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Warabandi in Pakistan's Canal Irrigation Systems

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Widening Gap between Theory and Practice

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Cover photograph by D.J. Bandaragoda: Farmer diverting water from the watercourse at the beginning of his warabandi turn.

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Foreword

THE MAJORITY OF watercourses in the Punjab have an official warabandi established by the Provincial Irrigation Department at the request of the farmers, which prescribes the time allocation among each of the landholdings for the water supply entering the watercourse command area. This official warabandi is the only record of a "water right" held by each landowner, so it also has importance for settling disputes by arbitration.

Farmers exchange water turns quite often. Sometimes, they sell a water turn, However, for the canal surface water supply to the watercourse, the exchange is more common than selling, whereas the opposite is the case for tubewell groundwater supplies.

The major finding of this applied field research is the high degree of inequity in the water supply entering the watercourses. which is more than a singlequestion of head versus tail watercourses along a minorordistributary. Within each watercourse command area, there are significant deviations in the list of water users, the timing of water turns, and the duration of water turns, as well as deviations in day turns and night turns.

All the deviations cited above are further accentuated by the variability ofthedischarge rate throughout the day at the *mogha* (outlet) structureserving the watercourse. The combination of warabandi deviations and discharge variability is a major constraint to achieving reasonably good irrigation application efficiencies when irrigating the croplands, resulting in significant reductions in crop yields.

This report provides important information regarding the problems associated with achieving equitable water distribution among watercourses and the farmers within each watercourse command area. Most of all, valuable insights have been attained concerning solutions for overcoming these problems.

The Punjab Irrigation Department has begun a collaborative program with IIMI on the Fordwah Canal in implementing the Irrigation Management Information System that will facilitate the canal managers in providing more stable flows to the distributaries, which in turn will reduce the discharge variability at the watercourse inlets. This is a pilot program being assessed for future implementation in other canals.

The most essential solution involves social organization. Well-organized, viable fanner groups have the best potential for resolving the problems of inequity. Farmers need to be organized into a legal water users' association, for which there exists legislative ordinances. However, there is a need to "learn how to organize" farmers both at the watercourse and distributary levels. This is presently the highest research priority in IIMI's Pakistan Program.

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Glossary

Agro-climatic zone	A region where climate makes a well-defined demand for water and where a general cropping pattern prevails in a majority of the farms.
Authorized supply	The design discharge of water from a channel
Bandi	Fixed.
Basmati	A cultivated aromatic long-grain rice of South Asian origin.
Biraderi	Kinship group, or a subdivision of a caste group.
Chak	Block of land identified as the smallest administration unit with reference to irrigation.
Chakbandi	The gross area of land fixed for irrigation in relation to an outlet.
Chakbandi map	A map showing the area of a chak with irrigation boundaries.
Command area	The area served by a watercourse or a distributary or a main canal.
Culturable command area	The portion of the command area that can be cultivated.
Discharge	The volumetric rate of water flow or delivery, expressed as cubic feet per second (cusec). or liters per second.
Distributary	The water channel on which distributing points are located. The hierarchy of channels in terms of size (in descending order) is: main canal, branch canal. distributary, minor and watercourse. *Moghas* (outlets) into watercourses may be placed on any of the first four categories of channels, but usually they are on distributaries and their minors.

Doab Land between two rivers.

Gross command area The portion of the entire village area is commanded by gravity canal irrigation and includes roads, schools, graveyard.,canals, etc.

Haq Traditional (water) rights.

Haqooq Right to irrigation water.

Kachcha Unofficial or unregulated or informal.

Khal Bharai Time required for :Filling a unit length of an empty watercourse.

Kharif Summer time warm (wet) season cropping, officially from mid-April to mid-October.

Killa Acre = 220' x 198' = 0.40 hectare.

Lambardar Headman of the village, the person who enters into an agreement with the canal authorities to collect land revenues, as are due from the third party, viz., occupier or owner in respect of any land or water.

Minor A water supply canal smaller in discharge than a major canal but lesser in capacity than a distributary.

Mogha An ungated outlet of fixed size through which water passes from a canal to a watercourse.

Mouza A territorial unit with a separate name, definite boundaries and its area precisely measured and divided into plots and survey numbers.

Nakka A cut in the watercourse from which water is carried direct into the fields.

Nikal Water left in a watercourse at the end of a turn or at the complete rotation of warabandi.

Nan-perennial (Canals receiving) single water supplies only during kharif.

Parchai milkiyat Record of land rights kept by the Civil Administration.

Patwar circle The jurisdiction of a patwari. There may be one mouza or more, settlements, villages, etc., in this circle.

Patwari Revenue official at the field level for a particular patwar circle, keeper of revenue and warabandi schedules record, surveyor of crops, etc.

Perennial Channel supplied with water all year-round.

Private tubewell A small discharge irrigation well individually or jointly owned by farmers.

Pucca Official or regulated.

Rabi Winter time cool (dry) cropping season, officially from mid-October to mid-April.

Rachna doab Land between the Ravi and Chenab rivers

Square Normally a 25-acre block of irrigated land.

Tubewell An irrigation well.

Wahr Turns.

Wahr-bandis The list of rotational turns or times when each shareholder in a watercourse obtains his water supply.

Wara Water turn.

Wara shikni An irrigation offence. Any water user who violates the official arrangements of turns for taking water is liable to penal action under the Canal and Drainage Act.

Water duty The area irrigated per unit of water per season of the year.

Watercourse A water supply channel placed on a 16-foot wide government right of way, constructed and maintained by farmers to deliver water from a mogha to farmers' field ditches.

Zilladar Junior member of supervisory staff of revenue establishment of the Irrigation Department, supervising a number of patwar circles.

Executive Summary

WARABANDI. AS IT has been institutionalized in Pakistan, is a rotational method for distribution of irrigation water, with fixed time allocations based on the size of landholdings of individual water users within a watercourse command area, It presupposes an overall shortage of the water supply. The primary objective of the method is to distribute this restricted supply in an equitable manner over a large command area. For warabandi to achieve this main objective, it needs to be supported by a set of physical and institutional conditions, which form the environment of warabandi, transcending the boundaries of the tertiary system in which warabandi is actually applied. As the system has been designed with minimum control to allow a "free flow" of water into the outlets, these conditions require that the rate flow of water in the canal system should be uniform *so* that each water turn receives its proportional share. This is achieved by maintaining the main canal's distributing points and the distributary canals themselves at a predetermined water supply level. Also, all the outlets in a distributary should operate at the same time, each outlet discharging a constant flow of water into the watercourses, so that the warabandi roster would not bedisturbed. The field-level warabandi operations, along with these necessary conditions, constitute a warabandi system, which implies in its design an equitable distribution of water *so* that each fanner receives the total allocated flow of the watercourse for a fixed duration proportional to the farm area. The successful application of this procedure requires a well-maintained physical system and a high degree of cooperative behavior among the water users.

The origin of warabandi has to be placed somewhere in the precolonial period. When the British started to build the canal irrigation network, warabandi was adopted from an existing practice as a water distribution method at the watercourse level. The time allocation schedule was locally determined and mutually agreed upon by the fanners in the watercourse command. However, with changes in social conditions, intermittent water-related conflicts among the fanners led to increased official interventions in this original farmer-managed *kachcha* (unofficial) warabandi tradition, resulting in the widespread conversion of kachcha warabandi practices into more rigid *pucca* (official) warabandi schedules. Today, there are only a few watercourses in the Central Punjab, which are not covered by pucca warabandi. Field observations reported in this paper cover 22 sample watercourses in 4 distributary canals in the Punjab Province of Pakistan. 'These observations revealed that, in actual practice, most of the theoretical characteristics of official warabandi did no longer hold. The reality that emerges in the field contrasts with several myths associated with the popularly known concepts of warabandi, which are commonly shared by many, including some staff of operating agencies, professionals of research institutes, and members of foreign missions.

Foremost among these myths are two interrelated notions. One is that warabandi in practice corresponds to an equitable distribution of water. The other common assumption, not validated by field observations, is that warabandi in operation is a totally fixed and rigid water distribution practice.

The principle of equitable water distribution underlying the design of warabandi is eroded by an increasing variability in the water flow in the canals, as well as by the nonadherence to standard operational rules, both of which are in turn related to a combination of physical and institutional factors. Poor maintenance due to lack of funds combined with low institutional accountability, maintenance-related physical deterioration of the canal system, and operational deviations caused by power and influence of some water users characterize this practical field situation. In sum, these are the changes in the necessary conditions of a warabandi system. The changes that occur in the operational conditions above the outlet tend to induce corresponding behavioral changes related to warabandi kperations below the outlet.

In practice, there are marked deviations from the officially recognized fixed warabandi time turns and timings. Against the official perception, there are many instances of sharing and exchanging of water turns. The steady state that has been reached over time appears to be one in which water is shared in a largely flexible manner and official warabandi schedules are retained as a formal standard to which the water users can fall back in case of any serious dispute.

The observed deviations from the officially fixed warabandi procedures represent an inequity that cannot be conclusively described as commonly accepted, or as arising from mutual agreement. This inequity generally affects the poorer and less-influential landowners. Generally, the policymakers and planners perceive equitable allocation and distribution of the limited supply of irrigation water as a desirable feature that positively contributes to overall production goals. Thus, the reality of the warabandi that is practiced today should cause some concern in terms of equity, and thereby, its contribution to declining overall system performance.

CHAPTER 1

Introduction

PAKISTAN CAN RE considered a water-short environment despite the large size of its resource base. The average annual water flow in the country's river system amounts to almost 170 billion cubic meters (m^3), or about 140 million acre-feet (MAF); of this, about 128 billion m^3 (104 MAF) are diverted to an integrated canal network meant to irrigate about 14 million hectares (ha) of land, About 50 billion m^3 (40 MAF) of groundwater are recovered from seepage losses and are used in conjunction with the surface water available at the farm gate. These impressive statistics seem to represent a favorable water resources availability,' hut they belie the constraints imposed by a number of other related features of the same system.

One constraint is that the water resources of Pakistan are unevenly distributed in time and space. The regulatory reservoirs, Tarbela, Mangla and Chashma, are unable to fully compensate for this unevenness, although they play an important role, particularly at the start of *kharif* (summer) when river flows are low. About 84 percent of the total annual river flow mentioned above occurs during the full kharif season, whereas, 36 percent of canal head withdrawal takes place during *rabi* (winter) (Pakistan National Conservation Strategy 1993: 36). Thus, the incompatibility between the streamflow in the major rivers and the pattern of water requirements of the main kbarif and rabi cropping seasons causes seasonal shortages of canal irrigation supplies for meeting optimal crop water requirements. Similarly, the relative abundance of water, causing problems of waterlogging in a few areas, coexists with severe shortages in other areas.

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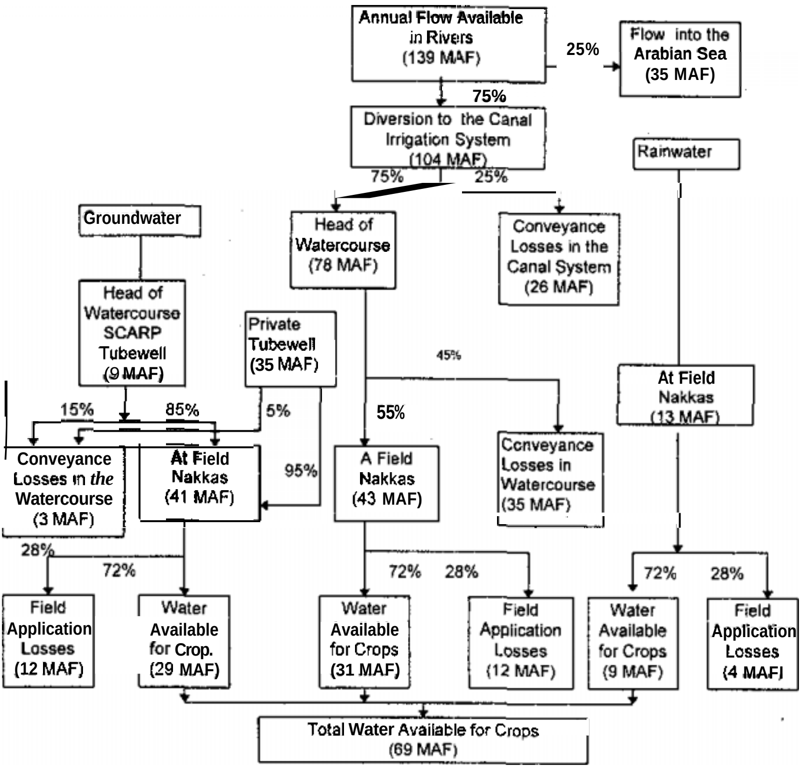
1 Kirmani (1990) argues that, with the "natural reservoirs" of the Himalayan glaciers having more than a billion acre-feet of water to feed the country's river systems, and a huge aquifer system having a usable storage of volume much greater than all the existing and potential storage reservoirs on the Indus and its tributaries, Pakistan is blessed with rich water resources.

Figure 1. Availability of Indus Basin water for canals.



Source. Pakistan National Conservation Strategy, 1993.37.

Under arid to semiarid conditions, the country obtains only a meager average annual precipitation of around 200 millimeters (mm), which adds to the above figures about 16 billion m^3 (13 MAF); therefore, Pakistan's agricultural effort requires irrigation as an 'essentialinput. Yet, the intervening physical and management conditions in the canal irrigation systems are such that heavy conveyance and field application losses' reduce this total quantity of water by almost 65 percent, leaving a mere ***85*** billion m^3 (69 MAF) for crop use (Figure 1). Also, this situation is compounded by the total groundwater being generally much more saline than the surface water supplies, which has detrimental effects upon the environmentally fragile soils. Also, there are areas where groundwater is too saline to be used as an irrigation supplement for producing the crops commonly grown in Pakistan.

Declining annual growth rates in farm gate water availability—of 3.9 percent for 1960–67, 2.7 percent for 1968–78 and 1.6 percent for 1978–86—also indicate the limitations of the overall water supply in Pakistan, and consequently, the expansion in the irrigated area has increased at even lower rates of 2.7 percent, 1.3 percent and 1.5 percent, respectively, for the same periods (Ministry of Food and Agriculture, Government of Pakistan 1988:288). These trends have to be viewed in the light of rapidly increasing population. Pakistan's population, growing at an annual compound rate exceeding 3 percent, has increased from about 34 million in 1951 to about 107 million in 1989, and is estimated to be 148 million in the year 2000 (Water Sector Investment Plan Study 1990: 2–2). This fast-growing population with a large rural sector (about 70%) has to be mainly supported by agriculture, and the increased demand for irrigation water is most likely to exacerbate the effects of water shortage.

The need for the judicious and economical use of this scarce resource has been the main concern of system designers from the early days of irrigation development in Pakistan. The design was for a run-of-the river system with the objective to command a maximum area with the available supplies in the river, ensuring equitable distribution[3] at all levels of the system—canals, branches, distributaries and outlets, and also among the individual water users.

According to this design, the duty of water or the "water allowance,'" was fixed relatively low in order to maximize the irrigated command area using the available water. However, the design assumed a low cropping intensity of about 75 percent to make irrigation reasonably productive in

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2 The low conveyance efficiencies in the Indus Basin are offset to a large extent by groundwater exploitation.

3 Equity attempted was in terms of allocation of water proportional to land

4 Water allowance is the design discharge assigned to the head of a distributary or a watercourse on the basis of the area to be irrigated and is given in cusecs per acre in local use, and in liters per second per hectare (l/s/ha) in this presentation.

these systems. For example, the perennial canals of the Fordwah Division have a design water allowance of about 0.25 l/s/ha of culturable command area (CCA) (**3.5** cusecs for 1,000 acres), whereas its non-perennial canals' design water allowance is about **0.5** l/s/ha of CCA. For perennial and non-perennial categories of canals, the cropping intensities fixed by the design were 80 percent (**32%** for the kharif season and 48% for the rabi season) and 70 percent (**35%** each for kharif and rabi) respectively.[5] Over the years, more and more commandable land were placed under irrigation in both seasons, and these design cropping intensities have now been exceeded considerably. On a 100 percent cropping intensity, an average water allowance of **0.28** l/s/ha (**4** cusecs for 1,000 acres) works out to a meager irrigation depth of 2.4 mm/day from canal water, which represents a considerable water-short situation indeed.

Tables 1 and 2, extracted from a previous study (Bandaragoda and Badruddin 1992) show, respectively, the 'water allowances given to some major perennial canals in Pakistan, and the discrepancy between seasonal water availability and crop water requirements. Another design feature was to keep the management and operational requirements also at a minimum level by having minimum control points in the systems.

The Indus River System was known to carry **a** large volume of suspended sediment during the flood season and this heavy silt load was considered the main cause ***of*** the old inundation canals deteriorating. Following the "Regime Theory" of canal construction during the British period, the canals were designed with slopes, velocities and sections in regime to minimize sediment deposition. The canals were to run most of the time at the authorized full supply level and be closed when the supplies fell to 70 percent–75 percent of the full supply discharge in order to avoid silting. The "equitable distribution" of water was to be effected without much operational control (e.g., the distributary outlets had no gates, but had fixed structures to provide constant discharges proportional to the area to be irrigated in each of the watercourse commands). Because supplies were designed to be less than the potential demand, canals were expected to run at levels above a certain cutoff discharge level throughout the year. Within this limited range of variability, the watercourses were expected to obtain an almost constant discharge. Thus, the method of water allocation and distribution that accompanied this design

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5 Kuper and Kijne (1992:7) calculated the actual water allowances at 0.81 l/s/ha for perennial canals on the basis of a fixed cropping intensity of 80 percent, and at 1.1–1.4 l/s/ha for non-perennial canals with a fixed cropping intensity of 70 percent.

was to fix water time turns for individual water users in the watercourse so that each received the full water supply in the watercourse during his or her turn. This method was called *warabandi*[6] (an outline of its concept is given in Chapter 3).

Table 1. Water allowance for major perennial canals in Pakistan.

Canal system	Year operations started	Canal capacity m³/s	(Cusecs)	Water allowance l/s/ha	(Cusecs per 1000 acres)
		73.58	(2,600)		
1 Central Bari Doab	1859	127.35 / 73.58	(4,500) / (2,600)	0.23	(3.22)
2 Sidhnai	1887	22.64 / 127.35	(800) / (4,500)	0.21	(3.00)
3 Lower Swat	1890	325.45	(11,500)	0.44	(6.15)
4 Lower Chenab	1892	150.00 / 325.45	(5,300) / (11,500)	0.22	(3.17)
5 Lower Jhelum	1901	53.77 / 150.00	(1,900) / (5,300)	0.20	(2.84)
6 Upper Jhelum	1915	254.7 / 53.77	(9,000) / (1,900)	0,21	(3.03)
7 Panjnad	1929	316.96 / 254.96	(11,200) / (9,000)	0.30	(4.20)
8 Rohri	1932	283.00 / 316.96	(10,000) / (11,200)	0.20	(2.84)
9 Thal	1947	130.1 / 283.00	(4,600) / (10,000)	0.23	(3.18)
10 CRBC	1987	55.0 / 130.1	(1,940) / (4,879)	0.53	(7.53)
11 Lower Swat (Remodeled)		55.0	(1,940)	0.78	(10.00)

Source: Revised Action Programme for Irrigated Agriculture, Vol I, WAPDA 1979. Item 11 from PC-I (Revised) CRBC Project, WAPDA May 1981. Item 12 from Final Project Plan, Mardan SCARP, June 1981 (Draft Report) Harza/Nespak Consultants.

6 For details of the concept of warabandi, see S. P. Malhotra (1982); and Douglas J. Merrey and James M. Wolf (1986).

Table 2. Ratio of wafersupply focrop water requirementsfor typical canal systems in Pakistan.

No.	Canal	Ratio of water supply to crop water requirements														
		Rabi							Kharif							Annual
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Season	Apr.	May.	June	July	Aug.	Sept.	Season	
1	Lower Swat P, LG	0.42	0.78	2.54	1.10	0.86	1.29	0.80	0.94	0.39	0.24	0.31	0.47	0.23	0.36	0.41
2	Upper Jhelum PP, GW	1.63	1.25	1.21	2.07	0.93	0.56	1.13	1.29	1.75	0.86	1.82	2.52	1.14	1.40	1.28
3	Sidhnai NP. LG	0.72	1.02	1.11	0.99	0.48	0.38	0.69	0.90	0.99	0.63	0.70	0.61	0.43	0.66	0.61
4	Muzaffargarh NP, GW	1.81	0.81	1.51	1.63	0.78	0.49	0.98	1.09	1.24	1.17	1.62	1.38	1.04	1.27	1.14
5	D.G. Khan NP, LG	1.21	0.51	0.43	0.85	0.21	0.08	0.46	0.38	0.58	0.77	1.10	1.06	0.65	0.83	0.68
6	Rohri P, LG	0.82	0.81	1.56	0.35	0.47	0.49	0.67	0.82	0.71	0.59	0.38	0.50	0.69	0.57	0.61
7	Rice	1.02	0.01	0.02	0.00	0.00	0.02	0.18	0.50	1.36	0.81	1.04	0.85	0.11	0.89	0.70
8		0.54	0.03	0.04	0.09	0.04	0.09	0.13	0.36	0.05	0.55	1.30	1.51	2.82	0.93	0.68

Notes: P = Perennial, PP = Partly perennial NP = Non-perennial
LG = Limited groundwater. GW = Groundwater supplement available.

Source: Revised Action Programme for Irrigated Agriculture, Vol I, WAPDA, 1979.

CHAPTER 2

Study Description

RATIONALE OF THE STUDY

PREVIOUS FIELD OBSERVATIONS in two **IIMI** study sites in the North-West Frontier Province (NWFP) of Pakistan had indicated that the ideal conditions for the warabandi system, as understood in its traditional concepts, would no longer hold true in actual practice.[7] The two NWFP systems studied in this instance were the newly established Chashma Right Bank Canal Stage I System and the recently remodeled old Lower Swat Canal System. They differed from each other in terms of maturity of their irrigation practices. In the former, the water allocation and distribution methods were still evolving, whereas in the latter, the established practices were disrupted due to prolonged construction activities for system rehabilitation. Consequently. the observations in these two systems led to the hypothesis that the deviations from the theoretical concepts of warabandi could be more widespread than were commonly understood, as the technical and institutional imperatives to make warahandi fully operational in its original form appeared to have gradually eroded with the changes in the physical, social and economic environment of Pakistan's irrigation.

To test these preliminary findings further, a study was undertaken in selected canal irrigation systems in the Punjab, where warabandi is known to have been fairly well established. While the theoretical interpretations of the concept of warabandi were derived from the various official documents. as well as from the common perceptions among many people including the

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7 Senior IIMI Associate Dr. Gilbert Levine was an early commentator who drew attention to the emerging reality of the present status of warabandi in marked contrast to its popular image as a fixed, formal and fair method (Levine 1991). In fact, this study was prompted by his comments.

officials, in-depth field investigations were conducted in selected watercourse commands in the Punjab to observe warabandi in actual practice. Apart from exploring the existence of the gap between the theory and practice of warabandi and identifying its scope, it was also felt that an attempt should be made to examine the social processes associated with the warabandi practice. Particularly, the intention was to better understand the causes of current warabandi practices and their effects on the criterion of equity.

However, because of some unexpected constraints during the course of the study, all of the intended field work could not be accomplished, and therefore the study concentrated on the scope of the present warabandi practices.

The existence and the scope of this gap between the theory and practice of warabandi have many implications related to irrigated agriculture in Pakistan. Significant among these issues are the linkages that a flexible farmer behavior in the tertiary-level water ,distribution would have with the management of salinity-related irrigation problems, and with the overall productivity of irrigated agriculture. However, an analysis of these issues was outside the scope of this limited study, but the intention remained in order to draw attention on these issues and to encourage further investigation. The major objective of this study was to present an analysis of the actual warabandi operations with a view to encouraging further field research on relationships between warabandi and sustainable irrigated agriculture. The need to promote field studies on the effect of warabandi on soil salinity and agricultural productivity, of which there have been only a few in the past (Vehmeyer 1992), cannot be overemphasized.

Despite some doubts against the validity of warabandi as an efficient method of water allocation, which were mainly on the grounds that it is in conflict with crop water requirements (Reidinger 1980), an attempt has been made recently to popularize it in India. The method has already been adopted in Andhra Pradesh, Gujarat and Maharashtra as variants of the traditional North Indian practice (Singh 1981). The proponents of the warabandi method (Malhotra 1982) point out that its validity has not diminished in any way as the supply constraints have continued to characterize irrigated agriculture in this region. A closer scrutiny of how the method is actually practiced would help to clarify some of the different perceptions emerging through this developing controversy about the concept of warabandi as an efficient water distribution method.

A number of studies on various aspects of warabandi in Pakistan have already been reported, some on its social dynamics (Lowdermilk et al. 1975;

Lowdermilk et al. 1978; Merrey and Wolf 1986; Merrey 1987 and 1990), others on its economic aspects (Chaudhry and Young 1986; Qureshi et al. 1994), and yet others on its performance implications (Bhatti and Kijne 1990; Latif and Sarwar 1994). This presentation focuses simply on the emerging gap between the traditional concept of a warabandi system and its actual practice. Within this focus, the paper also outlines some institutional implications of the present practice of warabandi and identifies further research and policy needs.

DESCRIPTION OF FIELD STUDIES

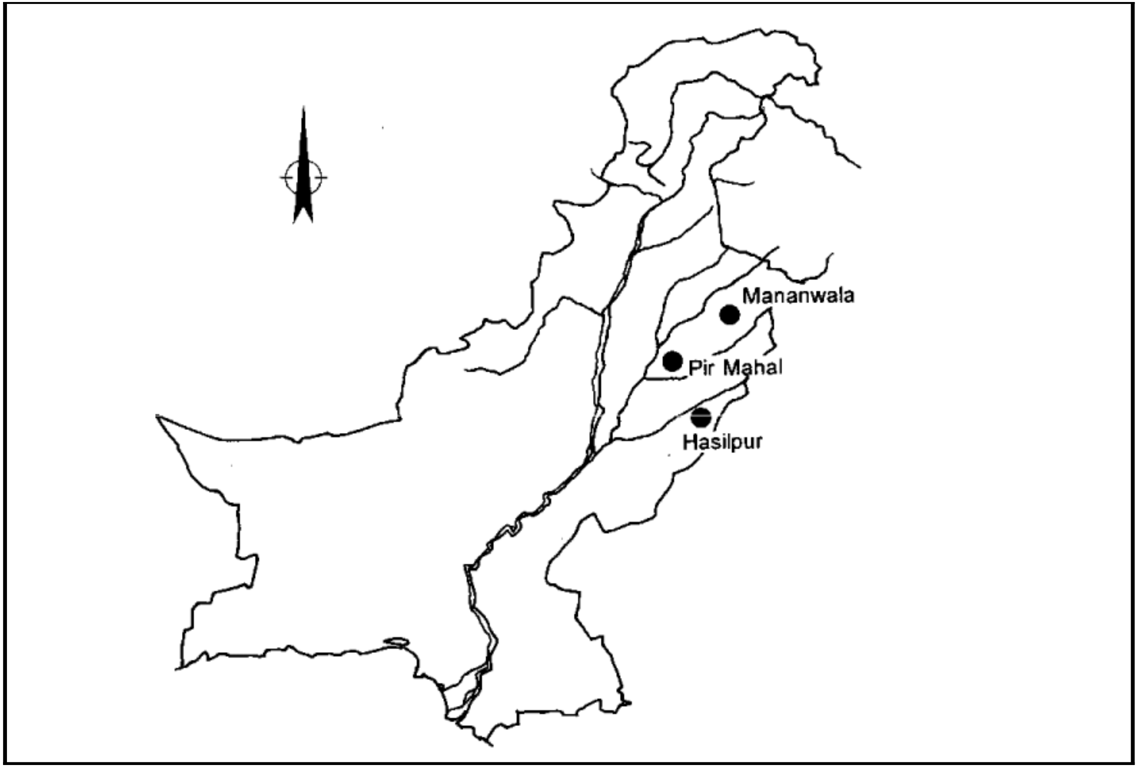
The actual practice of warabandi was observed from June to October in the kharif season of 1993, through field studies conducted in three different locations in the Punjab Province, Mananwala, Pir Mahal and Hasilpur (see composite Location Map in Figure 2).

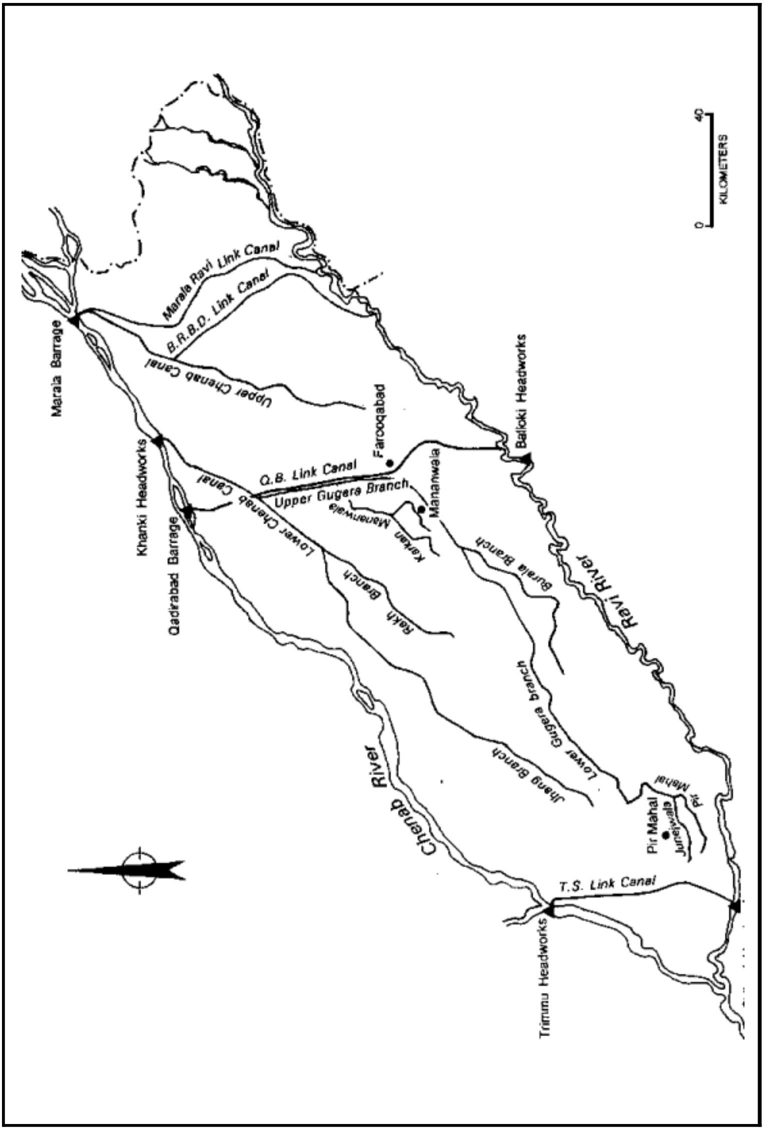
A total of 22 watercourses were selected in 6 secondary canal commands served by the Gugera Branch Canal in the Lower Chenab Canal (LCC) System covering central Punjab's Rachna Daub (Figure 3), and by the Fordwah Branch Canal in the southeastern Punjab (Figure 4).

In the Upper Gugera, data collection was limited to the command areas of the Mananwala Distributary and its minor Karkan. The Mananwala Distributary which is 45 kilometers (km) long offtakes from the Upper Gugera Branch in Farooqabad Subdivision, about 68 km downstream from the Khanki Headworks of the LCC System, and has a design discharge of 5.2 m^3/s to serve a CCA of 27,064 ha. The Mananwala Distributary and the Karkan Minor are located in the Punjab rice-wheat agro-ecological zone. Rice, specially the high value Basmati variety, is the predominant crop in this area during the *kharif* season (mid-April to mid October), and wheat is the principal crop during the rabi season (mid-October to mid-April).

In the Lower Gugera, field activities covered the commands of the Pir Mahal Distributary and its Junejwala Minor. The Pir Mahal Distributary which is 47.5 km long offtakes from the Lower Gugera Branch Canal at the Bhagat Head Regulator in Bhagat Subdivision, more than 200 km downstream from Farooqabad, and has a design discharge of 4.67 m^3/s for a CCA of 14,891 ha. The Pir Mahal Distributary and the Junejwala Minor are in the transitional area between the rice-wheat zone and the Punjab's cotton-wheat agro-ecological zone, and represent a mixed farming system.

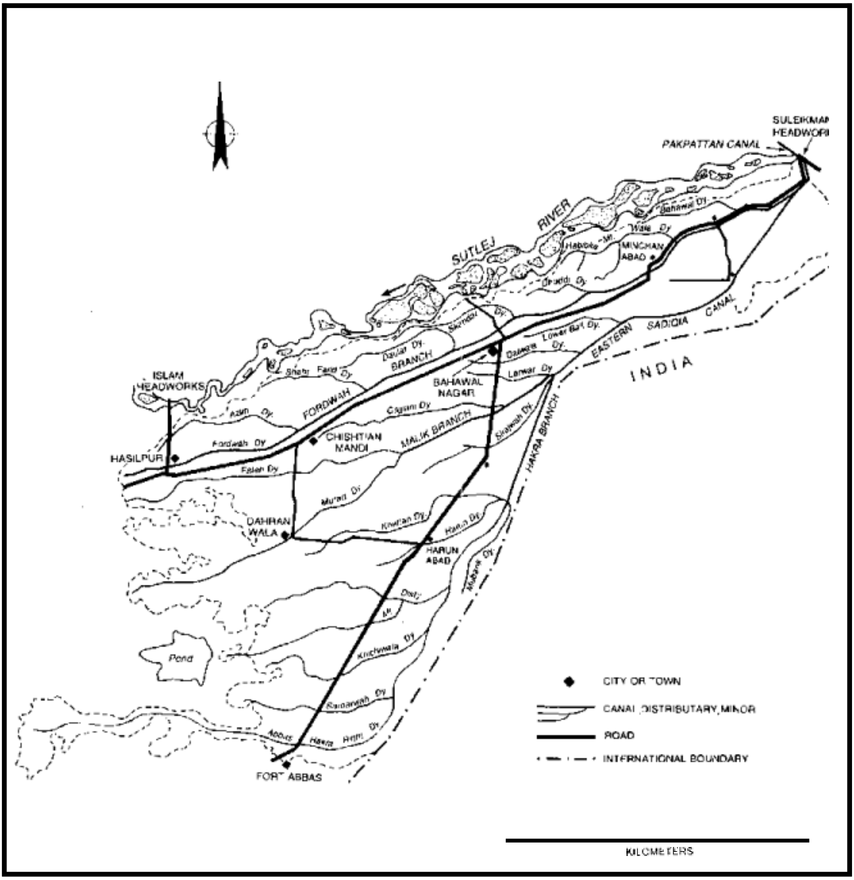
Figure 2. Map of Pakistan indicating study sites





Marala Barrage
Marala Ravi Link Canal
B.R.B.D. Link Canal
Upper Chenab Canal
Farooqabad
Balloki Headworks
Khanki Headworks
Qadirabad Barrage
Q.B. Link Canal
Upper Gugera Branch
Mananwala
Mananwala
Karkan
Lower Chenab Canal
Rakh Branch
Burala Branch
Ravi River
Lower Gugera branch
Jhang Branch
Chenab River
Pir Mahal
Pir Mahal
Junejwala
T.S. Link Canal
Trimmu Headworks
0
40
KILOMETERS

Figure 4. Location map of the Fordwah/Eastern Sadiqia System.



The LCC System is one of the earliest built canal systems in Pakistan, and has a long history in the application of the warabandi system. Several other IIMI field studies were also located in the LCC System, and therefore it offered useful supplementary field information already collected by IIMI through these studies.

The Fordwah Branch Canal is located in the cotton-wheat agro-ecological zone in the southeast of the Punjab and, unlike the Gugera Branch of the LCC System, represents a mix of perennial and non-perennial channels. For this study, the Azim and Fordwah distributaries in the tail of the Fordwah Branch Canal were selected as IIMI's other study activities were already under way in that area. The Fordwah Distributary is 42.1 km long and has a design discharge of 4.50 m^3/s. Originally, the Azim Distributary had a length of 37.8 km but its tail portion was cut off in 1976, and is now supplied directly from the Bahawal Canal. The design discharge, however, remains unchanged at 6.9 m^3/s. While the Fordwah Distributary is a perennial canal, supplied with water all year round, the Azim Distributary is a non-perennial canal, officially having a right to receiving water only during kharif.

The 6 selected distributary and minor canals offer a fair range of features that characterize the Punjab's secondary canal systems. The Mananwala and the Karkan, as well as the Pir Mahal and the Junejwala, represent a paired combination of a distributary and one of its minors. The sample also includes large, medium and small-size secondary canals, in terms of their CCA, as well as in design discharge. Also, it includes both perennial and non-perennial distributary canals.

The 22 selected watercourses represented the head, middle and tail areas of the respective distributaries or minors, considering the length of each canal. Six watercourses (located at RDs[8] 24, 43, 71, 87, 121 and 141) were from the large Mananwala Distributary (MW), two watercourses (RD 10 at the head and RD 54 at the tail) from its Karkan Minor (KN), three watercourses from the Pir Mahal Distributary (PM) at RD 70, RD 89 and RD 133, and three from its Junejwala Minor (JW) at RD 6, RD 27 and RD 41. In the command areas of the Azim (AZ) and Fordwah (FW) distributaries, 8 watercourses were selected to maintain the sample already under investigation for IIMI's other research purposes (RD 14, RD 43, RD 62 and RD 130 on the Fordwah and RD 20, RD 46, RD 63 and RD 111 on the Azim

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8 Reduced distance is the distance in measures of 1,000 feel of any paint on the center line of a canal from the head of the canal (RD 24 = 24,000 ft from the head of the canal).

Distributary). The details of the distributaries selected for the study are listed in Table 3, while the details of sample watercourses are given in Table 4.

Table 3. Characteristics of the sample distributaries and minors

Distributary/Minor	CCA (ha)	Status	Design discharge (m^3/s)	Water allowance (l/s/ha)
Mananwala	271,59	P		
Karkan	946.2	P		
Pir Mahal	148,91	P		0.32
Junejwala	405,1	P	1.0	0.24
	Fordwah Branch Canal Irrigation System			
Azim	121,99	NP	6.9	0.57
Fordwah	149.41	P	4.38	0.30

bandi schedules, and the warabandi schedules in practice, giving timing and duration of water turns for each of the water users in the sample watercourses.

Table 4. Characteristics of the 22 sample watercourses.

Watercourse	CCA (ha)	Design discharge (l/s)	Water allowance (l/s/ha)	No. of land-owners	No. of cultivators
	Uppe	ugera Command Area (LC			
MW 24873-R	171			30	41
MW 43506-R	225			74	81
MW 71683-R	289	38.2		114	116
MW 87670-R	240	47.9	0.20	48	58
MW 121735R	255		0.13	237	254
MW 141542R	514	68.0	0.13	153	158
KN 10435-R	158	31.4	0.20	71	70
KN 54892-R	231	46.2	0.20	124	92
	Lower	gera Comm	l Area (LC		
PM 70076-R	187	37.1	0.20	93	77
PM 89250-L	174	46.2	0.27	103	124
PM 133970-L	223	44.2	0.20	186	180
JW 6619-R	118	31.1	0.26	131	122
JW 27290-R_2	140	29.2	0.21	56	51
JW 41234-L	159	31.7	0.20	92	81
	FORDWAH BR.	CH CANAL IRRIGATIO	SYSTEM		
AZ 20610-L		45.9	0.39	26	26
AZ 43260-L		25.5	0.39	16	16
AZ 63620-L		59.2	0.49	20	20
AZ 111770-L		45.9	0.39	27	27
FW 14320-R		52.1	0.26	82	82
FW 46725-R	172	44.7	0.26	47	47
FW 62085-R		33.4	0.25	47	47
FW 130100-R	256	68.0	0.26	58	58

CHAPTER 3

Warabandi in Theory

MEANING OF WARABANDI

WARABANDI IS A rotational method for equitable distribution of the available water in an irrigation system by turns fixed according to a predetermined schedule specifying the day, time and duration of supply to each irrigator in proportion to the size of his landholding in the outlet command (Singh 1981, Malhotra 1982). Since the beginning of Pakistan's canal irrigation, warabandi has been traditionally practiced as a tertiary (watercourse)-level water distribution method based on a rotation of water turns among the individual water users. The term warabandi means "turns" (*wahr*) which are "fixed" (*bandi*).[9]

Malhotra (1982:38) points out that "warabandi is not just distributing water flowing inside a watercourse according to a roster," but is an integrated water management system extending from the source to the farm gate. The need to equitably distribute the limited water resources available in an irrigation system among all the legitimate water users in that system is a basic premise underlying the concept of warabandi. Clearly, in that sense, it involves more than the watercourse. In fact, the literal meaning of warabandi, as given above, prompts one to focus attention on the roster part of the warabandi system. A clear understanding of the warabandi roster and its functioning will help in reaching a broader interpretation of the warabandi system.

The warabandi is a continuous rotation of water in which one complete cycle of rotation lasts seven days (or in some instances, ten and a half days), and each farmer in the watercourse receives water during one turn in this

9 The Punjab Public Works Department (PWD) Revenue Manual (Reprint of 1987:3).

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 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. The time duration for each farmer is proportional to the size of the farmer's landholding to be irrigated within the particular watercourse command area. A certain time allowance is also given to farmers who need to be compensated for conveyance time, but no compensation is specifically made for seepage losses along the watercourse.

In the theoretical understanding of the jointly managed large canal irrigation systems in Pakistan, warabandi rules and traditions act as the binding glue for an agency-fanner interface. A central irrigation agency manages the primary main canal system and its secondary level "distributary" and "minor" canals, and delivers water at the head of the tertiary level "watercourse" through an outlet, popularly known as a ***mogha,*** which is designed to provide a quantity of water proportional to the CCA of the watercourse. The agency bas to ensure a uniform flow in the watercourse so that it continuously receives its allotted water duty (quantity of water meant for each unit area). Farmers within the watercourse are expected to manage the on-farm distribution of water according to a warabandi schedule, officially "sanctioned," or established solely on the basis of mutual agreement by the farmers. Once this arrangement of turns has been agreed upon, the agency does not interfere unless a dispute arises among the farmers and it is brought to official notice. The dispute is resolved through an adjudication process according to prescribed rules leading to either an amendment of the existing official warabandi schedule, or the sanctioning of a new one if an official schedule did not exist before the dispute.

Although warabandi is practiced below the mogha and within the watercourse command area, to ensure some of its functional features, the agency that delivers water has to establish some essential conditions in the canal system above the mogha. The water users have to maintain the watercourse in good condition. Successful warabandi operation relies heavily on the hydraulic performance of the conveyance system. These conditions, and those who are responsible for maintaining these conditions. together with an expected behavioral pattern among both the agency staff and the farmers, form the concept of a ***warabandi system.***

The warabandi system in Pakistan includes the following functions and characteristics, among other things: (1) the main canal distributing points operate at supply levels that would allow distributary canals to operate at no less than 75 percent of full supply level; (2) only "authorized outlets draw their allotted share of water from the distributary at the same time; and (3) outlets are ungated and deliver a flow of water proportional to the area commanded. Cooperative behavior among agency staff and water users is an overriding requirement to follow an agreed set of rules.

KACHCHA WARABANDI AND PUCCA WARABANDI

Today, two types of warabandi are frequently mentioned in Pakistan. The warabandi which has been decided by the farmers solely on their mutual agreement, without formal involvement of any government agency, is known as ***kachcha*** (ordinary or unregulated) warabandi, whereas, the warabandi decided after field investigation and public inquiry by the Irrigation Department when disputes occurred, and issued in officially recognized warabandi schedules, is called ***pucca*** warabandi.

The old farmer-established kachcha warabandi, which also operated below proportional ungated outlets, was used as a very flexible method of water distribution. While the turn durations were predetermined through agreement and fixed to a large degree, their timings were not fixed, allowing for flexible exchange of turns. This also ensured water for all the farmers, in that when the watercourse flow was temporarily disrupted for some sudden canal closure, or for any other reason of water shortage, the restoration of supply conditions would allow the cycle to continue at the farm where the water was last received. This was possible because the timing of the roster was not fixed. As long as the group could amicably and collectively manage the distribution pattern, this flexibility was functional and there was no need for official intervention.

However, kachcha warabandi became increasingly unpopular among the majority of the farmers as it was prone to exploitation by large landowners. Wherever this pressure could be challenged openly, disputes were registered with the canal authorities, and after prescribed adjudication processes, the kachcha warabandi was converted to official pucca warabandi schedules. The reason for having kachcha warabandi still in operation as the preferred method in southern Punjab and Sindh is attributed to the more skewed distribution of land favoring larger landowners in these areas. In central

Punjab, the majority of watercourses have: pucca warabandi, which is the focus of analysis for this paper.

OBJECTIVES OF WARABANDI

As an integrated water management system, warabandi is expected to achieve two main objectives, high efficiency, as well as equity in water use (Malhotra **1982).** Water use efficiency is to be achieved through the ***imposition ofwarer scarcity on each and every user,*** and equity in distribution through ***enforced equal share of scarce waferper unit area among all users.*** An All-India Workshop on Warabandi, held at Hyderabad in April **1980,** listed a number of other advantages of warabandi including increased cropping intensity, greater irrigation discipline, common interest, greater economy and dependability (Singh **1981).** Further, its transparency and the simplicity of implementation were identified as two of its main positive features. However, the equity issue dominated the analyses on what warabandi could conceivably bring about as benefits. In sum, the Worlkshop noted, warabandi was to introduce "some kind of system, some kind of fair play" into the use of water, to make sure that the available water is really used in "every plot in the area being irrigated, not simply the plots that belong to the most powerful individual in the village" (Singh **1981**:iii-iv). Makin **(1987)** identified equity of distribution as warabandi's primary objective. He found that warabandi, with some minor modifications, was still operating successfully in Indian Punjab, and despite several externally imposed factors, the farmers in the Mudki Distributary study area were finding ways of maintaining equity, which they see as the underlying spirit of warabandi.

The reliance on this theory of warabandi is fairly strong and widespread. Consequently, relying on the many virtues of warabandi as theoretically framed, particularly its fairness, the tendericy is to believe that warabandi "ensures equity in distribution to each fanner's field, regardless of whether the land is situated at the upper reaches of the outlet or at the tail end, whether the farmer is economically or politically powerful or not, and whether he belongs to a low or high caste" (Singh **1981: 23).** With the **usual** preference to rely on conventional wisdom, very little investigation has been made to explore how well the theory is applied in the field.

In Pakistan too, the equity in water distribution is commonly perceived as the central operational objective for the management of its large canal system through warabandi (Ministry of Food and Agriculture 1988; Kirmani 1990; Bhutta and Vander Velde 1992; Latif and Sarwar 1994). Equity is usually assumed to occur if the system functions as designed, or if each water user gets the share that was intended in the design (Levine and Coward 1989). In this sense, equitable water distribution in the Indus Basin Irrigation System can be interpreted as an intention to deliver a fair share of water to all users throughout the system using warabandi. The need has been recognized for head to tail equity in terms of equalizing the delivery of water between the extremities in the conveyance system; there is also the need to see equitable distribution among various distribution points in the system, as well as among the various categories of water users.

The emphasis on the objective of equity has tended to ignore the importance of the objective of efficiency. High water use efficiency was to be achieved through the imposition of water scarcity on every user so that the limited water supply was shared equitably among a large number of users to whom irrigation was ensured (Malhotra 1982). As the imposed scarcity was administered by the well-established, "self-policing"[10] rotation system, and was seen as a sharing of shortage on an equitable basis, there was no major disruption of the practice. In fact, considering the usual turmoil and social tension that would be normally associated with a shortage of irrigation water, the fact that warabandi has continued as a method of imposing such extreme scarcity, over such large areas, and for such a long time, is considered "little short of a miracle" (Malhotra et al. 1984).

The average water duty or "water allowance" designed for this system is around 4 cusecs for 1,000 acres, or about 0.28 l/s/ha, an equivalent of 2.4 mm/day of irrigation, and it implies that the water was not sufficient to fully irrigate the total area and each farmer was expected to leave part of his land fallow during each season. The productivity of imgated agriculture through the warabandi method is an important research issue yet to be fully explored.

10 The end of each water turn according to the established roster was expected to be monitored by the user receiving water from the next turn.

CALCULATION OF WARABANDI SCHEDULES

Theoretically, in calculating the duration of the warabandi turn given to a particular farm plot, some allowance is added to compensate for the time taken by the flow to fill that part of the watercourse leading to the farm plot. This is called watercourse *khal bharai* (filling time). Similarly, in some cases, a farm plot may continue to receive water from a filled portion of the watercourse even when it is blocked upstream to divert water to another farm or another part of the watercourse command. This is called *nikal* (draining time), and is deducted from the turn duration of that farm plot.

The calculation for a warabandi schedule starts with determining by observation, the total of such filling times (T_F) and the total of such draining times (T_D). Then, for a weekly warabandi rotation, the unit irrigation time (T_U) in hours per hectare can be given by:

$T_U = (168 - T_F + T_D) / C$, where C = culturable command area of the watercourse.

The value of T_U should be the same for all the farmers in the watercourse. A farmer's warahandi turn time T_t is given by:

$T_t = T_U \times A + T_f - T_d$, where A is the farm area, and T_f and T_d are filling time and draining time, respectively, for the farm area.

Only some of the farms in a watercourse may be entitled to either filling time, or draining time, or both. The warabandi schedule is prepared on the basis of the different turn times calculated for each farm plot on the basis of these values, wherever they occur, and the area of each farm plot.

WARABANDI AS PART OF THE LEGAL SYSTEM

The institutional framework for warabancli was provided initially by the Northern India Canal Drainage Act of 1873. Several amendments and departmental rules were added later.

The warabandi is framed under Section 68 of the Canal and Drainage Act (VIII of 1873) in which rights to form and maintain water distribution within watercourses are vested with the Canal Officers of the Irrigation Department. Outside this provision, Canal Officers have no authority to interfere in the internal distribution of water in a watercourse. Section 68 helps in regulating the distribution of water to settle the mutual rights and liabilities of cultivators jointly interested in a watercourse command and empowers the authorities to control ***wara shikni*** (an offence committed when any water user violates the official arrangements of turns for taking water according to the warabandi schedule) and provides a base for a case liable to penal action under the other related sections of the Canal and Drainage Act. ***The step-wise official procedure is outlined below:***

1. A farmer is required to submit an application addressed to the Divisional Canal Officer to which a two-rupee stamp should be affixed as the court fee. The applicant mentions in this application: i) the description of his/her land supported by the ***Parchai Milkiyat*** (Civil Record of Land Rights), and ii) the source from which the farmer is already irrigating, or from which s/he intends to irrigate. (Two or more farmers together could also submit an application.)

2. When an application is received under Section 68, and is found genuine, it is sent to the Sub-divisional Canal Officer for identifying it with the Part Watercourse Plan (sanctioned ***chak*** plan) and for a detailed report of the case. The attachment of documentary proof depends upon the nature of the case. In case of a new warabandi, a complete ***chakbandi*** map below the outlet is required, or else a copy of the sanctioned warabandi may be sufficient.

3. For the investigation of the warabandi case, the application is sent to the concerned ***Zilladar*** through the Deputy Collector for on-site investigations. The Zilladar asks the concerned ***Patwari*** to probe into the matter, who in turn would then fix a date for investigation in consultation with the Zilladar. The Canal Patwari prepares the hand-sketch of the outlet command area according to the details given in the Part Watercourse Plan attached to the application and identifies the area owned by the applicant. The Patwari verifies whether the area of the applicant is within the bounds of an existing chakbandi, then checks whether the area is

commandable, marks the location of tha square, and identifies the place according to the Part Plan of the watercourse where the applicant's "*wara*" (water turn) is to be placed. Then the Patwari reports the details to the Zilladar, who after scrutiny, and correction if necessary, sends the report to the Subdivisional Canal Officer through the Deputy Collector.

4. After receiving the proposed warabandi or warabandi modification, the Subdivisional Canal Officer issues a 14-days notice to the affected cultivators for a formal inquiry meeting specifying the subject, date, time and place. The duty of the Canal Patwari is to serve notice to the farmers in compliance with Rules 79-A through 79-I, and take signatures or thumb impressions of the concerned farmers as acknowledgement of the receipt of notice.

5. The Subdivisional Canal Officer who functions as a Canal Magistrate explains the proposed warabandi to the shareholders present in open court, records statements of the petitioner(s), objections of the shareholders, and findings of the Irrigation Department, and thereafter announces a judgement regarding the new warabandi.

6. The order, along with the new warabandi schedule, is explained further by the Zilladar and is implemented at the site. A copy of the new **warabandi** is also handed over to the Lambardar.

WARABANDI AS PART OF THE LOCAL CULTURE

The idea that there is a distinct irrigation-related culture in South Asia relates to the region's long history of irrigation development and practice (Bandaragoda 1993). The culture, in this instance, refers to a set of values, beliefs, rules and perceptions (Merrey 1992), and is characterized by the institutional framework. This culture has tended to contribute to the original design as well as to the eventual quality and shape of irrigation institutions such as warabandi in the region. The rigidity of warabandi in its structure, and the principle of equity embodied in the calculation of warabandi, can both be linked with this cultural background.

The origin of warabandi is traced to the early period of irrigation development by the British in the northwestern part of the subcontinent in the mid-nineteenth century (Malhotra 1982). However, the origins of the concepts underlying warabandi could well go back much earlier, although no recorded history can be found referring to this linkage. The legal framework for water distribution seems to reflect some local traditions, which may have been transferred from various cultural influences of many different eras, such as those of the Indus Civilization, the Aryans, the Greeks and the Arabs. The preference for social control of natural resources, the ruler's responsibility for social welfare, local participation in resource management, ready compliance with regimented and formalistic administration, adherence to legalism and subservience to local feudalistic power are only some of the features of a highly complex cultural milieu. In this amalgam, the principle of equity in water distribution that is central to irrigation laws in this region has the stamp of an influence by the Islamic principles, such as communal ownership and equitable sharing of water, and the social control over water (Radosevich 1975; Caponera 1968). The legislative enactments of the mid-nineteenth century have likely benefited from the same principles, which the British might have discovered in the Moorish elements of the irrigation traditions found in Spain. In sum, warabandi can be seen as part of the local culture, which has evolved through centuries of. association with irrigation including its formalized administration since 1873. Also, the colonial irrigation administration could have been partly modeled on the earlier irrigation development experiences of Europe, which the British studied before introducing irrigation laws in the subcontinent.

However, just as equity was related to some facets of local culture, the erosion of equity in its application was also caused by other facets of the same culture. In this region where warabandi was first introduced, the social conditions largely determined how the system operated, and how its flexibility was used. Malhotra (1982:1) opines that "the arrangement could have fitted well with the then political system," when the administration found it more convenient to use the few big landlords for settling local disputes and maintaining law and order. As the big landlords "managed to arrange some sort of consensus," field-level water distribution posed no difficulty, but the flexibility could have been used at the expense of the weaker sections of the community. A similar comment made in a more recent assessment of warabandi in Pakistan's southern Punjab and Sindh is that kachcha warabandi is a type that "suits the irrigation needs of large farmers" (Qureshi et al. 1994).

With increased political awareness and social development, and also with the gradual subdivision of large landholdings, the role of the big landlords was increasingly challenged, and the disputes started to undermine their authority. With increasing cropping intensities, the demand for water increased, thereby causing greater competition, and obviously more conflicts. Increased frequency of disputes among farmers led to greater agency involvement. In an attempt to formalize the traditional arrangement, the more regulated "pucca warabandi" system emerged in which the rotation was designed in greater detail.

Agency staff intervened to assess the ownership of land, its size and proximity to water, and also filling and drainage times, before fixing the time turns and durations.[11] Once fixed, it assumed common agreement; the turns were supposed to be followed unaltered and became binding on all the farmers who have to take water at their turn irrespective of need. Even when water flow was disrupted due to some physical condition in the canals, the time schedule was not to be altered so that the loss had to be absorbed by the unlucky individual farmer or farmers who happened to be rostered for that particular time interval. The authority and influence of the big landlords were replaced in some instances, and supplemented in others, by the authority and influence of the officials.

The rigidity of the pucca warabandi was meant to ensure equity. Basically, the idea was "to prevent exploitation of the weak by the strong, or of tail-enders by head-enders" (Chaudhry and Young 1989). Merrey (1987 and 1990) questions the sustainability of this rigid centrally determined warabandi system in Pakistan. He acknowledges, however, the limitations of available technical alternatives, particularly in view of the "imbeddedness" of warabandi in rural Pakistan. Generally, the concerns on its sustainability and criticisms against the continued practice of warabandi (Reidinger 1980) are based on the assumption that official warabandi (as originally conceptualized and described in manuals) is actually being practiced today. On the contrary, the situation in Pakistan is characterized by the existence of a dualism between a set of formally establishsd rules and organizations, and a parallel set of informal institutions, with the latter appearing to have an overriding effect over the former (Bandaragoda and Firdousi 1992). Given the changes in rural society, to question the: viability of continuing with the

11 Appendix Eaf the Punjab's Public Works Department Revenue Manual (Reprint of 1987:3) provides detailed instructions for preparation and modification of wahr-bandis, and explains the responsibilities of Patwaris, Zilladars and the Canal Officers.

warabandi in its traditional form is logical, but at the same time, to ignore the increasing deviations from warabandi that are taking place in the field is equally unrealistic.

CHAPTER 4

Changes in the Warabandi Environment

A WATER ALLOCATION method such **as** warahandi. with its underlying primary objective of distributing the restricted supplies of canal water equitably over a large command **area,** typically suited the "protective" nature **of** irrigation in Pakistan. The original systems design tried to maintain a steady pattern of hydraulic performance for the canal system; the application of an official warahandi had to heavily rely on this steady pattern. However, the deterioration of the required physical conditions in the canals has increasingly invalidated the original assumptions for equity-based warabandi. **A** 1988 field study reported that discharge variation at the head of the distributaries greatly exceeded the original design criteria (Bhutta and Vander Velde 1992). Further, two design assumptions for outlets were seen to be no longer valid, namely, the continuous authorized water supply level in the distributary, and the outlet modular flow conditions. While confirming these findings, the present study found other changes in the canal environment, which have also invalidated the original design stage assumptions. Notably, the changes that have occurred in the social value system seem to accentuate the effect **of** the physical system deterioration.

VARIABILITY IN DESIGN-RELATED WATER ALLOWANCES[12]

Before discussing the changes that have occurred in the warabandi environment, a brief reference to one important design concept seems to be in order, particularly because the theoretical basis of the warabandi system is assumed to be in congruence with the original design concepts of the Indus Basin

12 See Footnote No. 4, p.3, far the definition.

Irrigation System. One of the common design objectives of Pakistan's canal irrigation has been to provide water sparingly in a large commandable area to maximize the number of beneficiaries, and to generally impose a sharing of the supply shortage equitably among the water users throughout the system. Therefore, the six distributary systems covered by the study sample can be expected to have a uniform set of water allowances (discharge per unit area).

However, the data in Table 3 (p.14) indicate that the design characteristics of the selected distributary canals have a wide-ranging set of water allowances that vary from a very low 0.19 l/s/ha in the Mananwala Distributary to a high 0.57 l/s/ha in the non-perennial Azim Distributary. More importantly, there is a marked difference in water allowances between the Pir Mahal Distributary (0.32 l/s/ha) and its own Junejwala Minor (0.24 l/s/ha). The data indicate that the design itself has caused significant differences in water allowances per unit area between the different distributaries or minors.[13] The data given in Table 4 confirm these inter-canal differences.

The original design criteria also implied that the distributing points would have to maintain a sufficient supply level so that the required amount of water, depending on its command area, is constantly made available at the head of each watercourse ***mogha,*** so that each water user within the watercourse could have the same amount of water per unit area.

To test this criterion, information relating to the designs was collected from the Provincial Irrigation Department (PID), and was analyzed to calculate the water allowances (design discharge per unit CCA) for each sample outlet.[14] Table 4 (p.15) shows the water allowances given to the 22 outlets. Data show that there are both inter- and intra-canal differences in water allowances. Differences between the distributary canals (e.g., between Mananwala and Karkan) can be attributed to design errors, but the conspicuously high water allowance values for watercourses within a single distributary canal point towards physical modifications to outlets subsequent to the original design. While these modifications are entered in the official outlet registers, there are other unauthorized modifications, which are locally referred to as "mogha tampering." Apart from the effects of these informal outlet modifications, the officially recognized values for discharge and CCA

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13 Alternatively, it is also likely that command areas under some canal systems were subsequently increased while their supply levels remained unaltered.

14 Among the various records kept by the PID's Divisional Offices are the "Outlet Registers; which refer to design discharge. design CCA and other details of each outlet in the ma.

in the sample canals and watercourses show that there is considerable variability in the water allowances.

In a further analysis of design data, Table 5 gives the ranges and averages of design water allowances of all of the watercourses in the six distribution systems.

Table 5. Variability of water allowances given to watercourses in six selected distributary/minor canals (n=the number of water courses).

Distributary/Minor	Range of water allowance (l/s/ha)		Average water allowance (l/s/ha)	Coefficient of variation (%)
	Minimum	Maximum		
Mananwala (n=74)	0.13	0.52	0.15	35
Karkan (n=47)	0.17	0.30	0.20	8
Pir Mahal (n=47)	0.20	0.84	0.27	58
Junejwala (n=19)	0.14	0.28	0.21	13
Azim (n=75)	0.38	0.67	0.44	14
Fordwah (n=87)	0.24	0.55	0.26	14

In Table 5, a wide variation can be seen in water allowances assigned for individual watercourses along each of the six distributary/minor canals. The results show a substantial divergence between the common design intention of providing a uniformly low water allowance and the application of this design parameter during construction of the physical system.

An interesting aspect of this divergence is that, within each of the six canals, the minimum water allowance for a watercourse is closer to the average than the maximum water allowance. In the case of the Mananwala Distributary, the maximum water allowance given to a watercourse is exceptionally high, almost three times the average, whereas the minimum is at 86 percent of the average. Similarly, in the Pir Mahal Distributary, the maximum water allowance given to a watercourse is 311 percent of the average and the minimum is 75 percent of the average. Both the Mananwala and Pir Mahal distributaries have very high variability in the water allowances given to their individual watercourses, and in each case, the variability of watercourse water allowances is very much higher than in the respective minors of each.

In Table 4 (p.15), the water allowances of the selected watercourses show some degree of uniformity for each of the six distributary/minor canals, with the notable exception in Watercourse No. 87670-R of the Mananwala

Distributary. This information, coupled with the data given in Table 5, seems to suggest that a few watercourses have been designed with exceptionally large water allowances. Informal pressure brought about by some influential people during design or construction of the irrigation system cannot be ignored as a cause for these large allowances. Irrespective of the causes, these inter-canal supply differences and sporadic supply increases to a few watercourses greatly affect the overall equity in water distribution within the whole irrigation system.

FLOW VARIABILITY AT DISTRIBUTARY HEAD

The theory of the warahandi system assumes that each distributary canal, by and large, maintains a flow close to about 75 percent of the full supply level. To test this criterion, the actual discharges into the six selected distributaries/minors were measured once a day for the kharif 1993 season, and the monthly averages were calculated. The results of this exercise are given in Table 6. The presentation of data in Table 6 includes the standard deviation for each average, and the monthly average as a percentage of the design discharge for the respective distributary canals.

During kharif 1993, flows in the Mananwala Distributary varied from 85 to 103 percent of the design discharge level, while flows monitored during the same period for its Karkan Minor ranged from 70 to 86 percent. For both canals, the month of July saw the highest variability in the flow. The Minor's monthly average supply never reached the design discharge level, and lagged behind that of the parent distributary. A similar situation can be seen in the Pir Mahal Distributary and its Junejwala Minor. For both, the variability of flow within a month was highest in July. Seasonal flow variability was also quite high in the Pir Mahal during kharif 1993, as flows varied through the season from 66 to 106 percent of the design discharge, whereas the Junejwala Minor had a much greater fluctuation of supplies ranging from 29 to 66 percent of the design discharge (Figures 5 and 6).

Likewise, during kharif 1993, the Azim Distributary received low flows from 28 to 65 percent of the full supply discharge, while in the case of the Fordwah Distributary, the monthly average supplies at the head ranged from 56 to 117 percent during the season. In the beginning of the season, flows ranged from 94 to 104 percent, and increased to 107–117 percent during September and October.

Table 6. Monthly averages of actual discharges for sample distributaries during kharif, 1993.

Distributary/ Minor	Design discharge (m^3/s)	Average actual discharge in cubic meters per second and as a percentage of design discharge					
		May	June	July	August	September	October
Mananwala	5.21	4.64 (0.17) 89%	4.59 (0.85) 88%	4.45 (1.59) 85%	5.32 (0.14) 102%	5.38 (0.57) 103%	5.10 (0.25) 98%
Karkan Minor	1.98	1.42 (0.08) 71%	1.56 (0.08) 79%	1.39 (0.59) 70%	1.61 (0.08) 81%	1.70 (0.28) 86%	1.70 (0.08) 86%
Pir Mahal	4.70	4.02 (1.56) 85%	3.96 (1.76) 84%	3.12 (2.24) 66%	4.47 (2.27) 95%	4.98 (2.32) 106%	4.64 (2.89) 99%
Junejwala Minor	0.99	0.37 (0.14) 37%	0.42 (0.14) 43%	0.37 (0.20) 37%	0.28 (0.14) 29%	0.59 (0.17) 60%	0.65 (0.14) 66%
Azim	6.91	3.57 (1.61) 52%	4.50 (1.67) 65%	1.95 (2.15) 28%	3.60 (1.90) 52%	3.77 (2.46) 55%	2.95 (2.44) 43%
Fordwah	3.99	4.19 (0.31) 104%	3.74 (1.05) 94%	2.24 (2.24) 56%	3.88 (1.59) 97%	4.28 (1.50) 107%	4.67 (1.25) 117%

Parentheses give the Standard Deviation for each average value.

Generally, the distributaries frequently remained consistently below the design supply level. Monthly averages and their standard deviations show considerable daily variations in the actual discharge. The consequences of distributary water-flow variability on the warabaiidi practice are twofold. First, the flow variability during the season imposes severe inequity in water distribution within the watercourses, as the irrigation time per hectare does not change according to this variable flow. Second, when the flow drops substantially, say below 70 percent of the design discharge, some watercourses receive very little water or no water all, causing inequitable water distribution among the watercourses. This is sometimes circumvented by effecting a rotation along the distributary, which again causes a disruption of the warabandi schedules.

Variability at the distributary level can be a major reason for "mogha tampering." This is evident from the data on variability of the discharge at the watercourse head.

Figure 5. Average actual discharge as percentage of design discharge, kharif 1993, (Mananwala and Karkan Minor).

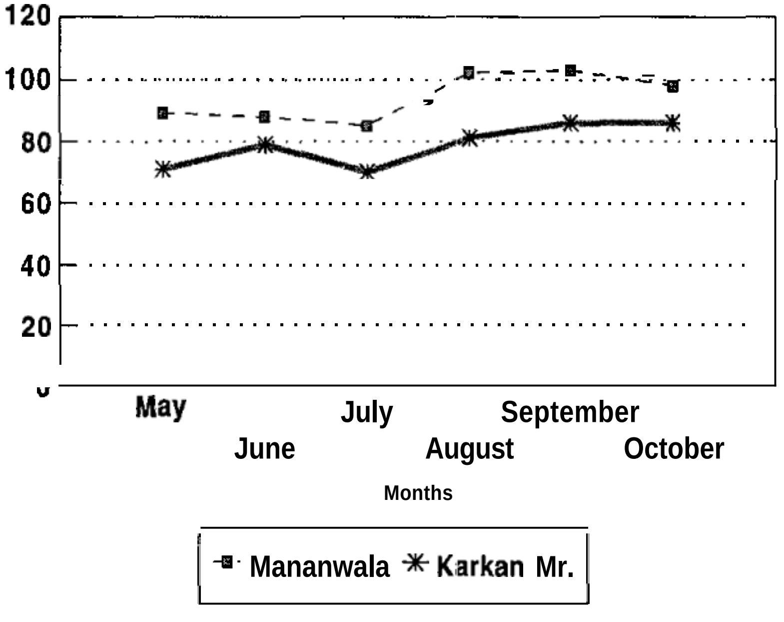
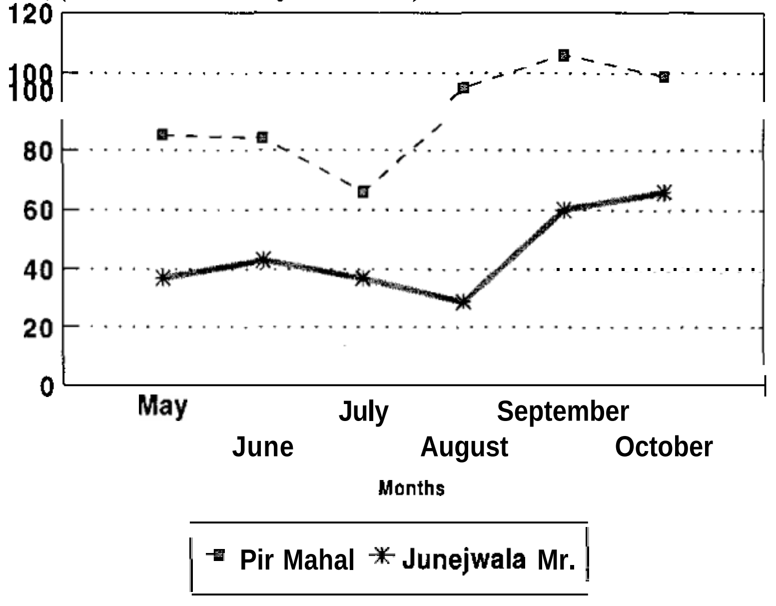


Figure 6. Average actual discharge as percentage of design discharge, kharif 1993, (Pir Mahal and Junejwala Minor).



FLOW VARIABILITY AT WATERCOURSE HEAD

Generally, it is believed that the watercourses in the tail reach of a distributary draw only a fraction of their sanctioned water allowance, while those watercourses located in the upper half of the channel commonly draw more water than is officially allowed. In order to assess the actual water distribution, this study monitored daily discharges in sample outlets (Tables 7 to 9).

The results **of** this monitoring effort, as given in Tables 7 to 9, show that the actual average discharges into watercourses deviate significantly from their design discharges. Because the design discharge is closely related to the irrigable area of a particular watercourse, the parameter for assessing the performance is the percentage **of** design discharge actually delivered (also known as the Delivery Performance Ratio). Monitoring of data indicates that the average design discharge actually delivered to watercourses varies from a very high **212** percent in May (Fordwah 46-R; Table 9) to a low percentage in July, September and October (Mananwala 121-R, 141-R and Karkan 54-R, respectively; Table 7).

Of the 22 watercourses, 8 had an actual average discharge at the mogha over 110 percent of the design discharge for this period, whereas, 11 watercourses had an average discharge which was less than 90 percent of the design value. Both in terms of time (monthly averages) and space (between watercourses within each distributary canal), there was considerable variation in water delivery at the mogha head. Thus, one of the most critical conditions for warabandi has ceased to exist when thr: flow into the watercourse has fluctuated so widely.

Few allocation methods can he effective in providing sufficient irrigation if there is high variability in the flow of water in the channels. A method such as warabandi, which relies on a constant flow in the watercourse for its allocations of time proportional to land size, is much less-effective when confronted with the extent of variability as shown in the above data. One hypothesis at this stage is that the widespread modification of official warabandi schedules by the water users may have been prompted by the high variability of the water supply at the farm gate.

Data collected by IIMI field stations for another year (1991) confirm the flow variability at the watercourse head. The graphs shown in Figures 7 to 14, are based on the field data for 8 selected watercourses in the sample, 5 watercourses from the Mananwala Distributary and 3 from the Pir Mahal Distributary.

Table 7. Monthly averages of actual discharges for sample outlets in the Upper Gugera (LCC) during kharif, 1993.

Outlet no.	Design discharge (l/s)	Average actual discharge in liters/second and as percentage of design discharge					
		May	June	July	August	September	October
MW 24-R	24.4	32.8 (6.5) 135%	34.3 (15.6) 141%	38.2 (18.4) 157%	47.6 (14.4) 195%	51.5 (9.1) 212%	42.8 (9.1) 176%
MW 43-R	29.7	33.1 (0.6) 114%	33.4 (0.6) 112%	29.2 (11.3) 98%	34.5 (0.6) 116%	34.5 (1.4) 116%	34.3 (0.6) 115%
MW 71-R	38.2	43.3 (0.6) 113%	43.3 (0.8) 113%	37.9 (14.7) 99%	44.5 (0.8) 116%	44.2 (2.3) 116%	44.5 (0.6) 116%
MW 87-R	47.9	88.6 (4.8) 185%	90.6 (4.0) 189%	84.1 (36.5) 176%	99.1 (6.8) 207%	102.2 (9.9) 214%	101.7 (7.1) 212%
MW 121-R	33.7	43.6 (3.1) 129%	43.0 (1.4) 128%	31.4 (3.7) 93%	44.7 (2.3) 133%	43.3 (2.0) 129%	43.6 (0.8) 129%
MW 141-R	68.0	26.1 (7.1) 38%	16.1 (6.8) 24%	15.0 (11.0) 22%	16.7 (7.4) 25%	0 0%	0 0%
KN 10-R	31.4	32.0 (2.8) 102%	33.4 (3.4) 106%	27.2 (12.7) 87%	31.4 (8.5) 100%	37.9 (9.1) 121%	33.4 (2.3) 106%
KN 54-R	46.2	36.0 (3.7) 78%	37.9 (4.2) 82%	27.5 (5.9) 60%	44.5 (4.8) 96%	45.3 (4.5) 98%	47.3 (3.1) 102%

Parentheses give the Standard Deviation for each average value.

Table 8. Monthly averages of actual discharges for sample outlets in the Lower Gugera (LCC) during kharif, 1993.

Outlet no.	Design discharge (l/s)	Average actual discharge in liters/sec[illegible] and as percentage of design discharge					
		May	June	July		September	
PM 70-R	37.1	26.6 (5.1) 72%	25.8 (7.1) 69%	29.2 (7.6) 79%	(9.1)	(8.8)	(11.6)
PM 89-L	46.2	26.6 (5.9) 58%	25.8 (8.2) 56%	29.4 (9.6) *64%*	24.1 (11.3) 52%	20.7 (11.0) 45%	22.1 (14.2) 48%
PM 133-L	44.2	36.5 (5.9) 83%	37.7 (4.0) 85%	41.1 (1.7) 93%	37.1 (5.4) 84%	36.2 (5.9) 82%	37.1 (5.1) 84%
JW 6-R	31.1	31.1 (6.5) 100%	(4.8)	(9.3)	32.0 (11.6) 103%	37.1 (8.2) 119%	34.0 (13.0) 109%
JW 27-R	29.2	42.2 (8.5) 145%	(11.3) **151%**	(12.2) 134%	49.3 (2.0) 169%	48.1 (6.2) 165%	50.4 (3.7) 173%
JW 41-L	31.7	27.2 (12.2) 86%	(14.7) 94%	(18.1) 68%	30.3 (17.6) 96%	29.4 (15.9) 93%	28.6 (**14.7**) 90%

Parentheses give the Standard Deviation for each average value

Table 9. Monthly averages oj actual discharges for sample outlets in the Fordwah Branch Canal Area during kharif,1993.

ıtlet no.	Design discharge (l/s)	Average actual discharge in liters/second and as percentage of design discharge					
		May	J	J ıly	A	September	October
AZ 20-L	45.Y	65.4 (28.0) 143%	b88 (29.2) 150%	37.4 (37.7) 81%	66.5 (29.4) 145%	67.1 (42.5) *146%*	29.4 (41.6] *64%*
AZ 43-L	25.5	33.7 (13.9)	**41.1** (17.0)	18.1 (20.4)	31.4 (15.3)	33.4 (21.0)	11.9 (18.4)
AZ 63-L	59.2	45.0 (7.4) 76%	46.2 (10.8) 78%	41.9 (10.5) 71%	37.9 (6.2) *64%*	47.6 (2.5) **80%**	37.1 (13.3) 63%
AZ 111-L	45.9	13.0 (17.8) 28%	12.2 (10.8) 27%	7.1 (11.0) 15%	0.6 (3.1) 1%	7.6 (7.9) 17%	3.4 (6.8) 7%
FW 14-R	52.1	56.1 (5.7) 108%	49.8 (17.3) 96%	33.1 (24.1) *64%*	43.0 (27.2) 83%	55.5 (20.7) 107%	56.4 (12.5) 108%
FW 46-R	44.7	94.9 (3.4) 212%	89.5 (19.5) 200%	52.7 (39.9) 118%	62.9 (41.1) 141%	85.5 (27.2) 191%	68.0 (36.8) 152%
FW 62-R	33.4	37.7 (2.5) 113%	34.0 (7.6) 102%	24.9 (12.7) 75%	29.4 (14.2) 88%	42.2 (9.6) 126%	382 (5.9) 114%
FW 130-R	68.0	75.0 (13.9) 110%	70.5 (4.0) 104%	44.7 (19.5) 66%	54.1 (7.9) 80%	61.7 (9.6) 91%	54.9 (9.9) 81%

Figure 7. Daily discharge in 24R of Mananwala.

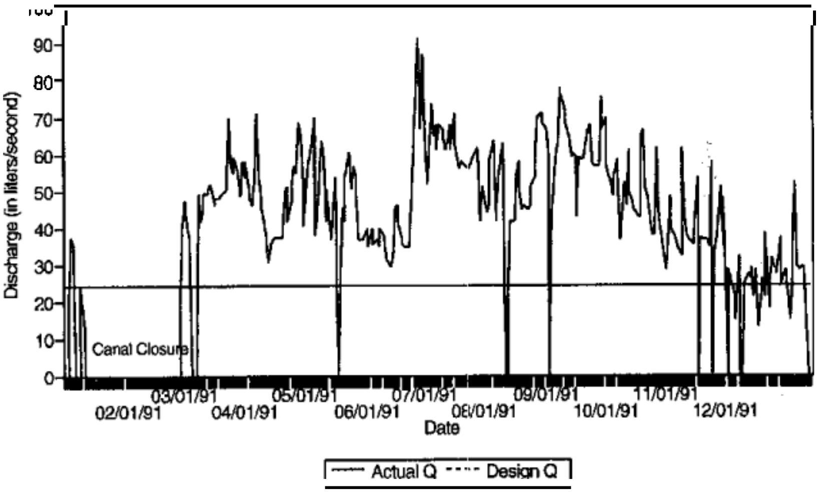


Figure 8. Daily discharge in 71R of Mananwala.

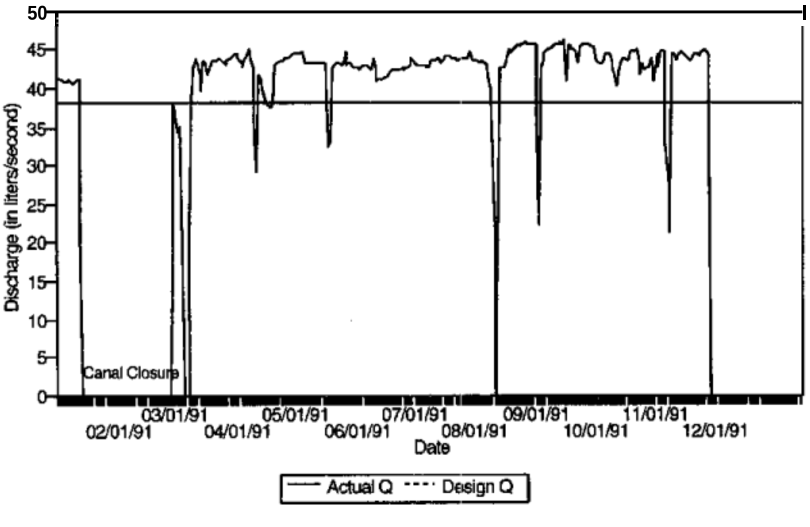


Figure 9. Daily dischurge in 121R of Mananwala.

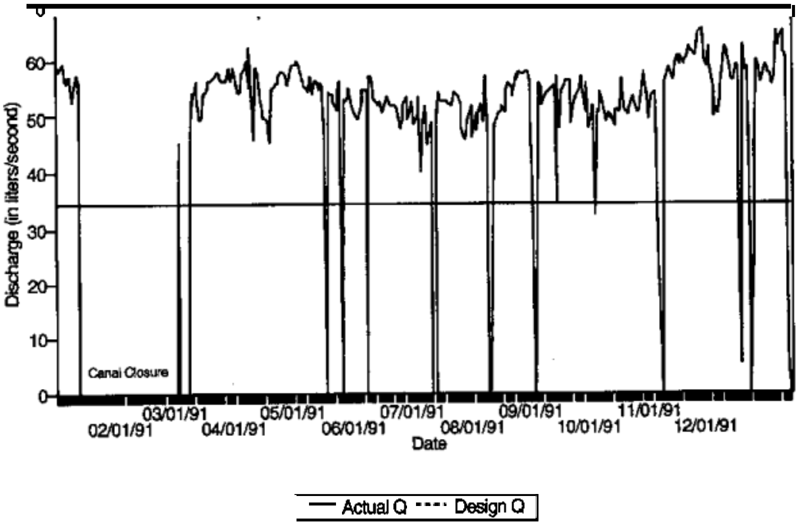


Figure 10. Daily discharge in 43R of Mananwala.

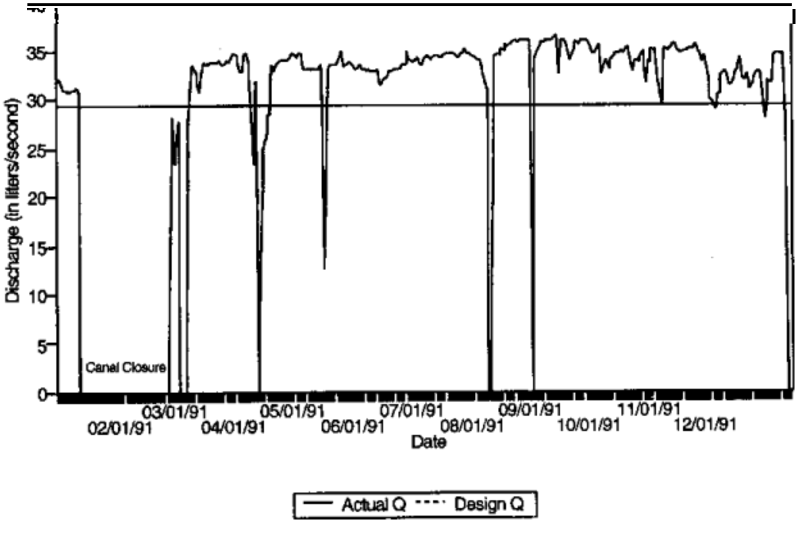


Figure 11. ***Daily discharge in*** *87R of* ***Mananwala.***

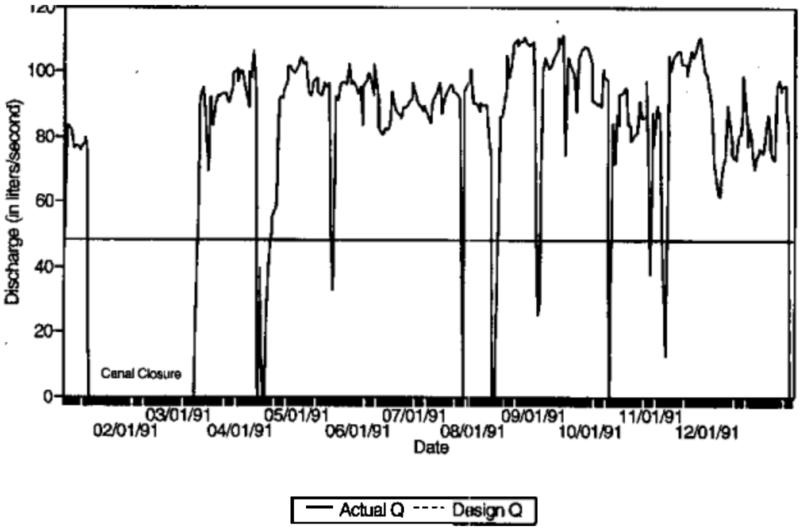


Figure 12. *Daily* ***discharge in*** *70R* ***of Pir Mahal.***

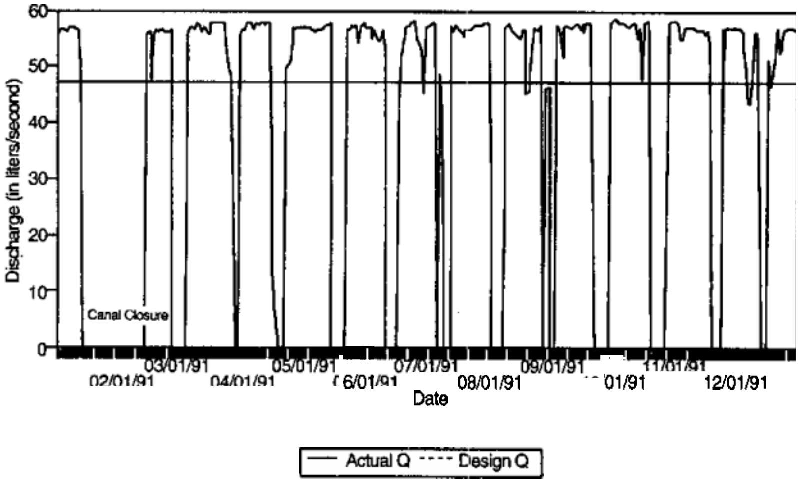


Figure 13. Daily discharge in 89L of Pir Mahal.

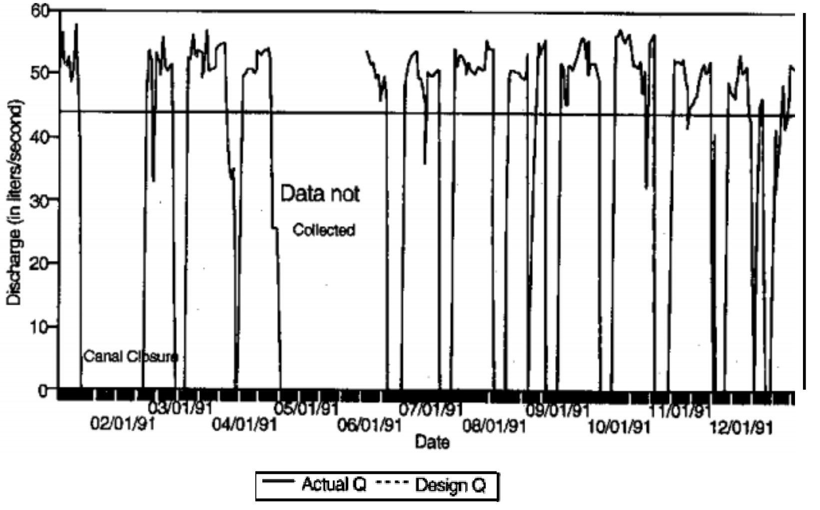
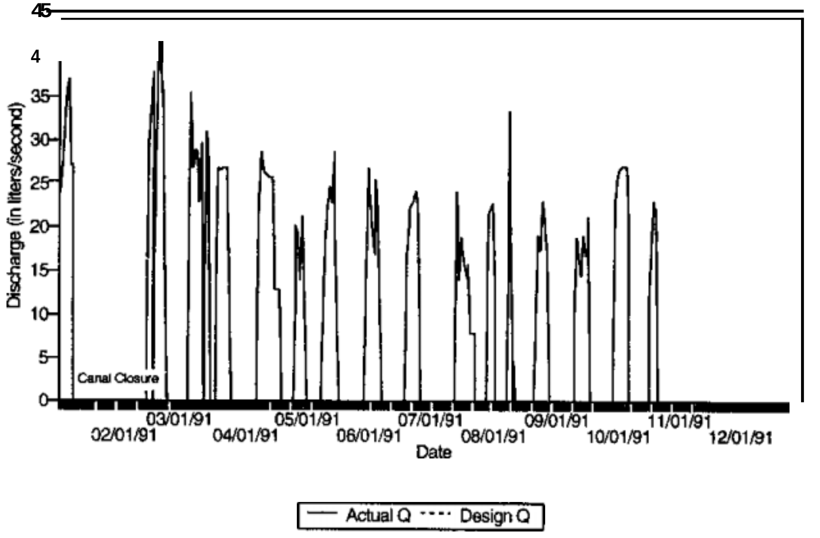


Figure 14. Daily discharge in 133L of Pir Mahal.



FLOW VARIABILITY WITHIN THE WATERCOURSE

During the short duration of this study, flow measurements could not be taken within the watercourse. However, the existence of a substantial variability in water allocations given to individual farm plots was discovered during farmer interviews carried out by the study. The results of these interview data (presented in Chapter 5), are corroborated by field data collected by a state agency, the Watercourse Monitoring and Evaluation Directorate (WMED).

The WMED measured conveyance losses in watercourses as part of the evaluation of a watercourse improvement program. The discharge was measured at the head of the watercourse, at some selected Farms and at some selected fields within the farms, ranging from 0.50 to 1.00 acres. Measurement data collected in kharif **1993** from the watercourse No. 15050-R of the Sirajwah Distributary of the Fordwah Eastern Sadiqia System are presented below.

In the analysis, one measurement from each farm (fields from 9 farms were studied) has been taken. The area of each field analyzed was one acre except farm 9, field 1, which was 0.78 acres. The results of data analysis given Table 10 show considerable variation in the volume of water received by different farms from June to October 1993. Discharges at the watercourse bead (Qs), at the farm head (Qfm) and at the field (Qfd) all show considerable variability, which in turn affects the time taken for actual irrigation.

Table 10. Analysis of discharge measurements within watercourse no. 15050-R of the Sirajwah Distributary.

Farm #	Field #	Qs (cfs)	Qfm (cfs)	Qfd (cfs)	Qfd (cms)	Area (acres)	Area (ha)	Time minutes)	Volume (m^3)	Volume per area (m^3/ha)
2	5	3.10	2.70	2.50	0.071	1.00	0.40	64	271.87	671.51
3	4	2.10	1.70	1.59	0.045	1.00	0.40	72	194.52	480.48
4	5	2.55	1.85	1.85	0.052	1.00	0.40	90	282.92	698.80
5	6	3.00	1.72	1.72	0.049	1.00	0.40	131	382.86	945.67
6	5	3.00	1.73	1.73	0.049	1.00	0.40	88	258.69	638.95
7	3	2.m	1.40	1.40	0.040	1.00	0.40	I18	280.71	693.35
8	5	2.55	1.33	1.33	0.038	I.M	0.40	119	268.93	664.26
9	I	3.10	1.45	1.45	0.041	0.78	0.32	84	206.96	655.38

Notes: Qs = Discharge at the source (watercourse head)
Qfm = Discharge at the farm.
Qfd = Discharge at the field.
cfs = Cubic feet per second (cusecs).
cms = Cubic meters per second (cumecs).
The time used for converting the discharge into volume is the one given in column 9 (time in minutes) and is taken from WMED data.

CHAPTER 5

Warabandi in Practice

OFFICIAL, AGREED AND ACTUAL WARABANDI

THE CONCEPTS, OBJECTIVES and the necessary conditions underlying a "warabandi system" were discussed in Chapter 3, whereas the changes that have occurred in these conditions were mentioned in Chapter 4. In this discussion, reference was made to two types of warabandi, the official pucca warabandi, and the communally determined kachcha warabandi, Except in a few places where kachcha warabandi is still practiced, the tertiary-level water distribution in Punjab's canal irrigation systems is largely covered by official pucca warabandis.

This chapter analyzes the results of the field studies described in Chapter 2. An analysis is given of the main features of the variations that have taken place in the popularly known version of warabandi (mainly pucca warabandi), including how the officially recognized warabandi schedules have been modified by the water users and what type of further deviations have been observed between these modified warabandi schedules and the way they are actually applied in the field. Field observations in the study sample of distributary canals and watercourses showed that the official warabandi schedules are not followed in actual practice.

For the purpose of this presentation, three terms are used to represent three different versions of warabandi: ***official warabandi, agreed warabandi*** and ***actual warabandi.*** They refer, respectively, to the warabandi schedule officially determined and recorded in official documents, the schedule of water turns after this official warabandi has been adjusted through mutual agreement by the water users for practical purposes, and the turns and timings of warabandi actually observed in the field. The "agreed warabandi" schedules were developed by the study team through extensive farmer interviews, whereas, direct field observations during a whole rotation period (7 or 10.5 days) helped in the identification of "actual warabandi."

OFFICIAL WARABANDI REPRESENTING WATER RIGHTS

In theory, the official warabandi is supposed to be implemented according to an officially determined **fixed** schedule, which is meant to be strictly adhered to by all of the water users ***so*** that its underlying objective of equitable distribution can be achieved. If properly executed, the schedule is determined on the basis of an equal share of water per unit of land to be irrigated. However, the present study reveals that, contrary to common belief, the rigidity of the official pucca warabandi has almost ceased to exist. The real practical meaning of the official warabandi appears to lie in the fact that it fixes the ***right to irrigation wafer*** for the participating water users, a right that they can continue to exercise if they have to, or can relax in actual practice, but that can be used in any litigation, or in any appeal for further arbitration or adjudication, when their access to water is jeopardized in any way. Farmers refer to this function of warabandi as *haqooq* (right to irrigation water).

Contrary to the traditional water rights derived from a long-uninterrupted use of water, the form of rights defined by **an** official warabandi assumes a more formal "legal right." **Also,** the official warabandi is accepted by the majority of small farmers as more equitable than the traditional "rights," as the latter are based on the historical use, and are often determined by a few powerful rural elite. For this same reason, it is difficult to sustain the official warabandi schedules in their original form, as the informal pressure from the local elite can supersede the formal rules in the long run.

According to official procedure, a canal patwari is required to keep updated records of the latest sanctioned official warabandi list for their *patwar* circle. Surprisingly, it was only for two watercourses in the sample of **22** watercourses that the required lists were readily available.[15] Most of

15 These up-to-date warabandi lists were available because they were revised while the study *was being conducted, due to some changes in their* Gross Command Areas (the Fordwah Distributary).

the concerned officials could not provide the latest warabandi lists for their respective watercourses in the study sample. Failing to collect all of the official warabandi schedules from the patwaris, an effort was made at the Divisional Canal Offices to retrieve the remaining lists for the sample watercourses. The study team could collect only 15 official warabandi schedules[16] from the Irrigation Department for the 20 pucca warabandi watercourses in the sample (2 sample watercourses are on kachcha warabandi). Details are listed in Table 11.

Table 11. Some details of official warabandi for 15 sample watercourses.

Distributary	Watercourse	Warabandi interval (days)	No. of water users	
			At the last official amendment	As at present
Monanwala	43506-R	7	76 (1989)	81
	71683-R	10.50	88 (1989)	116
	87670-R	7	29 (1986)	58
	141542-RR	7	72 (1986)	158
Karkan Minor	10435-R	7	55 (NA)	70
	54892-R	10.50	30 (NA)	92
Pir Mahal	89250-L	7	27 (1977)	I24
	133970-L	7	30 (1976)	I80
Azim	20610-L	1	6 (1979)	26
	43260-L	1	10 (1991)	16
	63620-L	7	12 (1974)	20
Fordwah	14320-R	7	78 (1992)	82
	46725-R	7	31 (1992)	47
	62085-R	7	48 (1971)	47
	130100-R	7	44 (1981)	58

16 Examples of official warabandi schedules for 7-day and 10.5-day cycles are given in Annex-I A and Annex-IB, respectively.

a watercourse. These interviews showed that most of the Irrigation Department field personnel dealing with warabandi operations were not fully conversant with the procedure and not skilled enough to frame the roster, or even to explain the procedure. Only two of the canal patwaris interviewed were able to explain the required procedure. They acknowledged the existence of agreed warabandis based on consultation and compromise amongst the farmers. When a dispute arises, some of the serving officials seek guidance from retired and experienced patwaris and try to resolve the dispute informally.

The results of the interviews with canal patwaris also indicate that they resort to a simple method of calculating the water-turn times for the warabandi schedules. Once the *chakbandi* (gross area **of** land fixed for irrigation from an outlet) is established, uncommanded areas like the village area, graveyards, highland, roads, railway lines, school building, etc., arededucted from the gross command area (area commandable by the outlet from within the chakbandi), and the culturable command area (CCA) is determined. Then, the total time (in minutes) during the rotation period is divided by the CCA. This calculation results in the fixed time per unit area for that watercourse command, which is then applied to determine the turn time for each of the farmers in proportion to his/her farm size without considering any allowances for filling or drainage time. When filling time and drainage time are included, they are based on rough assessments

AGREED WARABANDI REPRESENTING GROUP CONSENSUS

Field investigations showed that the officially sanctioned warabandis in most instances were not adhered to in practice, and were found to be superseded by substantially modified schedules. The reported reasons for these modifications were the changes in water supply, the physical layout of the watercourse, the changes in landownership and tenurial status, and other power relationships among the water users. Interviews with farmers showed that, except in the case of a very recently updated warabandi, fanners in all other sample watercourses had adopted, on mutual agreement, adifferent schedule. This version is referred to in this paper **as** ***agreed warabandi.*** Unless a strong dispute arises in the process of modifying the official warabandi, a general consensus among the water users in the watercourse would lead to this agreed rotation schedule.

As indicated in Table 10(p. 45), most of the official warabandi schedules have not been updated for a number of years despite the fact that the number of water users have increased substantially since the last official amendment. This delay itself could lead to unofficial modifications of the schedules by the water users themselves. As long as they are not disputed by an individual water user, or a group of water users, the procedure does not allow any official intervention. The two interrelated reasons explain the present high prevalence of agreed warabandi.

ACTUAL WARABANDI REPRESENTING REALITY ON GROUND

Direct field observations of the actual application of water turns by farmers showed that even the agreed warabandi was not strictly followed, and frequent changes took place on timing and duration of turns almost on a daily basis. The study team recorded these changed schedules for each sample watercourse as an approximation of a week's observations. This third category of schedules will be referred to as actual warabandi. While the reasons for introducing some flexibility in developing a more functional warabandi on mutual agreement can be easily understood, the divergence between the *official* warabandi schedules and what is actually practiced in the field is unexpectedly large.

The Case of Watercourse No. PM 89250-L

As an initial step to understand the actual warabandi practices in the field, data collected from official records, through farmer interviews and through direct observations in the field were analyzed to compare official, agreed and actual warabandi schedules for one watercourse (at RD 89250 of the left hank of the Pir Mahal Distributary). Annex-A gives its official warabandi schedule, whereas Annex-2A and Annex-2B give the agreed and actual warabandi schedules, respectively. Table 12 gives the variation in the three sets of water allocation values for different turns in official, agreed and actual warabandi schedules for this watercourse.

Table 12 shows that the changes made on the official warabandi have generally resulted in an increase in the irrigation time per unit of land (defined as "water allocation"[17] in this presentation). The average value for this measure derived from the official warabandi schedule having 36 water turns is 0.69 hours per hectare. In the agreed warabandi schedule, in which the number of turns has increased to 156, the water allocation measure has increased to 0.83 hours per hectare, and in actual practice, where the number of turns has shrunk back to 49, the value has further increased to 1.81 hours per hectare. This is mainly because some farm plots were not receiving any water at all. The increases in coefficients of variation also suggest that changes from the official warabandi schedule result in increased inequity.

Table 12. Variability of water allocation through warabandi turns (Water-course No. 89250-L Pir Mahal).

Description	**Official warahandi (n=36)**	Agreed **warahandi (n=156)**	**Actual warahandi (n=49)**
Range (hrs/ha)	0.42 – 0.93	0.47 – 3.29	0.65 – 6.30
Average (hrs/ha)	0.69	0.83	1.81
Standard Deviation	0.09	0.25	1.40
Coefficient of Variation (%)	13	31	77

VARIABILITY IN WATER ALLOCATIONS

The case study of Watercourse No. PM 89250-L shows that changes from the officially recognized pucca warabandi schedules tend to increase ineq-

17 The "water allocation" is defined. for the purpose of this presentation, as the irrigation time per unit of land on the basis of a constant discharge to the watercourse. The water allocation in the warabandi system is usually understood in hours per acre. It varies from one watercourse to the other, depending on the wmmand area to be irrigated. For equitable distribution the water allocation measure should not vary too widely among the different farm plots in a given watercourse.

uity. Accordingly, despite the consensus reached among the water users, the agreed warabandi may not correspond to a high degree of equity. To assess this proposition, agreed warabandi data for the 22 sample watercourses were analyzed to calculate the variability of the water allocations given to individual farm plots of each watercourse. The results of this analysis are given in Table 13, which includes the minimum, maximum and average water allocation values derived from agreed warabandi water turns for various farm plots within each watercourse, as well as the average water allocation assessed on the basis of the design CCA of each watercourse (i.e., duration of rotation period divided by CCA).

These results show a high variability in the water allocated according to these mutually agreed schedules, and indicate a high incidence of inequity in irrigation water distribution along the tertiary system. Common agreement implies that the water users are generally content with variations in the water allocation, or are unaware of the extent of inequity that exists. The differences between the two average values relate to the discrepancy between design intentions and the present situation.

Another interesting observation in Table 13 is that except in the case of the Azim Distributary, the variability is generally lower in the head reach watercourses in each canal. In the Mananwala Distributary, the watercourse at RD 24873-R has low variability in the agreed water allocation among the water users indicated by a coefficient of variation of 0.24, which has substantially increased towards the tail reaches of the distributary—0.61, 0.44 and 0.43 in watercourses at RDs 87670-R, 12173.5-R and 141542-R, respectively. Similarly, in the Karkan Minor, the coefficient of variation of water allocation has increased from 0.19 in the head-reach watercourse to 0.28 in the tail-reach watercourse. In the Pir Mahal Distributary, the increase is from 0.28 to 0.45, and in its Minor Junejwala, from 0.14 to 0.87, whereas, in the Fordwah Distributary, the coefficient of variation has increased from 0.22 in the head-reach watercourse to 0.30 in the tail-reach watercourse. This may be explained by the possibility that the volume of water that can be delivered per unit of land is relatively higher in the head reach of the canal. The Azim Distributary appears to be an exception to this behavior, probably because of the seasonal abundance in the non-perennial canal supply.

Table 13. Variability of water allocation in 22 sample watercourses.

Watercourse	Assessed average allocation (hrs/ha)	Minimum allocation (hrs/ha)	Maximum allmation (hrs/ha)	Average allmation (hrs/ha)	Coefficient of variation
MW 24873-R	0.98	0.62	1.85	0.91	0.24
MW 43506-R	0.75	0.27	2.47	0.82	0.38
MW 71683-R	0.87	0.42	2.72	1.01	0.39
MW 87670-R	0.70	0.44	3.58	0.86	0.61
MW 121735-R	0.66	0.27	4.13	1.06	0.44
MW 141542-R	0.33	0.37	2.92	0.72	0.43
KN 10435-R	1.06	0.64	I .90	I.04	0.19
KN 54892-R	I.09	0.30	2.82	1.14	0.28
	L	er Gugero (	mand Area		
PM 70076-R	0.90	0.67	3.04	1.04	0.28
PM 89250-L	0.96	0.47	3.29	0.83	0.31
PM 133970-L	0.75	0.20	3.29		0.45
JW 6619-K	I.42	0.74	I .85		0.14
JW 27290-R_2	1.20	0.84	3.29		0.44
JW 41234-L	1.09	0.32	8.23	1.51	0.87
AZ 20610-L	I.41	1.01	4.94	2.w	0.53
AZ 43260-L	2.54	1.70	3.46	2.59	0.16
AZ 63620-L	I.39	0.35	4.37	I.70	0.59
AZ I 11770-L	1.41	0.40	2.59	1.46	0.26
FW 14320-R	0.86	0.59	1.80	0.86	0.22
FW 46725-R	0.98	0.59	I.73	I.04	0.22
FW 62085-R	I.26	1.06	3.11	1.38	0.21
FW 130100-R	0.65	0.54	2.13	0.96	0.30

KHAL BHARAI/NIKAL ALLOWANCES

Part of the variability in time allocation per unit of land within a watercourse can be due to the time allowances given to various farm plots, related to filling and drainage time along the watercourse. The official warabandi system operates on the basis of officially recognized watercourse outlets (*nakkas*) off the main watercourse or its branches. The "in" and "out" nakkas for each water turn are sanctioned at the time of formulating the warabandis; the "in" nakka is the outlet from which water is taken at the beginning of the water turn and the "out" nakka is the outlet at which the water flow is transferred to the next turn-holder. Depending on the location of the farm plot in relation to the route of the watercourse, the transfer from the previous turn-holder and the transfer to the next can take place at the same nakka, in which case the "in" and "out" nakkas become the same. Annex-1A and Annex-1B in which two specimen official warabandi schedules are given, refer to the "in" and "out" nakkas and their locations in the field in terms of "square" and "killa" numbers. The shareholders are well aware of the specified nakkas.

Usually, when the irrigation time is fixed for different farms, some khal bharai (filling) time allowance is allocated to deserving shareholders depending upon their specific situation. Similarly, Nikal (drainage) time is deducted from the time turn, if the particular farm plot would benefit while drainage takes place. During this study, most of the water users were observed to ignore the official khal bharai/nikal time fixed in their turns; instead, they were observed to give and take these allowances at the rate of 5 minutes per acre distance for an already filled watercourse for khal bharai and 3 minutes per acre distance to get the benefit of nikal. In addition to these approximations in assessment, the practice itself was found to be arbitrary. However, the low incidence of such practices found in the sample areas, as shown in Table 14, reflects a relatively small contribution made by these time allowances in the high variability that exists in water allowances. This in turn points towards a high degree of inequity in water distribution.

Table 14. Khal bharai/nikal practice in selected sample watercourses.

Watercourse no.	Total number of turns in agreed warabandi	Percentage of turns wiih khal bharai/nikal
MW 24-R	37	3
MW 71-R	109	I
MW 121-R	230	42
KN 10-R	60	16
KN 54-R	94	24
PM 70-R	170	14
PM 89-L	121	5
PM 133-L	158	7
JW 06-R	8	I
JW 27-R	123	18
JW 41-L	97	9
AZ 20-L	26	4
AZ 63-L	12	8
AZ 111-L	5	0
FW 14-R	77	22
FW 62-R	53	6
FW 130-R	58	14

DEVIATIONS FROM WARABANDI SCHEDULES

The details of warahandi operations collected from the 22 sample watercourses reveal that the actual operations of warabandi differ substantially from the agreed warabandi, and that this phenomenon is widespread. Farmers make adjustments according to need and opportunity in the context of prevailing social and economic demands, demonstrating considerable cooperative behavior in doing so. In the present analysis, the divergences between thecurrent agreed warahandi and the actual warahandi in practice as observed in the field are referred to as "deviations." The deviations that occur from the agreed warabandi turns are both in terms of their durations, as well as in their timings.

Tables 15 and 16 show the changes in duration for the selected head, middle and tail watercourses of the Upper Gugera and the Lower Gugera systems, respectively.

Table 15. Deviations (in %) from agreed duration of water turns observed in 5 sample watercourses of the Upper Gugera (LCC) during kharif; 1993.

Water-course	zero deviation	0–0.50	Deviations in hours				
			0.50–1.0	1.0-2.0	2.0–3.0	3.0 and above	Total
MW 121-R			19	12			100
KN 10-R	15	18	24	22	6	15	tw
KN 54-R	15	34	17	15	9	10	i w

Table 16. Deviations (in %) from agreed duration of water turns observed in 6 sample watercourses of the Lower Gugera (LCC) during kharif; 1993.

Water-course			De	ions in	ırs		
	Zero eviatio	0–0.50	0.50–1.0	1.0-2.0	2.0–3.0	3.0 and above	Total
PM 70-R	45	29	8	11	1	6	100
PM 89-L	9	51	15	14	4	1	iw
PM 133-L	10	34	27	21	4	4	100
JW 06-R	33	33	18	9	4	3	100
JW 27-R	41	19	8	13	4	15	100
JW 41-L	35	18	13	19	5	10	100

Tables 15 and 16 indicate two important features of the deviations from agreed warabandi durations in the Lower Chenab Canal command area:

1. Generally, there is no tendency for either an increasing or a decreasing trend of these deviations from head to tail of both Upper and Lower Gugera canal commands.

2. In both areas, the incidence of small deviations is greater than that of the longer deviations.

The majority of the irrigation turns that have undergone some deviation in terms of their duration are in the 0–0.50 hour category in terms of deviated time. These statistics indicate that the farmers supplement the irrigation of their fields by mutually sharing time when the allocated time is short of 15 to 30 minutes of the required time for irrigation. This type of deviation is seen to be a daily irrigation practice in the study area.

Table 17 gives the deviations from agreed warabandi durations in the Fordwah Branch Area.

Table 17. Deviations (in %) from duration of water turns observed in 6 sample watercourses of the Fordwah Branch Area during kharif, 1993.

Water-course				
	Zero deviation	**0–0.50**	**0.50–1.0**	**1.0–2.0**
AZ 20-L	**61**	**3**	**2**	**6**
AZ 63-L	**40**	**3**	**3**	*I*
AZ 111-L	**20**	0	**3**	**9**
FW 14-R	**62**	**12**	**7**	**9**
FW 62-R	**86**	**3**	**3**	**2**
FW 130-R	**64**	**6**	**3**	10

In contrast to what was observed in the LCC area, the percentage of deviations is lower for smaller deviation categories in the Fordwah Branch sample. The higher level of deviations in the category of 3.0 or higher, is attributable to the large landholdings in this area, implying that those who can afford to effect changes in the official or agreed warabandi schedules tend to derive a substantial personal advantage from such changes.

DEVIATIONS FROM WARABANDI TRADITIONS

In the beginning, when the warabandi system was introduced in this area, the rigidity of the fixed schedule was designed to prevent the exploitation of water rights. However, with increased cropping intensities and changes in the cropping pattern, the water allocation per unit of land became inadequate. Generally, the warabandi schedules have been found incapable of providing sufficient irrigation per unit area for the average cropping intensity (Bhatti and Kijne 1990). Due to the increasing demand for water, some users have started to develop strategies to overcome supply inadequacy through flexibility in water turns. Since overall availability of surface water has not changed, the flexibility is very often at the expense of some part of the irrigable area within the watercourse command for some part of the rotation period. The main strategies are outlined below:

1. ***Rotation of Turns.*** Two to three farmers, and sometimes more, rotate their water turns in order to improve equity and, concomitantly, the flexibility of using the sanctioned supplies. This way, each week, a farmer will share the effects of aberrations in physical conditions that may apply to a number of individual water turns.

2. ***Merger of Turns.*** In this type of operation, water is used by two to three farmers or more, during a single water turn. This often happens when the farmers belong to the same family.

3. ***Substitution of Turns.*** This type of operation is prevalent in instances where a farmer has a small landholding with a short-duration water turn. This farmer gives the water turn to the nearby large landowner, and after two or three turns, the large landowner gives sufficient water to irrigate the entire plot of the small landowner.

4. ***Exchange of Turns.*** Farmers have the practice of increasing the flexibility of water supply by exchanging canal turns (lending and borrowing).

5. ***Trading of Turns.*** When farmers cannot meet their water requirements for one reason or another, they start buying canal water turns.

Description	Mananwala Distributary			Karkan Minor	
	24-R	71-R	121-R	10-R	54-R
Total agreed turns	37	107	242	68	113
Turns in practice	37	109	230	60	94
Borrowed (%)	14	9	39	29	37
Lent (%)	20	9	50	34	48
Trading (%)	0	0	0	48	0

Table 19. Trading and exchange of turns by the farmers in the Lower Gugera (LCC) during kharif, 1993.

Description	Pir Mahal Distributary			Junejwala Minor		
	70-R	89-L	133-L	6-R	27-R	41-L
Total agreed turns	77	156	186	122	53	91
Turns in practice	82	161	181	104	54	88
Borrowed (%)	3	6	12	12	11	8
Lent (%)	5	2	33	15	12	11
Trading (%)	8	12	8	8	2	2

Description	Azim Distributary			Fordwah Distributary		
	20-L	63-L	111-L	14-R	62-R	130-R
Total agreed turns	26	19	27	80	47	56
Turns in practice	26	12	5**	77	53	58
Borrowed (%)	12	33	2	13	6	5
Lent (%)	12	42	2	10	9	5
Trading (%)	0	0	0	0	0	0

Fordwah Irrigation System is located in the water-scarce cotton zone, no water transactions were reported by the farmers.

Watercourse	Agreed warabandi		Actually practiced warabandi	
	Day turns (%)	Night turns (%)	Day turns (%)	Night turns (%)
MW 24-R (Head)	59	41	68	32
MW 71-R (Middle)	51	49	60	40
MW 121-R (Tail)	77	23	69	31
KN 10-R (Head)	54	46	73	27
KN 54-R (Tail)	68	32	78	22

Watercourse	Agreed warabandi		Actually practiced warabandi	
	Day turns (%)	Night turns (%)	Day turns (%)	Night turns (%)
PM 70-R (Head)	58	42	38	62
PM 89-L (Middle)	43	57	52	48
PM 133-L (Tail)	47	53	53	48
JW 06-R (Head)	63	37	48	52
JW 27-R (Middle)	36	64	66	34
JW 41-L (Tail)	49	51	54	46

Table 23. Proportion of day turns and night turns in the Fordwah/Eastern Sadiqia System during kharif, 1993.

Watercourse	Agreed warabandi		Actually practiced warabandi	
	Day turns (%)	Night turns (%)	Day turns (%)	Night turns (%)
AZ 20-L (Head)	58	42	69	31
AZ 63-L (Middle)	47	53	68	32
AZ 111-L (Tail)	48	52	100	0
FW 14-R (Head)	51	49	56	44
FW 62-R (Middle)	53	47	62	38
FW 130-R (Tail)	55	45	62	38

CHAPTER 6

Discussion: The Myth and Reality of Warabandi

SUPPLY VARIABILITY AND DEMAND RESPONSES

GIVEN THAT WARABANDI is basically an allocation of time for irrigation in proportion to the size of the land to be irrigated, the effective application of warabandi presupposes a flow of water in the watercourse at a constant rate. One of warabandi's primary objectives, which is to distribute the scarce water resources equitably among the water users, implies that the rate of water flow is uniform among the different watercourses. However, the present study shows that neither of these criteria exists in practiced warabandi. Variability exists within watercourses, within distributaries, and even in the water allowances to different canals assigned by the design itself. Field observations show that the flow rates fluctuate widely, both spatially and temporally.

The variations of the water flow within the watercourses, as shown in Tables 7 to 9, have a combination of spatial and temporal dimensions. The standard deviation values given in these tables for monthly averages of actual discharges into the sample watercourses indicate how diverse the water flow rates can be on a daily basis. Although the data related to flow fluctuations within a day are not available, the interviews with farmers indicated that the variability in the flow within a watercourse is a common occurrence throughout the cropping season. With such flow fluctuations, the individual water turns for different farm plots within the watercourse command area during a 7-day warabandi rotation period can have widely varying quantities of water per hectare of land.

In assessing the criterion of equity in water allocation, the variability in canal water supply into different watercourse commands becomes a relevant issue. As Tables 3, 4 and 5 show, the design itself appears to have assigned varying water allowances to different distributaries and watercourses. At least part of this variability is attributable to changes in the command area and some ad hoc changes in the hydraulic structures. Although this design-related discrepancy does not affect the operations of warabandi within 'individual watercourse commands, it however imposes substantial inequity in water distribution among different sets of water users within the whole system and tends to induce corresponding behavioral strategies to circumvent the individual disadvantages. Similarly, the inter- and intra-distributary variations in the flow, as indicated in Table 6, not only represent some gross inequity in water distribution among the secondary canals, but also show to what extent they can impact on the flow into the various watercourses.

Even more disconcerting is the observation that time durations actually allocated through practiced warabandi are not closely proportional to the size of the land. Tables 11 and 12 illustrate the extent of this problem. In an analysis of data for one watercourse given in Table 11, the variability in water allocations in terms of time per unit area is seen to be the lowest for official warabandi, whereas, the mutually agreed and actually practiced warahandi schedules show very high variability, indicated by coefficients of variation of 31 percent and 77 percent, respectively. Compounding this situation of inequity further, substantial deviations even from the mutually agreed roster schedules exist in the day-to-day practice of the warabandi method. In most of the sample watercourses, more than 50 percent of the warabandi turns deviate from the agreed schedules, and most of these deviations are of less than one hour duration. The inference is that the frequent changes in the water flow compel the water users to resort to some informal exchanges in allocated time to meet the immediate or daily field requirements. Instances of water trading are not as common as informal exchanges of water turns.

Since the days of the original design, there has been no substantial increase in water availability in the canal systems. The upstream reservoirs mostly helped to store water and reduce the seasonal fluctuations; if they contributed to any increase in farm-gate availability, it was minimal compared to the increased demand for water. However, with the advent of private tubewells, the groundwater contribution to the overall water supply of canal commands was large enough to cause a significant change in the environment of warabandi. Apart from extracting additional supplies, the water users have increasingly resorted to using groundwater mainly as a response to the daunting fluctuation of the canal water supply.

The important role of groundwater in Pakistan's irrigated agriculture is well known. Tubewell data collected in different sample command areas were analyzed to quantify the private tubewell utilization. The peak utilization of tubewell water is during kharif. For the Mananwala and Pir Mahal distributary command areas, groundwater use varied between 26 percent and 100 percent of the total water supply. For the Fordwah and Azim areas, the groundwater utilization rates were in the range of 8 percent to 100 percent of the total water supply and, overall, showed an increased use towards the tail portions of the distributary command. The conclusion is that utilization rates for private tubewells vary along the distributary canals. Table **24** highlights the important role that groundwater plays in the irrigated agriculture in different canal commands in the study area.

Table 24. Contribution of groundwater *to* irrigation supplies.

Water-course	No. of tube-	Contribution of groundwater in percentage in comparison with canal supplies					
		May	June	July	August	September	October
		Mananwala and Pir Mahal areas (LCC)					
MW 71-R		58	63	80	76	70	75
MW 121-R		34	26	100	33	35	40
PM 70-R		40	56	63	68	65	50
PM 133-L	34	64	71	70	78	73	59
		Azim and Fordwah areas					
AZ 63-L		28	16	21	46	34	31
AZ 111-L		78	71	88	100	94	97
FW 62-R	14	8	9	13	37	14	10
FW 130-R	18	12	15	45	50	38	30

While groundwater helped the farmer to have an improved reliability of water supplies, they also tended to create anomalies in the warabandi schedules concerning canal water. Deviations from the warabandi procedure in terms of water trading and exchanges of turns mostly occurred in watercourse commands with access to groundwater.

Thus, at least two of the responses to the variability in supplies have become in turn strong influences on the application of warabandi. The amendments made to official warabandi schedules on mutual agreement by the water users, though initially a natural response to the variability in supplies, have tended to exacerbate inequity. Similarly, the availability of groundwater seems to encourage the water users to disregard the discipline of warabandi.

CHANGED SOCIOECONOMIC CONDITIONS

Historically, irrigation development has always been associated with the interest, demand and involvement of groups of local people or communities. The socioeconomic status of the community invariably determined the scope and quality of managing these irrigation systems. This linkage was reduced when the British built a massive canal network on the existing sporadic, community-based irrigation works. The weakening of this linkage between local community interests and the system management efforts has two discernible contributory factors. First, at least initially in these large systems, as the demand for water was generally **less** than the supply, canal water was not immediately considered an essential ingredient for the existing systems of rural production (Wade **1982).** Second, in formalizing the original inundation canals into the new irrigation systems, the mathematical calculations for more equitable water distribution patterns superseded the old traditional water rights (*haq*), which were often based on local political power, thus offending the entrenched local elite (Gilmartin 1994). As the society was basically feudalistic, the resentment of the local elite was matched by an enthusiasm among the new settlers who preferred to accept the more formalistic agency-controlled management practices. This conflict of interest was reflected in the frequency of water-related disputes that came up for adjudication by the canal officers, whose decisions increasingly served to replace the old kachcha warabandi practices with the officially recognized pucca warabandi schedules.

After independence, it appears that this development was again reversed. With no meaningful land reform in place, the large landowners had retained considerable power. With the green-revolution measures and related technological diffusion in rural areas, a new rich class had emerged. These elements combined to form a group of "influentials" with political and economic power, who started to exert their pressure generally on the law and order situation in the canal environment. Part of the deviations observed in the official or agreed warabandi schedules is attributable to these changed socioeconomic conditions. In the present stage of warabandi operations, the rather rigid, but more equitable, official warabandi schedules have been replaced by a flexible pattern of behavior among the water users despite the increased inequity associated with it.

Two reasons are discernible for explaining the stabilization of this pattern in the actual practice of warabandi, which seems to be suboptimal in terms of its original objective of equitable water distribution. One is that the lack of enthusiasm to bring out any dispute over warabandi before the relevant authorities is matched by a bureaucratic inertia in general, which represents the ineffectiveness of agency staff to address such equity-based issues. Data in Table 11(p.49) show that most of the current official warabandi schedules had been formulated several years ago. Meanwhile, for reasons such as subdivision of land, tenancy arrangements and change of ownership, a number of informal changes have been incorporated into the application of these schedules. The informal character of these modifications has a tendency to encourage other changes that are not directly related to changes in the schedule of water users, but are linked more with their convenience and their social interrelationships. The second reason is, thus, the increasing influence of informal institutions in the rural society (like caste, biraderi, political affiliation and elitism), which tends to favor the more influential people who can also afford to resolve minor disputes informally.

MAJOR REASONS FOR DEVIATIONS FROM OFFICIAL WARABANDI

In summary, the reasons for the increasing gap between the theory and practice of warabandi can be traced to a combination of factors related to the physical and institutional environment of the warabandi system. The deterioration of essential conditions in the physical subsystem, caused by increased costs and reduced budgets along with the related lack of motivation among the agency staff, contributes substantially to the present level of supply variability. This in turn results in the flexibility of warabandi application that can be observed in the field; whereas, the noncompliance of operational rules by some water users who could use their social status and economic power becomes another major reason for deviations from the agreed procedure.

CHAPTER 7

Conclusions and Recommendations

THE MAJORITY OF watercourses in the Central Punjab are covered by an official pucca warabandi. Of the 22 sample watercourses studied in the 6 selected distributary/minor canals of the Punjab, only 2 had kachcha warabandi. However, only 5 of the watercourses had their official warabandi schedules drawn within the last 5 years, and over half of the watercourses had pucca warabandi schedules more than 10 years old. Generally, in recent years, the farmers seem to have shown an increasing tendency to modify their warabandi schedules themselves whenever the need arose, and the involvement of the Provincial Irrigation Department appears to have been minimal.

Interestingly, not a single watercourse in the study sample had its official warabandi strictly adhered to in daily water-distribution operations. Instead, all watercourses with officially recognized pucca warabandi schedules had different schedules modified according to mutual agreement among the water users. All modified rotation schedules displayed a fair degree of flexibility in their application.

There were deviations in the list of water users, the timing of water turns and the duration of water turns. Also, there were marked deviations in the day turns and night turns. The exchange of water turns was a common feature among all the watercourses studied, while the trading of water turns was observed only in a few of them. Despite the apparent mutual agreement by the water users, the practiced warabandi schedules did not relate to a high degree of equity in water distribution. In the absence of any organized water users' groups, the initiative for these unofficial modifications appears to have been taken by a few influential individuals. Although considerable inequity has crept in through this process of locally effected modification, no strong feeling can be discerned among the water users against the flexibility that has been achieved. Farmer interviews served to clarify that this phenomenon is not different from what exists in other sectors of the rural economy.

This present study was limited to exploring and describing the gap between the theory and practice of warabandi as it is applied today in canal irrigation systems of the Punjab. The scope of the study, therefore, does not allow any recommendation for major reforms related to warabandi practice. However, the study results lead towards the following suggestions:

1. Even within a flexihle system, an officially recognized warabandi should be retained, and should cover all of the watercourses, to represent the "rights" of the water users, so that in case of major disputes they can he used as a basis for arbitration or adjudication;

2. With appropriate changes in the law, regular updating of official warabandi should be made possible to make it more realistic in terms of changes in tenure, ownership, and physical location of watercourses and outlets, and the records should be made freely available to the water users;

3. To improve the operations of warabandi, the calculations of water turns should be made more scientifically, taking into account seepage losses as well as conveyance losses;

4. For warabandi to be more meaningful as a rational water management measure and an equitable distribution method, operation and maintenance should be substantially improved to ensure that the variability of the water flow in distributaries and watercourses is at a minimum; and

5. The flexibility of water use, whenever necessary and wherever feasible, can be maintained by allowing the exchange and trading of water turns among water users, on the basis of their warabandi water rights.

References

Bandaragoda, D. J. 1993. Institutional framework for irrigation: Some salient Features of the South Asian situation. Paper presented at the DSE/IIMI Workshop on Institutional Framework For Irrigation, 1–6 November 1993, Chiang Mai, Thailand.

Bandaragcda. D. J. and G. R. Firdousi. 1992. Institutional factors affecting irrigation performance in Pakistan: Research and policy priorities. IIMI Country Paper - Pakistan No.4. Colomho, Sri Lanka: International Irrigation Management Institute.

Bandaragoda, D. I. and M. Badruddin. 1992. Moving towards demand-based operations in modernized irrigation systems in Pakistan. IIMI Country Paper - Pakistan No.5, Colombo, Sri Lanka: International Irrigation Management Institute.

Bhatti, M. Akhtar and lawb W. Kijne. 1990. Irrigation allocation problems at tertiary level in Pakistan. ODI-IIMI Irrigation Management Network Paper 90/3C, London: Overseas Development Institute.

Bhutta, M. N. and E. J. Vander Velde. 1992. Equity of water distribution along secondary canals in Punjab, Pakistan. Irrigation and Drainage Systems, Vol 6: 161–177.

Caponera, Dante A. 1968. Evolution and concepts of water legislation, Annales Juris Aquarum, Proceedings of the International Association for Water Law. September 1968.

Chaudhry, Muhammad A. and Robert A. Young. 1989. Economic impacts of alternative irrigation water allocation institutions: Pakistan's warabandi system, *In* R. K. Sampath and Robert A. Young (eds.). Social, Economic and Institutional Issues in Third World Irrigation Management. Papers in Water Policy and Management, No. 15, Westview Press.

Chaudhry, Muhammad A. and Robert A. Young. 1986. Economic analysis of alternative irrigation water distribution rules in Pakistan. Mimeo.

Gilmartin, David, 1994. Scientific empire and imperial science: Colonialism and irrigation technology in the Indus Basin. The Journal of Asian Studies, **53,** No. **4** 1127–1 149.

Harza - Nespak Consultants. 1981. Mardan SCARP final project plan (Draft Report). Pakistan: Water and Power Development Authority.

Kijne, J. W. and E. J. Vander Velde. 1992. Salinity in Punjab watercourse commands and irrigation system operations. *In* Advances in IIMI's Research 1989–91, Colombo: IIMI. 1992:139–175.

Kirmani, S. S. 1990. Comprehensive water resources management: A prerequisite for progress in Pakistan's irrigated agriculture, Working Paper on Policy and Management (unpublished) presented at the Consultative Meeting on Water Sector Investment Planning, Islamabad.

Kuper, M. and J. W. Kijne. 1992. Irrigation management in the Fordwah Branch Canal command area, South East Punjab, Pakistan. Paper presented at the December 1992 IIMI Internal Program Review. Colombo, Sri Lanka: International Irrigation Management Institute.

Latif, Muhammad and Shahid Sarwar. 1994. Proposal for equitable water allocation for rotational irrigation in Pakistan, Journal of Irrigation and Drainage Systems. **8:** 35–48.

Levine, Gilbert. 1991. NWFP thoughts: The status of warabandi. An internal memo to IIMI staff issued on the basis of a consultancy mission to IIMI Pakistan in October 1991.

Levine, Gilbert and E. Walter Coward Jr. 1989. Equity considerations in the modernization of irrigation systems. ODI/IIMI Irrigation Management Network Paper 89/2b. London: Overseas Development Institute.

Lowdermilk, Max K.: David M. Freeman and Alan C. Early. 1978. Farm irrigation constraints and farmers' responses: Comprehensive field survey in Pakistan. Water Management Technical Report No. 48 (Five Volumes). Fort Collins: Colorado State University.

Lowdermilk, Max K.; Wayne Clyma and Alan C. Early. 1975. Physical and socio-economic dynamics of a watercourse in Pakistan's Punjab System constraints and farmers' responses. Water Management Technical Report No. 42. Port Collins: Colorado State University.

Makin, I. W. **1987.** Warabandi in Punjab, India. Oxfordsbire, UK: Hydraulic Research Limited, Wallingford.

Malhotra, S.P. **1982.** The warabandi and its infrastmcture. Publication No. **157,** New Delhi: Central Board of Irrigation and Power, India.

Malhotra, S. P.; S. **K.** Raheja and David Seckler. **1984.** A performance monitoring study of the warahandi system of irrigation management. ***In*** Niranjan Pant (ed.). Productivity and Equity in Irrigation Systems. Delhi: Ashish Publishing House.

Merrey, Douglas J. **1992.** Overcoming artificial institutional harriers: Linking farming systems with imgation management research. Paper prepared for presentation at the Asian Farming Systems Symposium. **2–5** November **1992.** Bandaranaike Memorial International Conference Hall, Colombo, Sri Lanka.

Merrey, Douglas J. **1990.** Warahandi in Pakistan. Chapter 28 in Management of Farm Irrigation Systems. American Society of Agriculture Engineers, St. Joseph, Michigan.

Merrey, Douglas J. **1987.** The local impact of centralized irrigation control in Pakistan: A sociocentric perspective. Chapter **17** ***In*** Peter D. Little et al. (ed.). Lands at Risk in the Third World: Local Level Perspectives. Bowder. Colorado: Westview Press.

Merrey, Douglas J. and James M. Wolf. 1986. Irrigation management in Pakistan: Four papers. IIMI Research Paper No. **4.** Colombo, Sri Lanka: International Irrigation Management Institute.

Ministry of Food and Agriculture, Government of Pakistan. 1988. Report of the National Commission on Agriculture. Pakistan.

Pakistan National Conservation Strategy. **1993.** Where we are, where we should he, and how to get there. Environment and Urban Affairs Division, Government of Pakistan.

Punjab Public Works Department Revenue Manual. **1987** (Reprint)

Qureshi, Sarfaz Khan; Zakir Hussain and Zeb-un-Niza. **1994.** An assessment of warabandi (irrigation rotation) in Pakistan: A preliminary analysis. Islamabad, Pakistan: Pakistan Institute of Development Economists.

Radosvich, George E. 1975. Water user organizations for improving irrigated agriculture: Application to Pakistan. Water Management Technical Report No. 44. Fort Collins, USA: Colorado State University.

Reidinger, Richard B. 1980. Water management by administration procedures in an Indian irrigation system. *In* Walter E. Coward (ed.). Irrigation and Agriculture Development in Asia, Cornell University Press, Ilhaca.

Singh, K. K. (ed.). 1981. Warabandi for irrigated agriculture in India. Publication No. 146. New Delhi: Central Board of Irrigation and Power. India.

Vebmeyer, Paul Willem. 1992. Irrigation management strategies at the farm level in a warabandi schedule. Unpublished M.Sc. thesis, University of Delft. the Netherlands.

Wade, Robert. 1982. The system of administration and political corruption: Canal irrigation in South India. Journal of Development Studies, 18, 287–328.

Water and Power Development Authority. 1981. Revised PC-I for the Chashma Right Bank Project. Lahore, Pakistan: Water and Power Development Authority.

Water and Power Development Authority (Pakistan). 1979. Revised action program for irrigated agriculture, Vol I. Master Planning and Review Division, Water and Power Development Authority, Lahore.

Water Sector Investment Plan Study. 1990. Water sector investment plan (1990–2000). Lahore: Federal Planning Cell.

Official Warabandi List of Watercourse 89-L of Pir Mahal Distributary

Serial no.	Name	Total area (acres)	Start time PST	End time PST	Duration of turn (hours)	Nakka 1 In	Nakka 2 Out
A	Syed Zahoor Hussain	4.64	06:00	0716	1.27	Head	2/25
B	Syed Manzoor Hussain Shah	0.09	W 1 6	07:18	0.03	2/25	3/21
C	Ameer Zaman	27.80	07:18	02:49	7.52	3/21	515
D	Shadat	27.86	m 4 9	1021	7.53	515	4/1
E	M. Saleem	27.80	1021	06:17	7.93	411	1915
F	Wali, Lal	27.77	06:17	02:12	7.92	1915	2515
G	Ali Sheir	27.81	02:12	1008	7.93	2515	2615
H	Syed Zahoor Hussain	26.55	10:08	05:45	7.62	2615	56/5
I	Barkat Ali	12.20	05:45	0803	2.30	5615	5/5
J	Shafqat Ullah	24.48	0803	03:06	1.05	515	615
K	Fateh M.	2.06	03:06	03:39	0.55	615	615
L	Syed Zahoor Hussain Shah	0.29	03:39	03:44	0.08	615	1/25
M	Shafqat Ullah	20.16	03:44	W 4 8	6.07	1/25	7/25
N	Abdul Hamid	27.81	09:48	05:19	7.52	7/25	17/5
O	Jamal, Lal	13.85	0519	09:05	3.77	1715	18/1
P	Fazal Karim	11.62	W05	12:14	3.15	18/1	18/1
Q	Najam Bakhsh	2.36	1214	1252	0.63	18/1	18/1

Continued

Official Warabandi Lisl of Watercourse 89-L of Pir Mahal Distributary (Contined)

R	Saadat Ullah	12.38	1252	04:38	3.77	1811	8/25
S	Abdul Hamid	27.81	04:38	12:09	7.52	8/25	1615
T	Ghulam Bari, etc.	64.13	1209	05:44	17.58	1W5	28/5
U	Sharif Begum	27.80	0544	01:15	7.52	28/5	2711
V	Wali Muhammad	27.76	01:15	09:10	7.92	2711	5415
W	Manzoor Hussain Shah	26.55	09:10	04:21	7.18	5415	5511
X	Ghulam, Sultan	12.25	04:21	06:27	2.10	55/1	62/5
Y	Rashida Begum	13.35	06:27	10:32	4.08	411	20/5
Z	Riaz Hussain Shah	10.04	1032	01:15	2.72	2015	21110
AA	Rasheed Begum	13.91	01:15	0526	4.18	21110	2415
AB	Kishwar Sultana	12.15	05:26	09:00	3.57	21/10	24/5
AC	Riaz Hussain Shah	25.30	09:00	16:06	7.10	21/10	2314
AD	Abdullah, etc.	5.15	16:06	1737	1.52	2314	22/20
AE	Besara S/O Nithiana	8.74	17:37	20:11	2.57	22/20	58R
AF	Pisran Besara, etc.	2.18	20:11	21:00	0.82	58R	59110
AG	Pisran Nithiana, etc.	13.04	21:00	00:34	3.57	59/10	6113
AH	Pisran Besara, etc.	1.66	00:34	01:00	0.43	61/3	60/2
AI	Besara S/O Nithiana	5.98	01:00	0255	1.92	60/2	80/5
AJ	Abdullah, etc.	15.56	0255	06:00	3.08	80/5	8111

Notes: PST = Pakistan Standard Time.
In = Nakka at which wafer turn is taken over.
Out = Nakka at which water turn is handed aver.

Official Warabandi List of 54-R Karkan Minor (Mananwala Distributary)

Water Turn Interval = 10.50 Days

Serial no.	Name	Total area (acres)	Turn duration (hours: minutes)			Start due PST		Start time PST Odd year	End time PST Odd year
1	Jamal Din, Boota, Umer Din	13.28	06:00	Head	32/17.24	06:00	12:00	18:00	00:00
2	Noor Muhammad, Bakhsh, Shahab Din	27.28	13:11	32/17.24	22/24.25	12:00	01:11	00:00	13:11
3	Ramzan, Jamal Din	27.68	11:35	22/24.25	23/25	01:11	12:46	13:11	00:46
4	Umer Din, Piran Ditta & Sons	13.4	06:03	20/25	20/12.15	12:46	18:49	00:46	06:49
5	Amir Ud Din	17.31	12:11	20/12.18	21/5	18:49	07:00	06:49	19:00
6	Umer Din, Jamal Din	27.68	12:09	21/5	21/5	07:00	19:09	19:00	07:09
7	Rehmat, Shohab & Sons, Piran Ditta	13.36	06:02	21/5	19/13.18	19:09	01:11	07:09	13:11
8	Noor Muhammad, Muhammad Bakhsh	27.92	12:50	19/13.18	[illegible]	01:11	14:01	13:11	02:01
9	Karam Din	27.24	12:05	[illegible]	12/22, 1-2	14:01	02:06	02:01	14:06
10	Sardar Ali	14.05	06:15	22/12, 1-2 12/22	12/22, 1	02:06	08:21	14:06	02:21
11	Jamal Din	[illegible]	03:16	12/23/1-2	5/25	08:21	11:37	20:21	23:37
12	Mehbob Alam	15.65	07:58	12/23/1-2	24/4-5	11:37	19:35	23:37	07:35
12/1	M. Ishaq S/O M. Tufail	10.73	04:53	24/4.5	25/1-2	19:35	00:28	07:35	12:28

Continued

Official Warabandi List of 54-R Karkan Minor (Mananwala Distributary) (Continued)

13	Sarwar Ali	**5.25**	04:45	**24/1-2**	25/16-25	**00:28**	0213	12:28	1413
14	Bashir Ahmad	20.54	0858	12-25	11/20-21	02:13	**11:11**	1413	23:11
15	Mehboob Alam S/O of Jilal Din	6.71	03:15	**11/20-21**	10121	**11:11**	1426	2311.	0226
16	Sindhir, Faqir Mohd	13.27	05:45	10/21	9125	1426	20:11	0226	08:11
17	Pir Muhammad S/O Mir Bakhsh	27.55	1220	9/25	4/25	**20:11**	08:31	0811	2031
18	Jamal Din S/O Taboo, Farzand	13.88	m 3 4	4/25	3/17-24	08:31	1505	2031	03:05
19	Nathu, Umer Din, Noor Ahmad	27.5	09:47	3/17.24	2/16-25	15:05	00:52	0305	12.52
20	Jamal Din, Rasheed Ahmad	16.91	**07:40**	Head O/L	34/12-19	00:52	**08:32**	**1252**	2032
21	Rehmat Ali	27.51	11:50	34/12.19	3511623	0832	2022	20.32	0822
22	Muhammad Shafi	27.29	1215	**Head O/L**	31125	**20:22**	08:37	0822	2037
23	Rehmat Ali	27.2	1212	3 1 N	**30/25**	08:37	2049	2037	0849
24	Special Turn of Darbar		01:15	30/25	36/34	2049	22:04	08:49	**10:04**
25	Rehmat Ali, Ali Shah	26.97	1202	36/24-25	29/24-25	**22:04**	**10:06**	**10:04**	**22:06**
26	Muhammad Niz Ali	27.54	1220	29/24-25	28/24-25	**10:06**	2226	**22:06**	10:26
27	Ali Muhammad	13.72	**06:16**	28/24-25	27/25	2226	04:42	10:26	1626
28	Muhammad Ali	13.41	06:16	27/25	27/11/12, 19/20	04:42	1058	1626	2258
29	Muhammad Ali	13.79	06:03	27/11/12, 19/20	26115, 16	**10:58**	17:01	2258	**05:01**
30	Grave Yard	00:59	17:01	**18:00**	05:01	**mod**			

Notes: In = Nakka at which water turn is taken aver.
Out = Nakka *at* which water turn is handed over

Agreed Warabandi Schedule on Watercourse 89250-L of Pir Mahal

Serial no.	Cultivator	Operated acres	Day	Start time (hours: minutes)	End time (hours: minutes)	Duration (hours)	Allocation per acre
1	Nazam	2.25	MON	06:00	06:39	0.65	0.29
2	Ramzan	2.25	MON	06:39	07:18	0.65	0.29
3	Noor S/O Lal	15.00	MON	07:18	11:48	4.50	0.30
4	Hayder	3.63	MON	11:48	12:53	1.08	0.30
5	Shah Mohd	5.63	MON	12:53	14:35	1.70	0.30
6	Umar Sajid	0.75	MON	14:35	14:49	0.23	0.31
7	Shahdat	11.50	MON	14:49	17:05	2.27	0.20
8	Ahmed Shames	5.63	MON	17:05	19:21	2.27	0.40
9	Taj	8.38	MON	19:21	21:01	1.67	0.20
10	Saeed	1.00	MON	21:01	22:21	1.33	1.33
11	Shah Mohd	6.25	MON	22:21	00:20	1.98	0.32
12	Waryam S/O Mokha	8.25	TUE	00:20	02:57	2.62	0.32
13	Ismail	3.75	TUE	02:57	04:08	1.18	0.31
14	Umar Sajid	1.88	TUE	04:08	04:44	0.60	0.32
15	Sultan S/O Trazee	1.63	TUE	04:44	05:16	0.53	0.33
16	Noor S/O Vasawa	2.00	TUE	05:16	05:54	0.63	0.32
17	Hayder	0.75	TUE	05:54	06:08	0.23	0.31
18	Noor Ul Zaman	0.50	TUE	06:08	06:17	0.15	0.30
19	Naser	11.00	TUE	06:17	09:46	3.48	0.32
20	Chrag	0.50	TUE	09:46	09:55	0.15	0.30
21	Amir S/O Fazal	0.31	TUE	09:55	10:01	0.10	0.32

Continued

Agreed Warabandi Schedule on Watercourse 89250-L of Pir Mahal (Continued)

22	Sardool	1.00	TUE	10:01	10:20	0.32	0.32
23	Noor S/O Wasawa	3.75	TUE	10:20	11:32	1.20	0.32
24	Zahoor	0.25	TUE	11:32	11:37	0.08	0.32
25	Allah Ditta S/O Mamand	4.00	TUE	11:37	12:53	1.27	0.32
26	Shah Mohd	2.75	TUE	12:53	13:45	0.87	0.32
27	Hashim S/O Bahawal	0.50	TUE	13:45	13:54	0.15	0.30
28	Aslam	1.00	TUE	13:54	14:12	0.30	0.30
29	Ghulam S/O Kabeer	3.13	TUE	14:12	15:11	0.98	0.31
30	Mamand S/O Kabeer	1.00	TUE	15:58	16:17	0.32	0.32
31	Shamand S/O Kabeer	2.63	TUE	16:17	17:07	0.83	0.32
32	Nosheer	1.50	TUE	17:07	17:35	0.47	0.31
33	Amir S/O Wahab	0.75	TUE	17:35	17:49	0.23	0.31
34	Siddique	0.75	TUE	17:49	18:03	0.23	0.31
35	Allah Ditta S/O Sultan	1.50	TUE	18:03	18:31	0.47	0.31
36	Sheer S/O Amir	0.50	TUE	18:31	18:40	0.15	0.30
37	Lal S/O Amir	0.50	TUE	18:40	18:50	0.17	0.34
38	Mamand S/O Chrag	0.25	TUE	18:50	18:55	0.08	0.32
39	Hashim S/O Bahawal	0.13	TUE	18:55	18:57	0.03	0.24
40	Shah Mohd	2.00	TUE	18:57	19:35	0.63	0.32
41	Fareed S/O Dara	0.50	TUE	19:35	19:44	0.15	0.30
42	Allah Ditta S/O Dara	0.25	TUE	19:44	19:49	0.08	0.32
43	Nawar	0.50	TUE	19:49	19:58	0.15	0.30
44	Haydar	5.50	TUE	19:58	21:43	1.75	0.32
45	Sultan	0.31	TUE	21:43	21:50	0.12	0.38
46	Umar Sajid	0.63	TUE	21:50	22:08	0.30	0.48
47	Aggra	9.00	TUE	22:08	00:59	2.85	0.32
48	Shamand S/O Kabeer	1.00	WED	00:59	01:18	0.32	0.32
49	Mamand S/O Kabeer	1.00	WED	01:18	01:37	0.32	0.32

Continued

Agreed Warabandi Schedule on Watercourse 89250-L of Pir Mahal (Continued)

50	Nawaz	0.50	WED	01:37	01:44	0.12	0.24
51	Khan S/O Badhara	1.25	WED	01:44	02:08	0.40	0.32
52	Hashim S/O Bahawal	1.75	WED	02:08	02:41	0.55	0.31
53	Khan S/O Budha	2.25	WED	02:41	03:24	0.72	0.32
54	Ghulam S/O Salih	2.00	WED	03:24	04:02	0.63	0.32
55	Allah Ditta S/O Sultan	1.75	WED	04:02	04:35	0.55	0.31
56	Haydar	1.25	WED	04:35	04:59	0.40	0.32
57	Mamand S/O Chrag	0.25	WED	04:59	05:04	0.08	0.32
58	Fareed S/O Dara	0.75	WED	05:04	05:18	0.23	0.31
59	Manzoor	0.50	WED	05:18	05:27	0.15	0.30
60	Qader	0.25	WED	05:27	05:32	0.08	0.32
61	Waryam S/O Sheer	0.75	WED	05:32	05:45	0.22	0.29
62	Rub Nawaz	3.00	WED	05:45	06:20	0.58	0.19
63	Aggra	9.00	WED	06:20	08:03	1.72	0.19
64	Noorul Zaman	0.50	WED	08:03	08:22	0.32	0.64
65	Mahmood	0.50	WED	08:22	08:40	0.30	0.60
66	Ramzan	1.00	WED	08:40	09:16	0.60	0.60
67	Mohd Afzal	20.50	WED	09:16	15:45	6.48	0.32
68	Mohd Afzal	18.00	WED	15:45	21:48	6.05	0.34
69	Ghulam Rasood	12.50	WED	21:48	01:32	3.73	0.30
70	Akbar Ali	12.50	THU	01:32	05:16	3.73	0.30
71	Nazam	4.00	THU	05:16	06:30	1.23	0.31
72	Umar Sajid	2.13	THU	06:30	07:08	0.63	0.30
73	Noor Ul Zaman	3.00	THU	07:08	08:02	0.90	0.30
74	Mohmood	2.75	THU	08:02	08:52	0.83	0.30
75	Sultan S/O Bahdar	1.75	THU	08:52	09:23	0.52	0.30
76	Hayder	7.38	THU	09:23	11:38	2.25	0.31
77	Waryam S/O Mokha	1.00	THU	11:38	11:57	0.32	0.32

Continued

Agreed Warabandi Schedule on Watercourse 89250-L of Pir Mahal (Continued)

78	Ismail S/O Bage	2.88	THU	11:57	12:52	0.92	0.32
79	Mohd Afzal	10.75	THU	12:52	16:38	3.77	0.35
80	Ghulam Rasool	12.50	THU	16:38	20:24	3.77	0.30
81	Akber Ali	12.50	FRI	20:24	00:10	3.77	0.30
82	Abdul Ghani	25.00	FRI	00:10	17:45	17.58	0.70
83	Hayder	9.50	FRI	17:45	20:36	2.85	0.30
84	Ghulam Fareed	15.50	SAT	20:36	01:15	4.65	0.30
85	Nazir	8.00	SAT	01:15	03:47	2.53	0.32
86	Mohd Sharif	4.50	SAT	03:47	05:13	1.43	0.32
87	Shamand S/O Amir	3.25	SAT	05:13	06:15	1.03	0.32
88	Kabeer Khan	2.00	SAT	06:15	06:53	0.63	0.32
89	Allah Ditta S/O Ali Mohd	1.00	SAT	06:53	07:12	0.32	0.32
90	Quadrat Ali	1.50	SAT	07:12	07:40	0.47	0.31
91	Habib Khan	1.00	SAT	07:40	07:59	0.32	0.32
92	Mir Bu	1.75	SAT	07:59	08:32	0.55	0.31
93	Mohd Ali	1.00	SAT	08:32	08:51	0.32	0.32
94	Naser S/O Amir	1.00	SAT	08:51	09:10	0.32	0.32
95	Abdul Ghani	25.00	SAT	09:10	16:20	7.17	0.29
96	Mopal	4.00	SAT	16:20	17:40	1.33	0.33
97	Ijaz Hussain	1.50	SAT	17:40	18:10	0.50	0.33
98	Alam Sheer	1.00	SAT	18:10	18:25	0.25	0.25
99	Hutum	1.00	SAT	Only Nikal,			
100	Sharif	0.50	SAT	Only Nikal,			
101	Pir Bu	4.00	SAT	Only Nikal,			
102	Shahbaz	6.00	SAT	18:25	20:27	1.97	0.33
103	Ijaz Hussain	6.00	SAT	20:27	22:29	2.03	0.34
104	Ijaz Hussain	1.00	SAT	22:29	22:48	0.32	0.32
105	Shahbaz	0.50	SAT	22:48	22:57	0.15	0.30

Continued

Agreed Warabandi Schedule on Watercourse 89250-L of Pir Mahal (Continued)

106	Noor S/O Shamand	7.00	SAT	22:57	00:45	1.80	0.26
107	Noor S/O Vasawa	1.50	SUN	00:45	01:15	0.50	0.33
108	Mukhtar S/O Salah	5.00	SUN	01:15	02:50	1.58	0.32
109	Mathail	5.00	SUN	02:50	04:25	1.58	0.32
110	Sardool	4.00	SUN	04:25	05:41	1.27	0.32
111	Chrag S/O Taj	4.00	SUN	05:41	06:57	1.27	0.32
112	Mamand S/O Lakha	1.25	SUN	06:57	07:21	0.40	0.32
113	Naik Mohd	4.00	SUN	07:21	08:37	1.27	0.32
114	Abdul Rehman	10.00	SUN	08:37	11:47	3.17	0.32
115	Fazaal S/O Whab	3.50	SUN	11:47	13:03	1.27	0.36
116	Abul S/O Wahab	6.00	SUN	13:03	14:58	1.92	0.32
117	Sheer S/O Whab	4.00	SUN	14:58	16:05	1.12	0.28
118	Naser S/O Fazaal	0.50	SUN	16:05	16:15	0.17	0.34
119	Abdul S/O Lal	2.50	SUN	16:15	17:13	0.97	0.39
120	Hamed S/O Noor	0.63	SUN	17:13	17:27	0.23	0.37
121	Mamand S/O Noor	0.63	SUN	17:27	17:41	0.23	0.37
122	Trazee S/O Noor	0.63	SUN	17:41	17:56	0.25	0.40
123	Ghulam Mohd	0.50	SUN	17:56	18:07	0.18	0.36
124	Amir S/O Usman	0.63	SUN	18:07	18:20	0.22	0.35
125	Nasir S/O Fareed	1.13	SUN	18:20	18:44	0.40	0.36
126	Ahmad S/O Chawa	0.50	SUN	18:44	18:55	0.18	0.36
127	Bashir	0.50	SUN	18:55	19:05	0.17	0.34
128	Zahoor S/O Hamed	1.13	SUN	19:05	19:29	0.40	0.36
129	Shahian	1.00	SUN	19:29	19:50	0.35	0.35
130	Haq Nawaz S/O Trazee	1.00	SUN	19:50	20:11	0.35	0.35
131	Dalmeer	0.75	SUN	20:11	20:27	0.27	0.36
132	Haq Nawaz S/O Hameed	0.75	SUN	20:27	20:43	0.27	0.36
133	Kabeer S/O Vasawa	0.63	SUN	20:43	21:02	0.32	0.51

Continued

Agreed Warabandi Schedule on Watercourse 89250-L of Pir Mahal (Continued)

134	Ghulam S/O Trazee	0.50	SUN	21:02	21:17	0.25	0.50
135	Shahian	0.50	SUN	21:17	21:33	0.27	0.54
136	Zahoor S/O Hameed	0.38	SUN	21:33	21:44	0.18	0.48
137	Shahian	1.75	SUN	21:44	22:17	0.55	0.31
138	Kabeeer S/O Vasawa	1.00	SUN	22:17	22:36	0.32	0.32
139	Ghulam S/O Vasawa	2.25	SUN	22:36	23:19	0.72	0.32
140	Bashir	0.50	SUN	23:19	23:28	0.15	0.30
141	Sheer S/O Trazee	0.50	SUN	23:28	23:37	0.15	0.30
142	Ahmed Chawa	0.50	SUN	23:37	23:47	0.17	0.34
143	Amir S/O Vasawa	1.25	SUN	23:47	00:11	0.40	0.32
144	Dalmeer	0.50	MON	00:11	00:20	0.15	0.30
145	Haq Nawaz S/O Hameed	0.50	MON	00:20	00:30	0.17	0.34
146	Haq Nawaz S/O Trazee	1.00	MON	00:30	00:49	0.32	0.32
147	Ghulam S/O Trazee	1.00	MON	00:49	01:08	0.32	0.32
148	Ghulam Mohd	0.56	MON	01:08	01:18	0.17	0.30
149	Shahian	2.00	MON	01:18	02:09	0.85	0.43
150	Ghulam S/O Vasawa	1.63	MON	02:09	02:51	0.70	0.43
151	Naser S/O Fareed	0.75	MON	02:51	03:10	0.32	0.43
152	Dalmeer	0.25	MON	03:10	03:16	0.10	0.40
153	Bashir	0.25	MON	03:16	03:23	0.12	0.48
154	Ahmed	1.00	MON	03:23	03:41	0.30	0.30
155	Bashir	1.00	MON	03:41	03:59	0.30	0.30
156	Sheer S/O Trazee	1.00	MON	03:59	04:17	0.30	0.30
157	Haq Nawaz S/O Trazee	0.50	MON	04:17	04:26	0.15	0.30
158	Zahoor	4.25	MON	04:26	05:42	1.27	0.30
159	Ghulam S/O Trazee	1.38	MON	05:42	06:00	0.30	0.22
160	Amir S/O Vasawa	0.50	MON	Only Nikal			
161	Naser S/O Fareed	2.75	MON	Only Nikal			

Continued

Agreed Warabandi Schedule on Watercourse 89250-L of Pir Mahal (Continued)

162	Kabeer S/O Vasawa	1.25	MON	Only Nikal			
163	Dalmeer	0.50	MON	Only Nikal			
164	Ghulam S/O Vasawa	0.88	MON	Only Nikal			

Actual Warabandi Schedule on Watercourse 89250-L of Pir Mahal

Observed from 07/19/1993 to 07/26/1993

Serial no.	Date	Agreed hours	Observed hours	Hours per ha
1	07/19/93	0.65	0.65	0.71
2	07/19/93	0.65	0.65	0.71
3	07/19/93	4.50	7.52	1.24
7	07/19/93	2.27	2.27	0.79
8	07/19/93	2.27	2.27	0.79
9	07/19/93	1.67	1.67	0.65
10	07/19/93	1.33	1.33	0.75
11	07/19/93	1.98	2.15	1.25
12	07/20/93	2.62	3.00	0.90
14	07/20/93	0.60	1.78	2.35
23	07/20/93	1.20	1.75	1.15
26	07/20/93	0.87	1.42	1.28
29	07/20/93	0.98	3.88	3.07
41	07/20/93	0.15	0.80	3.95
44	07/20/93	1.75	4.25	1.91
47	07/21/93	2.85	2.67	0.73
52	07/21/93	0.55	1.90	2.68
53	07/20/93	0.72	2.07	2.27
56	07/21/93	0.40	1.57	3.10
63	07/21/93	2.72	2.72	0.75
65	07/21/93	0.30	1.22	6.03

Continued

Actual Warabandi Schedule on Watercourse 89250-L of Pir Mahal (Continued)

68	07/21/93	6.05	12.53	1.72
70	07/21/93	3.73	7.47	1.48
71	07/22/93	1.23	1.23	0.76
72	07/22/93	0.63	0.63	0.73
73	07/22/93	0.90	1.42	1.17
74	07/22/93	0.83	0.83	0.75
76	07/22/93	2.25	2.57	0.86
78	07/22/93	0.92	0.92	0.79
79	07/22/93	3.77	3.77	0.87
80	07/22/93	3.77	7.53	1.49
82	07/23/93	17.58	17.58	1.74
83	07/23/93	2.85	2.85	0.74
84	07/23/93	4.65	4.65	0.74
86	07/24/93	1.42	3.95	2.17
87	07/24/93	1.03	2.22	1.69
88	07/24/93	0.63	1.73	2.14
95	07/24/93	7.17	7.17	0.71
96	07/24/93	1.33	4.00	2.47
103	07/24/93	2.03	4.53	1.87
107	07/24/93	0.50	2.38	3.92
108	07/25/93	1.58	3.17	1.57
110	07/25/93	1.27	1.27	0.78
111	07/25/93	1.27	2.93	1.81
114	07/25/93	3.17	3.17	0.78
116	07/25/93	1.92	4.47	1.84
119	07/25/93	0.97	4.47	4.42
139	07/25/93	0.72	4.92	5.40
149	07/26/93	0.85	6.13	6.30