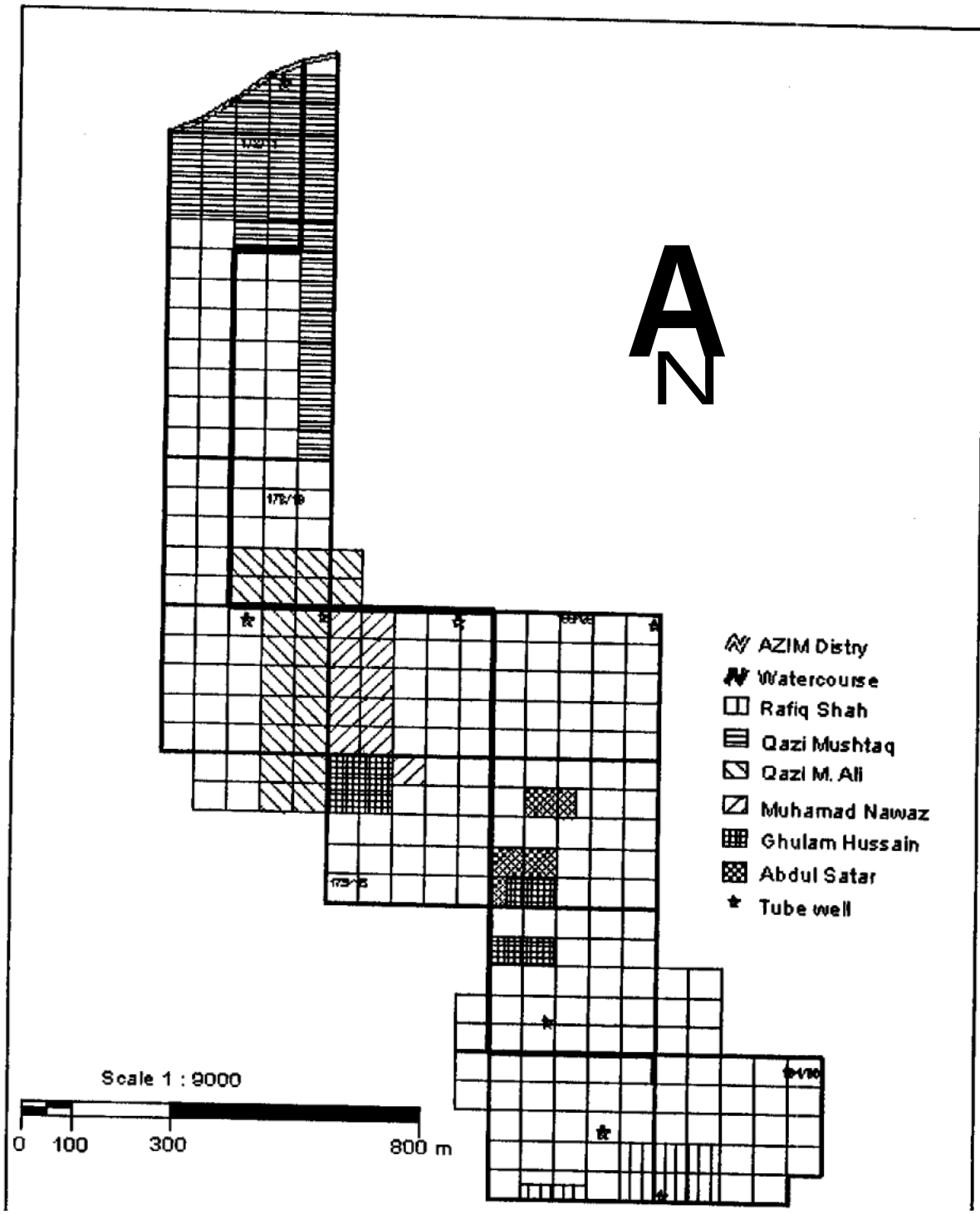
ANNEX 1-6

MAP OF WATERCOURSE FORDWAH 62-R



ANNEX 1-7

MAP OF WATERCOURSE AZIM 111-L



ANNEX 1-8 LIST OF THE SELECTED FARMERS

W/C Fordwah 14-R

Farmer no.	Code topic 1	Code topic 3	Name of farmer
1	0212am.14r	140101.14r	Manzoor ahmad
2	0312am.14r	150101.14r	Hafiz Naiz
3	0412am.14r	060101.14r	Mohd Ashraf
4	0412pm.14r	170101.14r	Iftikhar
5	0912am.14R	060102.14r	Mohd Aslam
6	0912pm.14r	140102.14r	Bashir Ahmad
W/C Fordwah 62-R			
7	2711am.62r	080101.62r	Bashir Ahmad
8	2711pm.62r	090101.62r	Abdul Djabar
9	2811am.62r	160101.62r	Rana Waris
10	0112am.62r	150102.62r	Mohammed Boota
11	0112pm.62r	080102.62r	Hadji Bullah
12	0212pm.62r	100101.62r	Mohd Aslam
W/C Azim 111-L			
13	0512am.111	180102.111	Qazi Mohd Ali Hashmi
14	0512pm.111	110102.111	Mohd Nawaz
15	0712am.111	180101.111	Rafique Shah
16	0712pm.111	110101.111	Gularn Hussain
17	0812am.111	120102.111	Abdul Sittar
18	1012am.111	120101.111	Mohd Ashik
Progressive farmers:			
I	130101.tar		Tareen farm
II	200102.kha		Khanpur farm
III	210103.681		Anwar-ul-Haq
IV	220104.111		Abdul Rashah
V	230105.96		Muhd. Aslam
VI	250106.111		Muhd. Ahmid
VII	260107.meh		Ch.Abdullah
VIII	270108.96r		Muhd. Rafique
IX	280109.93r		Nazir Ahmad
X	290110.111		M. Hussain

ANNEX 2-1 DESCRIPTION OF THE SOCIO-ECONOMIC SETTING OF THE FARMERS

The margins are for the small landowner class less than 5 acres, the medium class between 5 and below 25 acres, and the large class concerns farmers having 25 acres of land or more. This classification is based on the statistics presented in the Census of Agriculture (1990).

The sizes of the families are sometimes representing a single family, but most of the time the farmers indicated that they are living in a combined family system. This involves that uncles and aunts and their families are living together. Therefore, family size is variable, and 4 up to 20 people are forming a family together.

With respect to the labor, farmers mentioned that mostly they have their own family labor, helping full-time as well as part-time. Five farmers mentioned that women help in agriculture, especially in harvesting and picking of the crops. Sometimes, according to demand, the farmers hire labor on contract for harvesting and they said that they hire women only for picking. Farmers mentioned that the full-time labor, which is working in the fields are mostly 1 to 4 persons, while only one farmer stated that 7 full-time labor are available for his farm.

When studying the ownership of the land, it is noticeable that almost all farmers own land, from 2.25 up to 25 acres. Out of the 18 selected farmers, 17 farmers were landowners, 9 farmers have land on lease of other farmers and are cultivating the land of others. Three of the farmers were tenants and they were cultivating the land of others on share. Only one farmer is a tenant, and cultivates only leased land. About half of the farmers are able to lease land. About half of the farmers, selected from three different watercourses, belong to medium class with respect to land holding (including the leased land). Four of the selected farmers cultivate land at the head of the watercourse, eight farmers have their'land in on the middle of the official watercourse and six farmers have their land at the tail of the official watercourse.

Some farmers have other sources of income. A few farmers are serving as a government servant i.e. teacher or working within-the irrigation department, one farmer has a hotel and others a shop. But most of the farmers which are considered as a rich farmer on their outlet do not have other sources of income besides agriculture.

Out of the 18 farmers, 13 farmers have their own tubewell. Two have a tubewell on share, and three of them do not have a tubewell, but they hire tubewell water when it is needed. In W/C Azim 111-L, canal water is not available so all the farmers use tubewell water. The majority of the interviewed farmers do not have a tractor, while a few do own a tractor. Farmers indicated that when they need a tractor, they will lease one.

By making basins, farmers reduce the size of the field. Due to the infiltration pattern and advance front, it takes more time (and water) to irrigate a whole acre at once, than to irrigate twice half an acre. An important factor influencing the infiltration pattern is the roughness of the soil surface.

Division of land into bunded units

Concerning the division of land all farmers mentioned the main purpose as saving of water. Only some big farmers in W/C Azim 111-L indicated that only farmers with water shortage use basins. To save water is not the main purpose of the basin for them, since they have enough tubewell water. Another reason for basins, given by the farmers, is that basins give a good crop production, because the required water is easily available for the crop.

Topography

With respect to the land topography and division into small bunded units, another important reason for creating basins is because land is never totally leveled. In a small area, high and low spots are not so prominent as compared to a larger area and water can cover easier the higher patches. The levelness of a field is very important. By making bunded units, water can be saved, since farmers are irrigating a basin till all the area is covered by water. Especially in W/C Azim 111-L, this is an often given reason. In this watercourse, more sand dunes can be seen which makes the land more unleveled. Sometimes, basins are made of different sizes, each confining a high or low patch in a field. But, in general, basins are of the same size, especially where the land is flat and there are not many differences in levelness. Some farmers indicate that basins are not depending on the land levelness, but these farmers are situated on fields which have already an accurate levelness.

Number of basins

In W/C Azim 111-L the number of basins for different crops vary more. Cotton sown with the drill method is usually on basins out of one-fourth of an acre. For fodder, the farmers mentioned that they create 4-8 basins per acre, depending on the farmers' practices. This variety in number of basins in W/C Azim Ill-L can probably be explained due to the salinity problems that some farmers face. If there is a part of their land which is more accurately leveled, they make less basins, or only one basin in an acre.

The number of basins are also related to the soil type, according to the interviewed farmers. In w/c Fordwah 14-R, farmers do not mention the influence of the soil on the number of basins per acre, but the soil type remains similar in this area. Farmers in W/C Fordwah 62-R, stated that if the soil is loamy, four basins per acre are made, but on sandy soil five to six basins per acre are created because farmers indicated that more water is needed on a sandy soil. The farmers in W/C Azim 11I-L do not mention the soil type as one of the main reasons to make different numbers of basins per acre. The main criteria for setting the number of basins that are to be made, according to the farmers in W/C Azim 11I-L, is the levelness of the field.

The saving of water is not the only reason for farmers to use basins, although it is the main reason that they give, especially in W/C Fordwah 14-R and W/C Fordwah 62-R. The basins are also used to spread the water equally over the area. Without basins, there would be wild flooding of the area, and water would stagnate in depressions, in the lower parts of the region instead of flooding the fields. Even the farmers who say that they don not use basins are using them, although they make much bigger basins. Farmers stated that if they would make less basins per acre for the crops they grow, they would not have the profit of saving water and will not be able to irrigate more land per irrigation turn. Also mentioned is that with fewer basins, the water will not be sufficient to fill the inaccurate leveled land equally.

ANNEX 2-3 MOTIVATION TO USE THE BASIN IRRIGATION METHOD

- Savina of water: the discharge of canal water is according to the farmers too little to irrigate all of the land. With the help of basins, water can be used more efficiently.
- Savina of money: farmers stated that with basins they can save their time and money. Not much labor is required to open and close inlets and the irrigation interval is beneficial. Only a few inputs are needed to be able to use the basin irrigation method. Since many farmers do not have easy access to resources farmers like to use basins.
- Crop water reauirements: according to the farmers, some type of crops can only grow on a basin, like wheat, fodder and rice. Due to the use of basins, farmers receive good crop production, because the required water is easily available for the crop.
- Irriaation application: water can be maintained in the basin at a desired depth for a required time. After opening a *nakka,* farmers do not have to pay much attention to the irrigation application, because the water will spread automatically over the basin.
- Land topography: three farmers stated that their land is unleveled and due to this unleveled land, they have to divide the land into some parts. But in general, the flat land surface of the Punjab makes it ideal for farmers to use the basin irrigation method.
- Easiness: the basin irrigation method does not require much labor and skills. All interviewed farmers stated that the construction of the basin is easy and quick. Farmers can use all types of local machinery, like *sohaga* and craw, for land preparation.

Creafion of the bunds and the inlets

In general, farmers indicated that they create the bunds two times, before the rouni irrigation and before the first irrigation, after sowing. Only one farmer stated that he makes for a second time the bunds before the sowing. Sometimes, farmers make the bunds only one time, but this is related to whether or not the farmer is already ploughing his field after the harvesting of the previous crop. If a farmer does not plough or use the rotavator before the (first) rouniirrigation, the bunds are still there and there is no need to make bunds two times.

Planking

The number of plankings varies widely, from 1 to 7 times. If, for instance, the land was fallow during the previous season, they will plank more times. But if cotton is harvested, planking is done once after broadcasting. Another farmer mentioned that planking is done in the direction perpendicular to the plough direction to get a better result. Another practice is that sometimes somebody will sit on the plank, if compacting of the soil is needed.

Leveling

Sometimes, leveling is done before the *rouni* irrigation, sometimes after the *rouni,* and sometimes before and after. Farmers fix the blade up to a certain level, which will set the level of the field. Leveling is mostly done with the tractor. But if you visit the fields in W/C Fordwah **14-R** and W/C Fordwah **62-R** you can ***see*** some farmers who use their oxen to plank and plough the fields. In W/C Azim 111-L, no oxen are seen working on the fields, there the planking and leveling is always done by tractor. All farmers use experience and eye-view. A method, which is often used, is that when water is applied to the field for the crop, the flow of the water is observed. In lower patches, the water will pond, but in higher patches, the water doesn't reach easily. If farmers level the field for the next crop, they still know where the patches are that must be leveled. One farmer mentioned that he and the tractor driver discuss about leveling and they together make the decisions on leveling. This farmer will also sit in a corner of the field and watch the levelness. This, he repeats from every corner of the field. In this way, he uses his eyes to see if the land is level. Another farmer indicated that he makes a guiding bund in the basin, if the leveling is too difficult. The bund is used to guide the water to the difficult patches. In this way he doesn't have to level the land very correctly. Some farmers try to improve the leveling by using different methods to estimate whether a field is level or not. The farmers encounter difficulties with the availability of tractors, money and time. Leveling is preferably done every season by the farmers. The reason is that due to the irrigation's, the force of the water is creating higher and lower portions in the fields, according to the farmers. But leveling is costly for farmers, especially when they have to hire a tractor and driver for it.

ANNEX 2-5 NUMBER OF BASINS TO IRRIGATE AT ONCE

Three farmers indicated that they are exactly creating the bunded unit for the purpose of irrigating less land at once. If they would irrigate more than one basin at once, they would not have to create units and then there is no benefit of the basins according to them. One farmer stated that the water cannot distribute equally over the land if he would irrigate more than one basin at the same time.

Some said that they prefer to irrigate more basins at once, which would save the farmers time and water. Additionally, when two basins are irrigated at once, there is no need to have one person full-time involved to open and close the inlets, which is needed when one basin is irrigated at a time. Different situations are given in which it is possible to irrigate more basins at the same time:

- When the basins are situated lower with respect to the watercourse, the water flows quicker into the basins:
- When the water discharge is high (either high discharge canal water or when the canal water is mixed with tubewell water) two basins can be irrigated at the same time:
- For the second and later irrigation events, when the soil already has some moisture, then the irrigation water moves quickly and less water is used;
- When the crops become older and the roots more developed, whereas at the time of the first irrigation the roots are still weak and small and demands earlier water;
- When irrigating sugarcane, one farmer indicated that he irrigates two to three basins at once because sugarcane needs more water and is not very sensitive to water: and
- One farmer stated that in winter a basin needs less water, the water flows faster across the field than in summer, and two basins can be irrigated at once.

ANNEX 2-6 *ROUNI* IRRIGATION

Rouni irrigation is applied for all crops and, according to a few farmers, is not related to a crop type. But almost all of the interviewed farmers do distinguish between crops. They mentioned that only one *rouni* is necessary for wheat because wheat needs less moisture for germination. The *rouni* for wheat is normally the last irrigation of the cotton crop, given before the last picking of the cotton bolls. After the last picking, the farmers cut the dead cotton plants, plough the land and sow the wheat seeds. Some farmers mentioned the fact that wheat is sown in the winter season, the evaporation rate is lower as in the summer and, therefore, one *rouni* would be sufficient for the germination.

Another fact, mentioned by a few farmers, is that there is less time in the winter for two *rounis* and not much water is required for land preparation after the cotton crop. These farmers prefer to apply two *rounis* for cotton. Not all farmers are able to do so, due to water shortage or time shortage. The farmers indicated that if there is an excess of water available, they would apply two *rounis* for cotton. The first *rouni* (the so-called *kachi rouni*) will be given after the harvesting of the wheat crop, because it is not easy to plough in the dry field after the harvesting. The second *rouni,* the so-called pacci *rouni,* is applied just before the sowing of the cotton.

A few farmers stated that the second *rouni* takes more time for irrigation. Before the *kachi rouni,* the soil is hard and the infiltration rate is low. After the kachi rouni, the land is usually ploughed for two to three times, the soil becomes loose and the infiltration rate increases. Therefore, more water is needed to irrigate a basin for the *pacci rouni.* If the second *rouni* is not applied, the soil stays hard according to the farmers and the infiltration rate is low. Additionally, the soil reaches a proper moisture content for the germination of the seeds. Another benefit of two *rounis* is that the weeds will appear after the first *rouni.* Due to the second *rouni,* most of the weeds will die. There is no need for spraying to remove the weeds anymore.

Whether or not two *rounis* are applied, also depends, according to a few farmers, on the soil. If the soil is hard before sowing, two *rounis* are given to this field. Otherwise, one rouni is supposed to be sufficient by the farmers. The hardness of the soil also depends on the water quality. A farmer in W/C Azim 11I-L indicated that due to the use of tubewell water for irrigation, he has to apply two *rounis* for all crops, because the soil is otherwise too hard. One farmer mentioned that one rouni is sufficient for all crops. This farmer explained that when two *rounis* are given, the soil will become colder due to the water and there will not be enough heat in the soil for the germination of the seeds. But another farmer denies this fact. He mentioned that if only one *rouni* is applied to the cotton crop, the seeds cannot germinate due to a shortage of moisture in the soil. He also stated that, on a sandy soil, two *rounis* are required.

ANNEX 2-7 IRRIGATION INTERVAL

The decision of when to irrigate a crop is in general based on the condition of the crop. Most farmers indicate that their experience helps them in this decision. Four farmers stated they take the condition of the soil into account when deciding whether a basin needs to be irrigated. When the soil is somewhat dry, they have to irrigate. One said that if the crop gives no clearance for irrigation, he digs a pit of 6" in the soil. If the soil is wet in this pit, no irrigation is needed; otherwise, this farmer decides to irrigate this plot.

For cotton, the farmers apply, in general the first irrigation after 30 to 35 days of sowing. Four farmers indicated that the first irrigation is applied after 40 to 45 days and four others even 60 days, while two farmers irrigate after 20 to 22 days of sowing. Most farmers keep the interval of irrigation at after 15 days, two farmers indicated that they irrigate after 8 to 10 days, while two farmers use an interval of 20 to 25 days. The total number of irrigation events is in general 5 to 7.

For wheat, half of the farmers apply the first irrigation after 20 to 30 days, but the others apply after 15 to 20 days of sowing. Mostly farmers keep the time interval for the next irrigation up to 15 days. Two farmers keep an interval of 30 to 40 days and one irrigates after 10 to 12 days. Wheat is harvested after 4 to 6 irrigation events.

The types of fodder which are grown in winter receive their first irrigation just after sowing, but those types grown in the summer receive their first irrigation after 15 to 18 days of sowing. For subsequent irrigation, an interval is kept for both types of 7 to 8 days. The total number of irrigation events that will be given to fodder varies between 10 times up to 24 times, according to the type of fodder. Very few farmers indicated the interval and total number of irrigation that they used for sugarcane, therefore, no generalization can be made for this crop.

Two of the interviewed farmers mentioned that the interval depends on the rooting depth of the crops. They explained that cotton has very deep roots, and can survive with an interval of 12 to 15 days. Fodder, on the contrary has short roots and demands water after a smaller time period. Additionally, young crops still have small roots, therefor they need to be irrigated with little water and with a small interval, according to these farmers. Furthermore, some farmers indicated that sugarcane is a crop which needs much water for proper growth, therefore a shorter interval is kept for sugarcane. One farmer stated that during the fruiting stage, the crop needs much water and has to be irrigated more often, and the irrigation interval decreases. Another farmer has the opinion that if wheat is sown after the cultivation of rice, the first irrigation can be postponed up to 35 to 40 days.

The interval that is kept by the farmers is related to the soil. One farmer stated if he irrigates cotton cultivated on a sandy soil, the interval must be smaller than on a clay-loam soil (*merra*). But, if this farmer is facing water deficiency, he will dry up the sandy soil.

Some farmers indicated that due to inter-culture, the irrigation interval or duration increases. Due

to the appearance of weeds, 2 to 10 minutes more irrigation water is given to a basin according to the farmers. This is because, due to the weeds, the flow of the water encounters resistance and weeds also absorb the water. Another explanatipn given is that due to the weeding in cotton, the soil is disturbed and the infiltration rate increases. Therefore, after the weeding more water is needed to irrigate a basin. One farmer stated that normally 4 hr./acre is needed, but after weeding 5 hr./acre is used. About half of the interviewed farmers claimed that they have no problem with weeds and similar time is needed for irrigation. Another farmer mentioned that because he removes the weeds, the inter-culture has no effect on the irrigation timing.

Almost all farmers indicated that the weather has (strong) effects on the irrigation interval and timing. Only one farmer stated that there were no changes in irrigation due to the weather. One farmer indicated that in the summer, the first irrigation would take one hour more of water per acre, but for the later irrigation events, the duration is similar in summer and winter. One should take these statements carefully, since farmers are adjusting their irrigation interval in summer and winter and, therefore, sometimes indicating that the weather has no influences. Influences of weather are, according to the farmers, the rainfall. When rain falls, it is possible for the farmers to increase the irrigation interval. Furthermore, in the summer, the evaporation rate is higher and crops need more water. In this hot weather, the interval will decrease. In the winter, farmers explained that there is moisture in the atmosphere and in the soil and the crop can do with less water. One farmer mentioned that, if there is heavy rain, the water will stagnate on the lower situated fields and he would have to draw out the water with a pump. Most farmers take the influence of the weather into account by adjusting the irrigating time, the irrigation Interval, or both. Some farmers have the opinion that, in winter, less time is needed to irrigate a basin as compared to summer. Reasons told are that in the winter, the soil keeps some moisture and the water moves fast over the basin. But, in summer, the soil is totally dry before irrigating and the water needs more time to reach the end of a basin. Time differences stated are 2 to 10 minutes per basin, or even 1-2 hours more per acre.

Some farmers said that they only adjust the irrigation interval. One farmer is keeping an interval in the summer of 5 days, while in the winter the interval remains normal, which is 12 days. Another keeps an interval in winter for wheat of 30 days, while for cotton, grown in the summer, 7 days interval is kept. Other farmers are adjusting the irrigation interval and timing according to the season. One farmer is irrigating in the summer after 15 days for 20 min./basin, and in winter after 22-30 days for 12 min./basin. Farmers indicated that if less days are kept between the irrigation applications, the following implications are to be expected

1. The crop may suffer from waterlogging and wetness. Farmers stated that, due to the application of irrigation water too early, the roots of the crop will become weak and less air will be available:
2. Small crops may suffer due to compaction of the soil by the irrigation water, therefore, the seeds cannot break the crust which can appear on a loamy or saline soil surface;
3. Farmers indicate that when a crop is small, and the irrigation interval is small, there will be the problem of weeding; many weeds can grow because the crop does not cover the soil yet;
4. In early growth stage, if the crop is irrigated after a few days, the height of the crop, especially

for cotton, is increasing rapidly, but there will not be many flowers and the yield will be less: and

5. One farmer stated that for cotton, a decrease in irrigation interval will be beneficial (but due to deficiency of water this is not happening), but for wheat, an excess of water is harmful.

But, if more days are kept between the irrigation applications, the plants will suffer due to drought and there will be crop losses, according to the interviewed farmers. For wheat, for example, some farmers mentioned that it germinates after 10 days, and 10 days after the germination *(so* about 20 days after sowing) the seeds will be needing water. Farmers take into account the amount of water they have access to, along with the amount of water which is needed by the crops to survive to derive according to them, the most profitable irrigation interval. One farmer stated that his saline land requires much water, but due to a deficiency of water, he has to keep a large interval. If he irrigates with large amounts of water, the salts which are harmful for the crop will go down. If he irrigates cotton less times, the crop will be damaged because the germination will be less.

The total number of irrigation events depends, according to the farmers, on the soil type. Farmers apply, in general, more often irrigation water if the soil is sandy than if the soil type is merra (sandy-clay loam). Furthermore, the total applications depend on the crop. Some crops need more irrigation for a better yield. e.g. cotton needs more irrigation applications in total than wheat. Another farmer indicated that the total number of irrigation applications also depends on the canal tenure. If the canal closes for a longer period, the total number of irrigation for sugarcane can decrease from 20 times to 15 times. At last, the season also contributes to the decision of the number of irrigation applications, according to some farmers. When the wheat is hot (and cotton is grown), more irrigation events are applied than in the winter to the wheat crop. Furthermore, the farmers mentioned that the figures given are an average, the interval is not fixed at all, like the total number is not fixed.

ANNEX 2-8 CROP-BASED IRRIGATION STRATEGIES

Farmers keep the crops in their mind when creating an irrigation schedule. Three different strategies are kept by the farmers to decide which crops are to be irrigated. **Most** farmers irrigate the crop which needs water, so water is given with respect to crop demand. The second strategy, followed by some farmers, is to give preference to certain crops. The strategy is to prefer fodder, rice or sugarcane, cotton is irrigated last. As reasons, the farmers indicated that fodder is a crop which is sensitive to water, unlike cotton. Besides, fodder needs much water. Furthermore, because fodder is needed for the cattle, it is important for the farmers. If the fodder is damaged, their cattle will suffer. Some other farmers mentioned that fodder is not important, since it is not a cash crop and does not have a high market value like cotton. Because cotton and sugarcane are more important due to their market value to these farmers, those crops are irrigated first. These farmers prefer to irrigate sugarcane, cotton or vegetables first and last fodder.

The third strategy is followed by farmers who have access to sufficient water. 'The farmers in W/C Azim 111-L, who are only using tubewell water, do not have any preferences in this context, and are able to irrigate all of their crops easily. One farmer indicated that he takes the stages of the crop into account in deciding which basins to irrigate. According to him, **just** after germination fodder, needs to be irrigated first. When the plants are in a maturing stage, preference is given to cotton or wheat, and when the fruiting stage has started, the preference will be again on the main crop. Another farmer is cultivating one crop per season, so he has no preference for crops for irrigation. The irrigation and agricultural practices which are, in general, carried out by the farmers are listed below for each crop separately.

Cotton is sown in *kharif* season. The farmers mentioned that, for this crop two *rounis* are applied. Cotton is, in general, sown by a drill machine on flat land. When it reaches up to **1** to 2 feet, a ridger is used in these basins. This ridger is used for weeding and makes the soil loose and fertile according to the farmers. Due **to** the ridging, small furrows, called corrugations, are created. These small furrows, 2" to 3 deep, are made to cover the cotton roots again, because farmers said that the roots can become bare due to irrigation. The corrugations give support to the plant because the roots are supported by the soil.

The last irrigation applied to cotton by the farmers is viewed as the *rouni* irrigation for wheat, which is the only *rouni* irrigation that is given to wheat. Wheat is grown in the *Rabi* season. After harvesting the cotton, farmers use a rotavator to mix the soil and to destroy the roots of cotton. Then they plank and plough the land with tractor or oxen. Afterwards, broadcasting of the seeds and fertilizer takes place and, finally, the land is ploughed again.

Sugarcane grows whole year through. Sugarcane is cultivated with a combination of basin and furrow irrigation methods. First, farmers make furrows with a ridger. The sugarcane seeds are sown by hand in the down part of the furrow. The furrows are made **to** get enough soil above **the** seeds. According to the farmers, it is necessary for good production to put the seeds of sugarcane 6" deep. After sowing, the land is leveled again using a *craw* and irrigated as **a** basin.

One farmer covers the seeds with soil by foot instead of by craw, to make sure that not too much soil is covering the sugarcane. When the sugarcane grows up to 1 to 4 feet, small furrows (called corrugations) are created by the farmers with the ridger, like for cotton. These corrugations are used at the end of the season almost like furrows. The farmers mention that these furrows are beneficial, because there will be more soil around the roots and they support the sugarcane. The roots have a stronger base and, thus, the sugarcane can survive strong winds. One farmer indicated that by making the corrugations, the roots will be covered with soil again and more roots from sugarcane can appear. With corrugations, the roots of the sugarcane are provided with good fertile soil, moisture and air.

There are different types of fodder i.e. luhsim, bursim, maize, jowar, bajra etc. Some of these are grown in the summer season and some of these are grown in the winter season. This is used as the food for the cattle. Most of the farmers grow this crop for their own cattle.

Table A4 shows the number of acres that farmers mentioned they can irrigate per week with their irrigation turn.

Table A4. Irrigation scheduling.

Farmer no.	Total land (acres) Irrigated per turn	Irrigated per week with canal water (acre/week)	Irrigation interval with canal water (weeks)
1	20.5	5 - 7	3 - 4
2	19	8	2 - 3
3	4	2	2
4	23	6 - 7	2 - 3
5	6	1.5	4
6	5.5	1.75 - 2	2 - 3
7	6	3	2
8	25	8	3
9	12.5	6	2
10	11	4.5	2 - 3
11	20	3.5 - 5	4
12	9	2	4
13	22.5	--	--
14	14	--	--
15	16	--	--
16	12	--	--
17	3	--	--
18	11	--	--

The irrigation sequence, as followed by the farmers:

- First the field near the watercourse, at last the fields which are the most far away from the watercourse;
- Farmers try to judge which crops need water for this irrigation turn. Next, they make a plan to decide with which basin to start and with which basin to end;
- The higher situated basins are irrigated prior to the lower situated basins: and
- First one side of the farm is irrigated and then the other side of the farm is irrigated (which can be the next irrigation turn).

ANNEX 2-10 IRRIGATION DURATION

Table A5. Irrigation duration for an acre.

W/C			Fordwah 14-			
Farmer	1	2	3	4	5	6
Basins/acr	4	6 4 (sc.)	6	4-6	4-6	4
Time tw/acre	160	4" 360 5" 180	210	180	180	1st 300 next 150
Time cw/acre	60-80	60-72	90	150	100	1st 120 next 60
Time Mix/acre	40	---	---	120	80	never mix
W/C			Fordwah 62-			
Farmer	7	8	9	10	11	12
basins/acr	4	4	4-6 2-3 (sc.)	4 2 merra	4-5 1-2 (sc.)	6
Time tw/acre	120	120	160	120	80-100	360 winter 540 summer
Time cw/acre	---	120	80	---	80	---
Time mix/acre	---	60	60	48-56	40	72 winter 150 summer
W/C			Azim 111-L			
Farmer	13	14	15	16	17	18
basins/acr	1	2 wheat 6 cotton	2-3 3-4 fodder	2 level, 4-5 8 fodder	2-4	1 8 fodder
Time tw/acre	240-300	180-240	90-180	180-300	180	180
Time cw/acre	---	---	---	---	---	---
Time mix/acre	---	---	---	---	---	---

Times	=	*in minutes*	*1st*	=	*first irrigation*
Tw	=	*tubewell wafer*	*next*	=	*following irrigations*
cw	=	*canal wafer*	*4"*	=	*4 inch diameter fubewell*
mix	=	*mix of tubewell and canal wafer*	*5"*	=	*5 inch diamefer fubewell*

The interviewed farmers have different methods to set the time for irrigating a basin:

(i) During the night, when it is too dark, the basins are irrigated approximately in total by looking at the watch or estimating the time which has elapsed.

(ii) During daytime:

- When the water reaches the tail of the basin, the field inlet is closed. One farmer mentioned that he checks all sides of the basin to see if the water has covered all parts of the basin;
- In case of a basin with many undulations: the basins are irrigated until all the higher spots are covered with water. If the water level reaches too high and overflows the bund, a cut is made in the bund, so that the water can flow into the neighboring basin:
- Some farmers close the inlet of a basin when the water reaches up to a certain distance (5 meter to 10 meter) before the tail of the basin. Especially with lower situated basins, when the water is able to flow to the end is the practice. Otherwise, the farmers said that if they would cutoff the water when it reaches the tail in lower situated basins, the water will pond in the tail and damage the crop;
- When farmers want to irrigate with a lot of irrigation water (e.g. for fodder or sugarcane or *rouni* irrigation), the water level at the tail of the basin is the control point; and
- Some farmers mentioned that they apply water unil about 3 to 4 inches of water is standing on the soil surface.

In Table A5, the time allocated to irrigate an acre is presented. When tubewell water is used, the water discharge is very important. One farmer indicated that with a 5-inch diameter tubewell, he could irrigate an acre in half the time than with a 4-inch diameter tubewell. For canal water, next to discharge, also the soil type and climate are important. Furthermore, the time is affected by the size of the basin and the topography of the basin. Most of the interviewed farmers stated that, if the land is levelled and the water can run smoothly, it will take less time. The farmers mentioned that their canal water turn shifts by 12 hours in a year, ***so*** one year their turn can be in the morning and next year in the night. Some farmers prefer to irrigate at night due to the following reasons:

- At night, the evaporation rate is less than during daytime, because due to sunshine the water evaporates quickly: and
- One farmer stated that at night they can irrigate easily, because he does not have any other work and he can easily pay full attention to the irrigation. But, at night, he cannot check the *nakka* due to darkness; therefore, he always checks the field inlets on the following morning.

Those farmers who do not prefer to irrigate at night mentioned the following reasons:

- When the water turn comes at night, then they cannot sleep and become tired;
- The quantity of water given to a basin cannot be observed at night;
- One farmer stated that for cotton, irrigation application can be done at night, but not for wheat. Wheat requires less quantity of water and this farmer prefers to irrigate wheat in the morning; and
- Two farmers mentioned that they prefer to irrigate in the evening, especially the first irrigation. If they would irrigate in the morning, the seagulls will eat the seeds. If they would irrigate at night, they cannot rest, Therefore, they prefer to irrigate in the evening.

ANNEX 2-11 ARRANGEMENT OF IRRIGATION WATER

All of the interviewed farmers are using tubewell water to supplement the canal water for cultivation of their crops. A few farmers mentioned that, in some cases, they have a surplus of water, especially in the rainy season. During that period, farmers do not always use the canal water and let either their irrigation turn pass by or irrigate the fodder crop, which can use much water. One farmer has access to another source of water: run-off water. This rainwater is harvested in a drain well, from which the farmer can pump water when he needs it.

Tubewells are run either by a tractor engine, a portable high speed diesel engine (called *piter*), or run by electricity. Especially in W/C Azim 111-L, most of the farmers have a tubewell; however, a few farmers have a share in a tubewell. These shared tubewell owners indicated that there is a kind of *warabandi*, an irrigation rotation for the use of the tubewell water. One of them stated that very rarely can he use the canal water. The canal water is of better quality according to him, because there are silt particles in the water which are beneficial for the crops. But the canal water will only flow in W/C Azim 111-L when the rains falls, while no irrigation is needed during that lime.

The interviewed farmers who do not own a tubewell indicated that they are hiring tubewell water when they need to and when they have sufficient money to do *so.* Most of them use different tubewells. The rates given by the farmers is that for running a tubewell with a *piter* engine, about 30-35 Rs./hour is paid. But to hire electricity tubewell water, the farmers indicated that they pay about 70 Rs./hour.

Farmers mentioned problems concerning the arrangement of tubewell water, such as non availability of a tractor, diesel shortage, or no opportunity to use tubewell water (e.g. tubewell is already occupied by another farmer. Some farmers mentioned that if the crop needs water, they immediately irrigate the basins with tubewell water, and do not even wait for their canal water turn to come.

Like the use of canal water, most of the farmers irrigate their basins one-by-one with tubewell water. One farmer stated that he has to irrigate carefully with tubewell water, because this type of water is very costly. Another farmer mentioned that if they would irrigate two basins at the same time, the water would not be able to distribute equally in the basins. Most of the farmers mentioned that it takes a longer time to irrigate a basin with tubewell water, since the discharge of most of the tubewells is lower as compared with the canal water discharge. Some mentioned that it makes no difference at all.

ANNEX 3-1 CONTACT WITH FURROW IRRIGATION METHODS

Most of the respondents said that they had heard about the furrow irrigation methods by informal contact with neighbors or relatives. Their friends told them the benefits of the furrow irrigation methods e.g. like better yields and water savings. Then, farmers tried furrow irrigation themselves, with the help of advice from their friends. The furrow irrigation methods were used for different crops such as cotton, sunflower, maize or potatoes. Most farmers rented implements for creating furrows, first from other farmers. Later on, after facing success, they purchased their own equipment.

Two farmers met with officers from the Ayub research center and Agriculture Department in Faisalabad. The Ayub Agriculture Research Institute (AARI) is a research centre which provides information and knowledge to the educational institutes and the extension workers according to output after doing research. Then the farmers obtain information from the extension workers. The farmers are informed about seeds, cultivation and irrigation methods by the educational institutes and extension workers. However, progressive farmers can get information directly from this research center when having contact with people working at the AARI. At the University of Agriculture, Faisalabad (UAF), short courses classes are managed in which different agricultural techniques and implements are introduced. The UAF receives this information from the different research organizations. Farmers are acting upon the advice of the centers. One farmer explained that this visit to the research center was decided by the Agricultural Department of Hasilpur.

One farmer learned about furrows from his father. His father cultivated the land before the time of partition and used furrows for vegetables on 1 to 2 acres. Because they increased their area under furrow irrigation enormously, he had gained a lot of experience. He said that 'human being has his own mental thinking, with help of his thinking he knows where to put seeds of vegetables' on the beds with respect to crop, season andplace'.

ANNEX 3-2 REASONS TO SHIFT FROM BASIN TO FURROW IRRIGATION METHODS

One farmer changed the crop he was cultivating and, therefore, needed to change his irrigation method as well. First, he cultivated sugarcane using the basin irrigation method. But, because he did not receive the payment from the sugar mills to which he gave his sugarcane, he decided to change his cropping pattern. He started to cultivate potatoes instead of sugarcane. Because potatoes can only be grown on beds, according to this farmer, he shifted to the furrow irrigation method.

Some of the respondent farmers acted upon the advice of others, who told them about the advantages of using the furrow irrigation method. Another category of farmers has changed their irrigation method due to changing circumstances. Increasing salinity is one of the major influences. All farmers know that a crop cannot be grown on salt-affected land in basins, but can grow on beds or ridges The seeds are sown on the sides of the bed or ridge, where no salts accumulate and water is within reach. Additionally, the soil becomes loose by creating furrows and can absorb water easily. One farmer indicated that he has too many salts in his soil. If he would drill the seeds in basins, they would go too deep into the soil. When, due to the rains, a hardpan would be created, and the seeds would not germinate.

Furthermore, with the furrow irrigation methods, a crop can be saved when rainfall occurs just after sowing, or some days after sowing. The crop of one farmer has been destroyed once due to rain, while the crops of his neighbor (i.e.having beds - and - furrows) survived. One farmer was taught by his father about the furrow irrigation method. One farmer noticed that his neighbor got much more out put (yield) by applying less inputs with beds – and - furrows for cotton. Farmers, who are using the bed and furrow irrigation method, mentioned that they are very happy and satisfied by adopting this irrigation method because they get higher yields which are almost double the yield coming from basins. One farmer of Khanpur mentioned that in this year, the average yield of cotton in the District Rahimyarkhan was 18 maunds per acre, while he had obtained an average yield of 36 mauds per acre.

Land preparation

One farmer mentioned that he is using a rotavator more often to make the soil more soft. This is necessary because they sow on furrows by hand in the dry soil. If the soil is not soft, it will damage the hand of the person who is sowing. The farmers said that the extra land preparation is not necessary on basins. On basins, they use a drill machine for sowing.

Some farmers indicated that they use the plough a couple of times for land preparation, depending on the hardness of the soil and the time available. After ploughing, the land is leveled. Furthermore, farmers mentioned 'that a rotavator and a cultivator is often used during land preparation to break the big soil clods and to mix the soil. Most of the farmers do the sowing, hoeing, fertilizing and spraying by hand. After the land preparation, all farmers use a tractor and ridger to create ridges or beds – and - furrows. One farmer has developed his own ridger and other agricultural implements, so that he is able to perform all of the cultural practices with a tractor. This farmer mentioned that, with the furrow irrigation methods, less labor is required. He can perform the spraying and sowing at the same time to the crop on beds, while if the crop is grown in basins, spraying and sowing is done separately.

One farmer indicates that no hoeing needs to be done in furrows, he is only using spray against the weeds when the crop is young and small. Cotton can only be sprayed on a 30 - day old crop and the spray may not touch the cotton; otherwise the crop can be damaged. Some farmers mentioned that weeds are easy to remove when having beds – and - furrows. Some of the farmers mentioned that weeds appear very quickly due to frequent irrigation and rainfall with the furrow irrigation methods. They think that hoeing takes much time and much work.

One farmer indicated that he needs, sometimes, more labor is to pick the extra yield of cotton grown with the furrow irrigation method. Another farmer, who is growing potatoes on beds, has a harvester which brings the potatoes to the surface. He is hiring labor to pick the potatoes from the ground.

According to a farmer, an entire acre of furrows can be irrigated at once if the land is level. Another farmer mentioned that the size of the units which are irrigated also depend on the number of inlets he has to make to irrigate these units. He said that if he would irrigate less furrows at the same time, he has to make smaller units, then he has to increase the number of inlets in the supply canal. If he makes too many inlets in the supply canal, this canal will become very weak and can be damaged.

Some farmers stated that they would irrigate smaller units for the first irrigation. They find it more difficult to irrigate the furrows when they are new and have a rough surface. Once the furrows are irrigated a few times, the bed surface of the furrows will become smooth and the chance of breakage diminishes according to the farmers. Then, they would irrigate twice as many furrows, or even the entire acre at once. One farmer commented that it is easier to irrigate the entire acre of furrows. He indicated that he can irrigate the entire acre at night without hard work and no person has to stay awake to control the irrigation. When farmers make a feeder canal in the middle of the acre, then farmers usually irrigate one side first. Furthermore. farmers will make the inlet to a unit of furrows usually in front of the center furrow of the unit.

ANNEX 3-5 IRRIGATION INTERVAL

Farmers have different strategies for irrigation application with the furrow irrigation method. In general, farmers stated that they have no problem with irrigation application for the furrow irrigation method. They mentioned that the water moves quickly and irrigation can be done in a short time. They explained that to irrigate the furrows, a carefully controlled irrigation is required and mostly one person is full-time involved with opening and closing the field *nakka's* and to repair the furrows wherever necessary. Out of the 14 farmers, 3 farmers indicated that the first irrigation given to the furrows is a bit difficult. The furrows are still new and the farmers fear that the furrows might break. They stated that the next irrigation applications are easier, because the furrows are compacted by that time.

Most of the interviewed farmers mentioned that no rouni irrigation was applied when using the furrow irrigation method. The absence of rouni irrigation is a great benefit according to the farmers. Land preparation can be done quickly, because farmers do not have to wait for a proper moisture content in the soil. Some farmers said that due to this saving of time, they are able to use deep plough or a sub-soiler on furrows to break the subsoil and hardpan. One farmer indicated that he only applies rouniirrigation in the summer.

Because most of the times no rouni irrigation is applied, the first irrigation for the crop sown on beds is at the time of sowing. The farmers mentioned that the seeds need this moisture to germinate. Most farmers indicated that they estimate when the crop needs water. Only one farmer is using a neutron probe to estimate the water requirement of the soil and the crop. The interviewed farmers have the practice to change the irrigation interval given to a crop grown on beds according to the climate. They increase the interval when rain falls and decrease it according to the sun-heat.

Some farmers keep an interval of *7* days for cotton sown on beds, while others think an interval of 10 - 15 days (depending on the crop demand) is suitable. According to one farmer, it is necessary for maize to apply during the first two months water every week, and the last two months every 4 days. Another farmer applies the first irrigation for maize after two weeks and the next irrigation events, depending on the season, after 8 or **15** days. One farmer has the practice to keep after three irrigation events a dry spell of a month in the winter for vegetables grown on beds.

Other farmers mentioned that in total 15 - 16 to 24 times irrigation applications are applied for maize and 7 times for potato. Concerning cotton, the variety in total irrigation applications is even larger, from 5 - 6 times to 25 - 30 irrigation applications are mentioned by the farmers.

ANNEX 3-6 AGRICULTURAL AND IRRIGATION PRACTICES FOR MAJOR CROPS

The interviewed farmers who are using the furrow irrigation method grow a variety of crops. Some of the farmers are cultivating, besides the normal crops (cotton, wheat, sugarcane and fodder), also mango, maize, sunflower, melon, rice and vegetables like potato, onion, ladyfinger, tomato, pumpkin and cabbage. All of the interviewed farmers, who are using the furrow irrigation methods, mentioned that they use basins for wheat, fodder and rice. In this case, the required density of the plants makes these crops not suitable for furrows. They are not expecting a higher yield if they would use the furrow irrigation method. One farmer indicated that wheat is requiring a uniform irrigation, while with the furrow irrigation methods, the whole field is not wetted. But, a couple of farmers show a high preference for the use of furrows.

Cotton is sometimes grown on basins and sometimes on bed - and - furrows by some of the interviewed farmers. Furrows are useful because there is a higher yield. A few farmers do not observe much difference in yield, since their soil is affected with salinity.

Another interviewed farmer is experimenting to find out what density of cotton gives the best profit and has trials on seed dressing and pesticides. One farmer mentioned that he cultivates vegetables on beds, but is confined to basins for cotton because of the additional labor needed.

Concerning potatoes, the interviewed farmers mentioned that potatoes have always been grown with the furrow irrigation method. They said that the growth of potatoes is good when it is covered by the soil. If the potatoes will be exposed to the air, they will be damaged. Farmers restore the beds – and - furrows by hand after sowing to cover the seeds with more soil, because sometimes the seeds are not totally covered. Another reason to use the furrow irrigation method is that potatoes need a dry bed to grow on. For maize and sunflower, the interviewed farmers mentioned that they use the furrow irrigation method. They indicated that they have much better yield with this method.

ANNEX 3-7 DURATION OF IRRIGATION

Three different strategies are used by the farmers to arrive at the time to irrigate a certain number of furrows. The first, used by a few farmers, is to cutoff the water when it reaches up to a certain distance from the tail of the furrows. This is done with either very long furrows with slightly sloping land, or if many furrows are irrigated at the same time. In all cases, the water quantity or velocity is large enough to let the water reach to the end of the furrows.

The second strategy, used by 50% of the respondents, is to cutoff the water when it reaches the tail of all furrows, or when the water has reached a certain level in all the furrows of the unit which is being irrigated. The third strategy, mentioned by a few farmers, is to close the inlet when the water fills to a certain level in all the furrows which are being irrigated. One farmer keeps this level up to half of the depth of the furrow, while another wants 6 inches of water depth in the furrows.

Some of the interviewed farmers use a combination of the abovementioned strategies. One farmer makes a distinction between fields. Where the land is accurately leveled, the water will be cutoff when the water level is 6 inches deep in all furrows which are being irrigated. Where there is slightly sloping land, the water will be cutoff by the farmer when it reaches up to 15 feet of the tail of the furrow. He explained that due to water shortages, he has to follow these practices.

Another farmer supplies water to very small units for the first two irrigation events. He terminates the water supply to the unit when there is water standing up to 5 to 6 inches deep in all of the furrows. For the following irrigation events he irrigates an entire acre and terminates the irrigation when the water, in only 8 - 10 furrows, has not yet reached the end of the field.

ANNEX 3-8 INPUTS

The most important inputs, besides the inputs mentioned already, which are used by the interviewed farmers will be discussed. These inputs are labor, machinery and soils. Sometimes, the farmers could only tell about the input demands of the furrow irrigation methods if they compared it with the demand of the basin irrigation method. Therefore, this comparison, which is according to the interviewed farmers who are using the furrow irrigation methods, is made in a few cases and mentioned to illustrate the farmers' opinion of the demand for inputs.

Labor

According to a few farmers, the labor demand is not high with the furrow irrigation method, and less than for the basin irrigation method. One of the farmers has ample equipment for all cultural practices on furrows and, therefore, has a lower labor demand. Another farmer made the comparison of the cultural practices, which are to be done for basin and for furrow irrigation. According to him, less cultural activities need to be done with the furrow irrigation method.

But most of the interviewed farmers mentioned that (much) more labor is required with the furrow irrigation method. The amount of labor needed by the farmers varies from about twice as much, to ten times as much, as they would use with the basin irrigation method. These figures are sometimes given only for separate cultural activities, like for sowing or for hoeing on beds – and - furrows. One farmer indicated that it is very difficult to hire labor during the cotton season. Because at that moment, the weather is very hot and people do not want to work in the hot weather. According to one farmer, extra labor is needed for: (i) the final preparation of the furrows to be able to irrigate them; (ii) the sowing by hand; and (iii) the hoeing by hand. Another farmer indicated that more labor for harvesting is not required, although there is more cotton to pick with the furrow irrigation method.

Machinery

In the past, furrows were made with a ***jundra***. One farmer explained that he had only oxen to plough with and wooden implements for land preparation. The land preparation had been difficult with these implements. He stated that, nowadays, science has made it easy for him. because *so* much machinery is available. Most of the times, the ridger is first borrowed from friends and other farmers and tested. When farmers feel the profit of using the furrow irrigation method, they will buy a ridger.

One of the interviewed farmers is making and developing his own machinery since 1987 and makes them for other farmers on a non-profit basis. He has machinery for all types of cultural practices for cotton on bed – and - furrows. They are made in his own workshop:

1. Chisal cultural plough, of which the angle of the plough is adjusted and the blade has been made sharper to match the lower horsepower of the local tractors;
2. Roller which works like a ***sohaga,*** but only breaks the big clods instead of powdering the soil; with this roller, there is no compaction after irrigation, because small stone particles remain which are profitable;

3. Ridger which makes two beds – and - furrows at the same time, with a distance of 2.5 feet of each other. The end of the ridger is changed, to get a further compaction of the furrow sides. The bend of the ridger is changed so that the soil will not pile up in front of the ridger;
4. Seed planter or drill shapes the beds – and - furrows, it sows the seeds, and can spray pesticides at the same time; they are now developing a measuring device to control the plant-to-plant distance (the farmer tells that when they spray with sowing, it is not harmful for the plants, only after sowing it is harmful):
5. Rotary or hoeing machine which can do three beds – and - furrows at once, which has side blades that cut the grasses in the furrows, and a rotavator for inter-culture on the beds;
6. Fertilizer applicator which also reshapes the furrows; Furthermore, there is a harrow for use on the beds, while fertilizers are drilled in the soil, near the plants: and
7. Spray machine with shield which prevents the spray from coming closer than 1" to the cotton plants; they use it for the weeds that grow after the rains. The farmer says that it is risky to use spray after 30 days of sowing, because the spray can damage the crop.

Another big farmer indicated that he still has difficulties with the different implements. He said that there is no proper machine to do the weeding on beds – and - furrows. He is getting films from Australia, which shows the different machinery which are used over there. One of the farmers obtained his ridger from the Agricultural Department for half the price. He wrote an application for concession and retrieved half of his money back. He indicated that since there is mutual cooperation between the farmers, he had never hired machinery.

Soils

All of the interviewed farmers have the opinion that a clay-loam soil, a so called *merra* soil, is the most suitable for the furrow irrigation methods. On a soft merra soil, the farmers give preference to furrow irrigation, but on a hard and *pacca* merra soil, using beds – and - furrows is a must for cultivation. The farmers explained that if the basin irrigation method is used, the water will pond after rainfall, or irrigation on the saline land, either of which can damage the crop. According to one farmer, the basin irrigation method is preferable on merra land if there is enough time between the seasons kharifand rabito perform all of the land preparation activities. He explained that if he would use beds - and - furrows, he would have to hire more labor for hoeing purposes. Additionally, he would have to irrigate the furrows every week, which he finds more complicated. Most of the interviewed farmers indicate that beds – and - furrows can be made on semi-sandy land, but according to them it is impossible to make beds – and - furrows on pure sand. Some farmers indicated that if the furrow irrigation method is used on a sandy soil, then they will be destroyed due to the force of the flowing water. One said "*Furrows* on a sandy soil can be broken, they cannot survive, if they are irrigated because the soil is very soft and can damage the furrows". Other farmers expect the sand to be scattered during irrigation, because the beds - and - furrows are not stable enough to irrigate. Furthermore, one farmer explained that a sandy soil requires much water and to apply more water will results in too many expenses.

ANNEX 3-9 ADVANTAGES OF THE FURROW IRRIGATION METHODS

The following advantages were mentioned:

- Sowing is easier to manage with the furrow irrigation methods. The first irrigation of the crop sown on beds or ridges is at the time of sowing. There is no need to wail until a moisture condition exists in the soil, because the seeds can be sown in a dry soil. The time period required from land preparation to sowing is shorter and can be better controlled by the farmers. On basins, after the *rouni* irrigation much time should elapse to retrieve a proper moisture content before land preparation can be practiced. One farmer indicated that the number of plants sown on beds can be increased, i.e. a smaller plant spacing is required.
- The process of germination is better on beds or ridges, a farmer stated: "there is a vigorous start *of* the crop". According to the farmers, it is due to the early first irrigation and the frequent irrigations that the crop germinates quickly.
- There are no crop losses due to rain. With the furrow irrigation method, the soil is softer and the rain water can either infiltrate or stand in the furrows, so there is still germination of the seeds. Furthermore, continuous rain cannot harm the crop, because the rain water is collected in the furrows without damaging the crop. With the furrow irrigation method, the crop is sown on the bed or ridge and will not come in touch with water. For cotton e.g. the bolls will be protected against rotting due to wetness.
- There is no burning of a crop sown on beds or ridges. The farmers mentioned that moisture stays a long time in the soil with the furrow irrigation method and it prevent the crop from burning if there is extreme hotness, because the moisture keeps the temperature of the soil low.
- Due to the early germination and the favorable conditions for crops on beds, there is early crop maturity and the crop is more quickly ready for harvesting. Furrows are especially preferred by farmers when the harvest of the previous crop is late.
- Water is saved. All the farmers can save water with the furrow irrigation method, from 30% up to 50% and one farmer could even save 75%! One farmer said that he is applying 2 inches of water to beds – and - furrows, while with the same frequency 6 inches of water is applied to basins. Although the frequency of irrigation given by the interviewed farmers is (often) higher, the total amount of water supplied is less. One farmer has compared the two irrigation methods; if he irrigates furrows four times in a month, which takes in total of 6 hours, this is the same amount of water as the first irrigation application after 45 days on a basin.
- Fertilizers do not leach if furrows are used and can be saved up to 50%. Fertilizers like phosphorus and potassium are better utilized with the furrow irrigation methods, but some farmers indicated that nitrogen still partly leach. Most of the interviewed farmers broadcast the fertilizer, but some mix it with the water. By using furrows, the fertilizers can be concentrated in the furrows and the distribution of fertilizers can be very well controlled. One farmer indicated that because the area of coverage is much less with using the furrow irrigation methods, he can do with 2 bags of fertilizer per acre, but on basins he needed 5 bags.
- Some farmers mentioned that seeds are also saved by using beds – and - furrows, because if they sow by hand, all of the seeds will go where they should go, in the soil. They said that due

to broadcasting or drilling the seeds, which is happening on basins, many seeds can be misused.

- A crop can grow on saline land. Farmers said that, if they would use basins on land affected by salinity, they would not get any yield at all. Farmers also prefer beds – and - furrows on hard land, because they said that moisture doesn't disappear so quickly as on basins.
- Some farmers mentioned that there is not *so* much weeding with the furrow irrigation method. Water flows only in the furrows and there the weeds can grow. There are no weeds on the beds, because the beds remain dry. Weeds are either removed by spraying (by hand or with a tractor) or by hoeing with hands. One farmer states that that the spray will not work if it rains. Even after spraying, he said that the weeds near the stem of the plants are not done because they avoid spraying there, because it will damage the plants. Those weeds are cut by hand. According to another farmer, after 30 days of sowing, spraying cannot be done without damaging the cotton on beds. Another farmer indicated that the weeds are less with the furrow irrigation method because the sowing and the first irrigation is at the same moment.
- Farmers stated that they obtain a higher yield and more profit with the furrow irrigation methods. Only one farmer said he gets the same yield with the basin as with the furrow irrigation methods. Another farmer obtains on average 38 maunds/acre of cotton with using beds – and - furrows instead of 19 maunds/acre with using basins. One farmer said that in the past he got 85 maunds/acre of cotton, but nowadays, due to viruses, the yield is much less. Figures like 2 to 15 maunds/acre extra yield with the furrow irrigation methods were given by the farmers. Less input expenses with the cultivation on beds – and - furrows and a higher cost/benefit ratio are obtained by some of the interviewed farmers.

ANNEX 3-10 DISADVANTAGES OF THE FURROW IRRIGATION METHODS

Generally. farmers were not clear in mentioning the disadvantages of using the furrow irrigation methods. Disadvantages of bed – and - furrows were not perceived by most of the interviewed farmers. Some of the farmers have already some experience in the use of beds - and - furrows. They have been making furrows on daily payment for other farmers and have ample access to credit, machinery and other implements needed. These farmers are very happy to use beds - and - furrows, because they obtain a better yield. One farmer stated that he has not experienced any problems with the furrow irrigation method up to now, but he does not know what the future will bring.

However, some disadvantages were raised on agricultural matters, such as labor. Four farmers mentioned that they have to hire labor for hoeing, because they said that a tractor cannot be used for weeding. Figures given by them are that one person is enough in basins, but three to four persons per acre are needed to hoe on beds – and - furrows. One farmer states: ***"Although I have to hire labor, the production is much as compared to basins. I don't feel the labor as a headache".*** Other farmers do perceive weeding on beds - and - furrows as a major problem. They said that there is no machine to do the hoeing, and due to frequent irrigation applications, and due to the rain, weeds are appearing with the furrow irrigation methods.

Another disadvantage which is mentioned by one farmer is that it is difficult to make beds – and - furrows and to irrigate them. But many other farmers have the perception that the irrigation application it is not more difficult.

One farmer mentioned that difficulties are felt, when the rotavator is used after the harvesting of a crop when he is preparing the land for the next crop. Due to the furrow irrigation methods, there are ups and downs in the land. When this farmer is driving the tractor with the rotavator, he is not feeling comfortable, due to the unleveled land.

Another farmer mentioned that by using the furrow irrigation method, the crop location has to be changed each year. The farmer stated that ***"the land gels tired due to less water".*** After using furrow irrigation, he will have to use the basin irrigation method again, to make sure that the land receives more water and becomes fertile again. Another farmer thinks that the furrow irrigation method can be used continuously for five years on a piece of land. After five years, the land will become heated, according to this farmer, and plants will start to burn on this land. The explanation of the farmer is that the soil becomes soft due to creating furrows and will absorb much heat. To overcome this problem, the farmer is changing the crop which is grown on the land. He has the practice of using the basin irrigation method for two years after having used the furrow irrigation method for five years on a piece of land.

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