# THE SOCIOLOGY OF *WARABANDI:* A CASE STUDY FROM PAKISTAN

Douglas J. Merrey[1]

## The Problem

This paper uses a case study to address a fundamental issue in irrigation management: the relationship between technology and the organization required to use that technology productively. When an irrigation system is developed over time by a local community, the technology and the organization evolve together. However, when engineers design and construct large scale irrigation systems, there is a tendency to concentrate on the civil works, and to assume that, at least on the local level, whatever organization is required will evolve by itself. This was the assumption of the designers of the large irrigation systems built by the British and post colonial governments in present day Pakistan and the northwestern states of India.

*Warabandi* refers specifically to the roster of turns for taking water along the watercourses of these Indian and Pakistani irrigation systems. Basically, the irrigation system delivers a constant but limited quantity of water at the head of a watercourse. Farmers then take the full supply of water for a period of time proportional to the size of their landholding, at a specific time once a week. Since the amount of water supplied is far less than required to irrigate the whole area during the week, each farmer has to adjust his cropping pattern to the expected quantity of water.

In India the warabandi system has been seen by some irrigation specialists as a panacea to severe problems on irrigation systems outside the northwestern states (Singh 1980). However, whatever the merits of the system in northern India and Pakistan, it has proven extremely difficult to implement outside of this region. Even within the region, there are few detailed studies of the actual operation of warabandi (Malhotra 1982).

The present paper contributes to filling this gap in our knowledge of warabandi. Based on detailed field work in a village in Punjab Province, Pakistan, it takes an historical perspective on how the route of a particular watercourse, and the rotations on that watercourse, have evolved over time. It demonstrates the lack of "fit" or congruence between the imposed irrigation technology and the pre-existing social organization of the village. The attempts by some water users to adapt both the route and the rotation to solve social conflicts have proven unsatisfactory.

## An Overview of Pakistan's Irrigation System

The Irrigation System. The Punjab (Pakistan) irrigation system uses barrages to divert water from the rivers into the canals. The canals are designed for continuous operation at or near full capacity. They can be closed for repairs, during floods, or to conserve water in times of shortage, but the amount of flow cannot be regulated on demand. Water flows continuously from the main canals into distributaries and through ungated concrete outlets *(mogha)* into watercourses and finally into farmers' ditches and onto the fields. As an indication of the size of the main canals, the Lower Jhelum Canal has a discharge at the head of 151 cumecs and commands 628.000 hectares. Distributaries are designed with capacities up to 5,660 liters per second (l/s). They are the lowest level channels directly controlled by the Irrigation Department. Since distributaries have gates, rotations can be instituted in times of water shortage. The moghas are ungated modular outlets designed to deliver fixed amounts of water up to 113 l/s (4 cusecs) into watercourses,

[1] Social Scientist, International Irrigation Management Institute, Digana Village via Kandy, Sri Lanka

usually at a rate of about .21 liters per second/hectare (one cusec for 350 - 400 acres).

On average, each watercourse irrigates about 225 hectares of land, usually cultivated by about 50 farmers. The route and command area of each watercourse is laid out by the Irrigation Department, and legally can be changed only with its sanction; but the building, maintenance, and management of the watercourse are the responsibility of the farmers in its command area. Each farmer has a right to water proportional to the size of his land holding.

The irrigation system was originally designed to operate with a minimum of human regulation or interference. Aside from engineering considerations the British believed that a flexible system of water distribution would lead to uncontrollable abuses. They also wished to keep construction and operational costs at a minimum since they were interested in a quick return on their investment. These considerations also underlay the minimal local intervention: farmers were expected to build and maintain their watercourses and settle disputes themselves. Under the Canal and Drainage Act of 1873, still the basic irrigation law, the Irrigation Department retains considerable residual power, but this is only rarely used upon farmers' appeal (Jahania 1973). The major irrigation method remains flooding of small basins, as originally recommended by the Irrigation Department (Trevaskis 1931:293).

Efficient continuous operation of the system requires, at the local level, that a minimum of three tasks be accomplished: regular system maintenance; water allocation; and conflict management (Coward 1980:19). Regular cleaning and maintenance of watercourses, including de-silting, removal of weeds, and repair of banks, is essential because the earthen channels deteriorate rapidly, leading to high water losses. Water flow must be rotated because the rate and volume of flow is inadequate to allow irrigation from all the outlets simultaneously. Finally, conflict over shares in maintenance work and rotation of water, and accusations of water theft are inevitable, and dictate some means to resolve disputes and insure equitable sharing of water and costs of operation. The government did not make any provision for local institutions to fulfill these tasks. Given the principles of non-interference in local affairs and minimum bureaucracy, cultivators must depend on their own cultural traditions to fulfill these tasks.

*Land Demarcation.* As part of the colonization of new land through irrigated agriculture, the Punjab government established a policy to survey all the land and lay down squares on a common base line for the whole commanded area of each canal project. At the time the Lower Jhelum Canal was being built (1897 to 1917) it was decided to compel farmers in the old villages to conform to this requirement too, as a pre-condition to receiving canal irrigation. Accordingly, during the 1905-06 settlement in Gondalpur (a pseudonym), the village where I worked, all of the land was resurveyed and field boundaries were moved to conform to a grid'pattern (Hailey 1907:1-2). This involved imposing a grid of squares *(murabah)* which, within each *mauza* (revenue village), are numbered consecutively beginning in the northwest portion. Each square is further subdivided into 25 numbered killa, as shown in the key to Map I. This process was called *killabandi,* or "rectification."[1] The corners of the squares are marked by permanent concrete posts. Although the squares are not all exactly equal in size (Hailey 1907:2), they are supposed to be approximately 11.2 hectares, so each killa is about 0.45 hectares.

Today, most people know the location of their fields by the square and killa number; and the fields do form a grid even though the actual lines have shifted somewhat with time. The grid pattern does makes resolution of disputes over land boundaries easier. The watercourses also usually follow the grid lines with official turnouts usually located on the corners of squares.

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[1] See Douie (1960 Appendix XIV) for a complete description of the process

Construction and Operation of Watercourses. Map 1 shows the square numbers and the location of the residential area, paths, the railroad line, and the three watercourses found in Gondalpur. The watercourse routes shown are the official ones, as of 1976. They are approximately, but not exactly. accurate. Farmers' ditches to carry water from the watercourse to their fields are not shown; they form an intricate pattern since nearly every killa is irrigated. The low-lying land to the east of the Miani path, and north of the Pirpur path, was more valuable than higher land before canal irrigation was introduced, since rain water could be impounded; but today it is inferior to the rest of the village land because much of it is waterlogged and/or saline.

The system was not designed to irrigate all of the land during any one season. The Lower Jhelum Canal was designed for a total cropping intensity of 75% per year. The actual sown area, however, tended to average over 95% per year (Rudkin 1911:9). Watercourses on the Lower Jhelum Canal were designed to carry an average of 28.3 l/s (1 cusec) for every 142 hectares. According to Trevaskis (1931:293) the Irrigation Department assumed 1 cusec would irrigate 0.4 hectares (1 acre) in 1 *pehr;* that is, 3 hours. "Irrigate" here is defined as covering 0.4 hectares with 7.6 centimeters of water. By this standard, a maximum of 3.2 hectares can be irrigated in one 24 hour day. and 22.7 hectares in a 7 day rotation. This would mean only 16% of the command area could be irrigated in a week, and it would take 3 weeks to irrigate 50% of the commanded area.

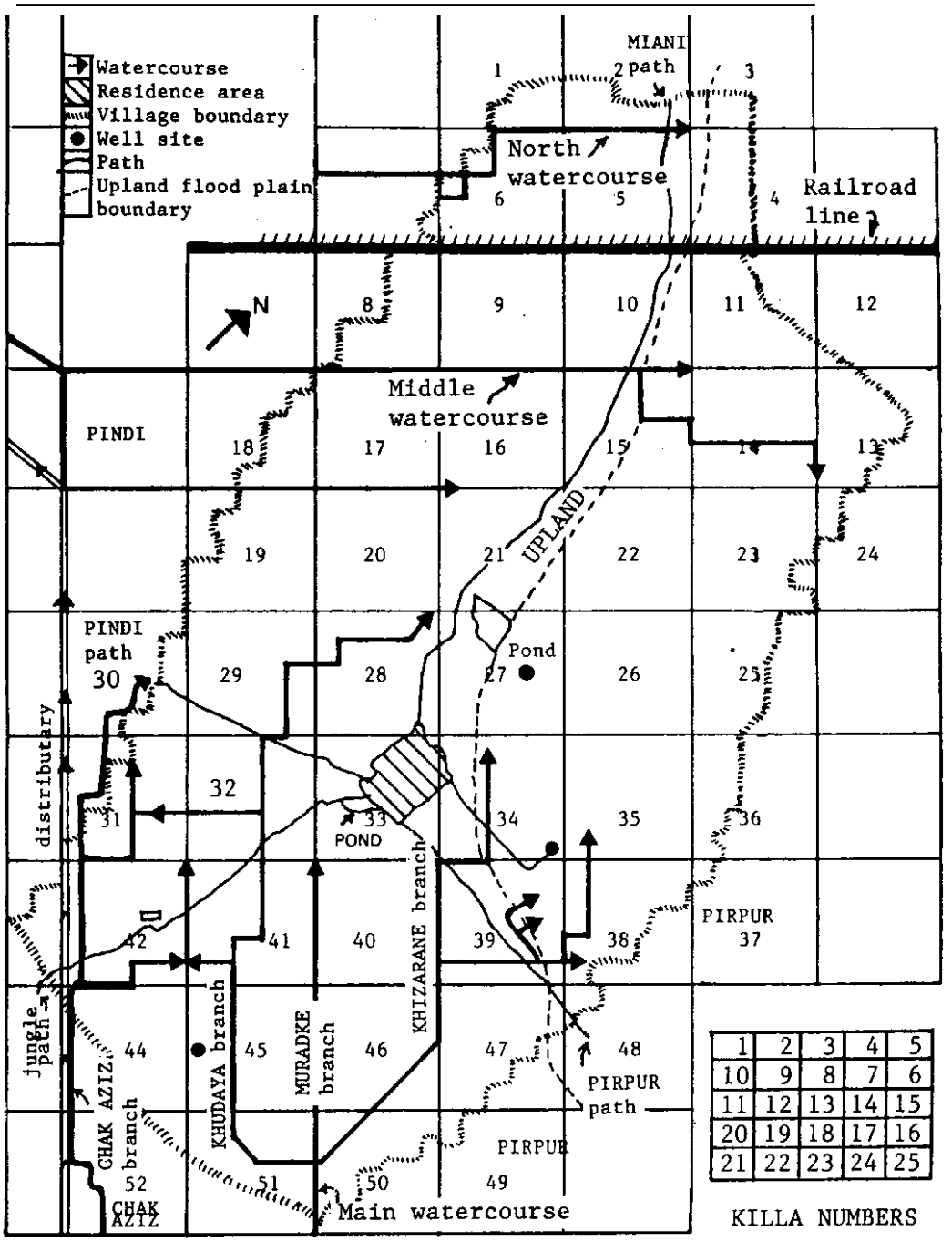
Given the high moisture deficit in the region, the shortage of water relative to area and crop water requirements necessitates a rationing system in order to distribute water widely and equitably. As every farmer on a watercourse has a right to water proportional to the size of his holding, water is rationed according to a rotation, usually of seven days. Within this period, each farmer is supposed to have sole access to the water flow during a fixed period of time. The rotation always begins with the farmers located at the head and proceeds to the tail of the watercourse.

In most cases, the farmers themselves established the first rotation. Farmer-established rotations are called *kachcha,* meaning impermanent, having no legal basis, or informal, while those established by the Irrigation Department under its own rules are called pakka, meaning solid, legal, regulated, or formal. Through the 1950s. the rotations in Gondalpur remained informal, and the rotation on the middle one is still informal in practice.

Informants say that unlike the formal rotation, the informal rotation takes into consideration local conditions such as the sandiness of soils and the height of the field relative to the ditch. Thus, a sandy or high field is awarded extra time to ensure it can be irrigated. More time is also allowed for filling long sections of the watercourse. However, an informal rotation seems to work only when there are relatively few irrigators, as in the past in Gondalpur, or where one or two irrigators have sufficient authority to enforce it. This is the case on the middle watercourse in Gondalpur, dominated by several large Pindi Village landlords who find the system advantageous.

In some cases, the one man in whose name the time is recorded has been succeeded by a number of sons and nephews; these individuals must then agree upon an informal rotation among themselves. There are several examples of this in Gondalpur. If some or all of the farmers become dissatisfied with a rotation, they can petition the Irrigation Department to set up a new one, as has happened on two of the Gondalpur watercourses.

This formal rotation is set up by the lowest Irrigation Department official on the revenue side, the canal clerk *(patwari)* and confirmed by a higher official when all the irrigators agree. It is established according to formal procedures laid down by the Irrigation Department (Jahania 1973: Appendix VIII). Basically, after allowing lead time for filling sections of the watercourse, the clerk divides the number of minutes in a seven day rotation by the total area irrigated to arrive at the number of minutes per hectare to be allowed. He then awards the amount of time to individual land owners according to the total amount of land they irrigate. The rotation on the main watercourse in Gondalpur, for example, allows 14.43 minutes per 0.4 hectares.




| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| 10 | 9 | 8 | 7 | 6 |
| 11 | 12 | 13 | 14 | 15 |
| 20 | 19 | 18 | 17 | 16 |
| 21 | 22 | 23 | 24 | 25 |

**Map 1.** Routes of Watercourses, Gondalpur, 1976. Based on 1910-11 revised settlement map and 1977 observations.

Every April 1, under Irrigation Department rules, the irrigation times shift forward and backward in alternate years, so that those who irrigate during the night one year will irrigate during the day the following year. However, the formal rotation does not allow for differences in soil or height of the field, or for losses of water due to seepage or leaking from the watercourse. This means the farmers near the tail of the branches do not get as much water per hectare as those at the head, and this difference in water supply is reflected in differences in cropping patterns and intensity and in land value.

In the Pakistani system there are no "ditch tenders," government or community officials diverting the water or overseeing the rotation; each man closes and opens outlets himself. Therefore, not surprisingly. taking water out of turn and trading water rights, though against Irrigation Department rules, are common practices.[3] I observed a number'of cases, and heard of others, in which farmers near the head opened outlets onto their land during others' turns. This often leads to disputes and arguments, but I never observed any serious fights caused by this. This is because the watercourses are long, so the irrigator may not know of the theft; and people are careful about whose water, and how much, they take.

Trading, even by people on different branches, is-also common. A man often needs more water than he is allotted one week, and less than he is allocated the next. Trading is therefore a way of making a formal rotation more flexible in practice. The Irrigation Department never takes action against trading or theft unless it receives formal complaints from the farmers. Another reason for trading water is that a farmer often has several pieces of land located on different parts of the watercourse. but all of his time is allocated at once. Time is allotted to people, not parcels of land.[4] (This is discussed further below.)

When asked how much time it takes to irrigate 0.4 hectare of land, the responses of farmers varied considerably. Generally, those near the division box of the three branches within Gondalpur (Map 1) said it takes 1.5 - 2 hours if the watercourse is clean and the tubewell running; on the middle and tail reaches the estimates ranged from 2 - 4 hours, with the same conditions. Since the rotation allows less than 15 minutes for 0.4 hectares, no one can irrigate all or even half his land in one turn, and farmers at the tail are able to irrigate only a small portion of their land.

One other notable characteristic of Gondalpur's watercourses is that all three originate in other villages controlled by relatively large and powerful landowners. The main watercourse originates on and runs along the line between Pirpur Village and Chak Aziz Village. Although there is no official outlet on the main branch leading to the division box among the three branches within Gondalpur. Pirpur and Chak Aziz landlords owning the adjacent land cut the banks and take water with impunity. The Chak Aziz branch runs through the land of three relatively powerful (and in one case ruthless) families of Chak Aziz; they too often take water out of turn, and refuse to do their share of maintenance.

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[3] Lowdermilk et al. 11978[II]:36) and Lowdermilk et al. (1975:54-56) show that trading of turns on watercourses is common.

[4] The Canal and Draingage Act provides for two procedures: outlet by outlet (nakka by *nakka*) process. and turns by holding (*rozwari*). In the former. if a man's holdings are fragmented he gets separate turns for each fragment along a watercourse (see Reidinger 1974). In the latter. time is largest fragment. The Act says that the shareholders may choose the procedure they wish to follow. See Jahania (1973:96). See also Lowdermilk et al. (1978 [II]:34-35) for a slightly different diefinition of rozawari.

The other two watercourses begin in Pindi Village, and irrigate the land of several powerful landlords who own land in both Pirpur and Gondalpur; many Gondalpur people are their tenants and clients, and depend on them for access to land as well as help with the bureaucracy. Even landowners on these watercourses are in a dependent (client) relationship with the Pindi landlords. The analysis in this paper concentrates on the main watercourse.

## The Main Watercourse in Gondalpur

Gondalpur village. Gondalpur is the pseudonym I use for a village in central Punjab where my wife and I resided and carried out research for 18 months in 1976-77. It is located on the Chaj Doab, the area between the Jhelum and Chenab Rivers. Its existence predates the first British colonial records on the village, in 1857. It grew rapidly. primarily due to immigration, during the decades before the turn of the century. Gondalpur began receiving water from the Lower Jhelum Canal in 1904, and within a few years all of the land in the village was under cultivation.

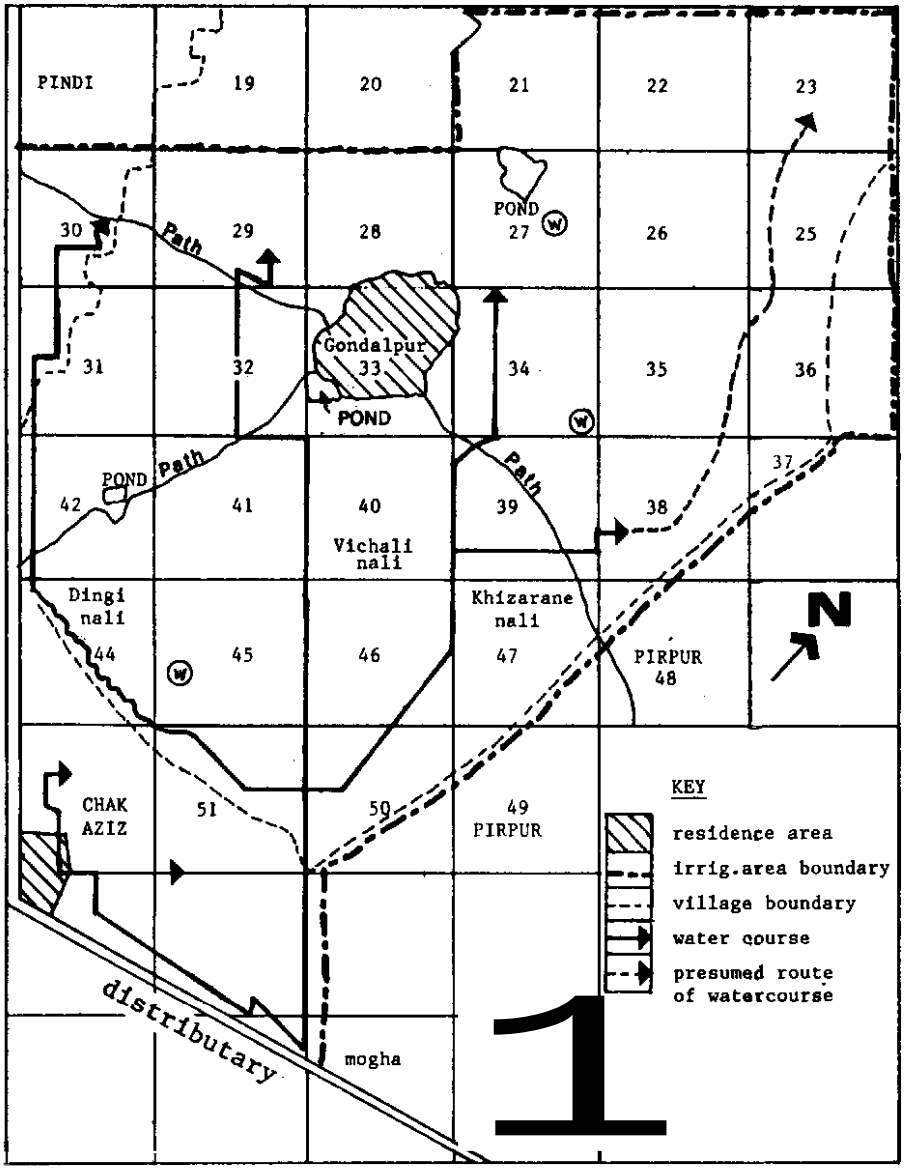
The dominant landowners, the Gondals, are divided into four named biradari, or brotherhoods, which are local co-resident groups based on a combination of patrilineal descent and marriage (Alavi 1972). The biradari members' lands tend to be concentrated on different branches of the watercourse, with some mixture. Table 1 summarizes the size and location of the lands of each biradari. Although in this paper I speak of land belonging to this or that biradari, land is registered in individuals' names, and patrilateral relatives hold residual rights. (For detailed discussions of village history and social organization, see Merrey 1982, 1983, 1986).

***Table 1.*** Biradaris on the main watercourse.[a/]

| | Number of Households | Number of People | Watercourse[b/] branch | Position on branch |
|---|---|---|---|---|
| ***Gondalpur biradaris:*** | | | | |
| Gondal-Khudaya | 11 | 70 | D; a little on B | H, M, T |
| Gondal-Khizarane | 212 | 105 | B | H, M, T |
| Gondal-Muradke | 7 | 43 | C, a linle on B | H, M, T |
| Gondal-Miane | 5 | 36 | D; a little on A | M, T |
| Langah | 5 | 36 | A | M |
| Awan | 11 | 47 | B and C[c/] | M . |
| Bhatti-Rajeaned[d/] | 18 | 78 | B (2 households) | M |
| Sayid | 3 | 25 | B | H, M |
| ***non-Gondalpur biradaris:*** | | | | |
| Kharal (Chak Aziz) | 3 | ? | A; a little on B | H |
| 3 Pindi biradaris[e/] | under 10 | ? | A & D | T on both |

Notes: Branches: A - Chak Aziz, B - Khizarane. C - Muradke. D - Khudaya, H - Head, M - Middle, T - Tail. [a/] This is not a complete list of all biradaris in Gondalpur; only those having land irrigated by the reconstructed watercour are listed. Values are based on 1977 complete household census. [b/] See Map 1. [c/] Very small holdings. [d/] Onlytwo households of this biradari have land on this watercourse. There are 7 Bhani biradaris in Gondalpur with a total of 90 households and 416 people as of 1977. [e/] These biradaris did not play an important role in the improvement project - their major holdings are on other watercourses; they generally acted together on this project.

The main watercourse, like others in Pakistan, was constructed by the farmers themselves, on a route laid out by the Irrigation Department at the time the Lower Jhelum Canal was built. The main channel, officially sanctioned by the Irrigation Department, is called the *sarkari khal,* or official watercourse. Its route cannot legally be altered without prior official approval. Map 2 shows the route of the official watercourse as it appeared until the early 1960s: there is no evidence of any changes taking place, and the official map of the SCARP tubewell[5] constructed in 1965 indicates the organization that built it, the Water and Power Development Authority (WAPDA), had not been informed of changes made at that time




Map 2. Original Route of Main Watercourse Gondalpur

[5]The Salinity Control and Reclamation Program (SCARP), implemented in stages since the early 1960s. involves the installation of large publicly managed tubewells in areas of high water table. Water is pumped into watercourses (unless it is too saline) to provide extra irrigation. Gondalpur is in the SCARP II area. See Johnson (1982) for an economic analysis of this program.

As Map 2 shows, the main watercourse has several major branches. The main branch follows the boundary between Chak Aziz and Pirpur villages to a three-way division box. The right hand (eastern side) branch was and still is called the *Khizarane nali* (Khizarane's channel), since it primarily irrigates land owned by members of the Khizarane biradari. The middle branch used to be called the *vichali nali* (center channel), and was used primarily to irrigate land owned by members of Muradke. Khudaya, and Miane biradaris. This branch still exists, but is shorter, and is now called the Muradke branch. The third branch used to be called the *utali* (high) or *dingi* (crooked) *nali*. It used to irrigate the high land owned today by a Chak Aziz village landlord, as well as land owned by the Langah biradari, and some Pindi village landlords. The other branch near the outlet irrigated the remainder of the land owned by the landlords of Chak Aziz. The routes of these two branches have been significantly altered in recent years.

Although there were apparently no changes made in the route of the official watercourse, the cultivators did add many unofficial ditches and turnouts over the years. For example, about 40 years ago, in squares 42 and **41** (Map **2).** a Langah man built a long unofficial ditch from the *dingi nali* to irrigate land officially commanded by the center branch. This ditch now links both branches. Similarly, in squares **32** and **31,** the Miane biradari people have built extra ditches so that they can bring water from either branch (*dingi nali* or center) to their fields located between the two, though their irrigation time is officially on the center branch. Further, although only one turnout per square is permitted on official channels, there has been a tremendous proliferation of locations where the channels are cut: this is true on most watercourses in Pakistan.'

The total cultivable commanded area (CCA). or potentially irrigated area, of the main watercourse is 275 hectares. This is called its *chakbandi*. Of this, **35.6** hectares are **in** Chak Aziz, near the head, while **9.9** hectares are at the tail end in Pindi. The remaining **229.5** hectares are in Gondalpur itself. However, because of waterlogging and other problems discussed below, not all of the commanded area within Gondalpur is irrigated by this watercourse. I estimate that only **150** hectares, about **55%** of the commanded area within Gondalpur is actually irrigated in most **years**.[7] In other words, of the total **275** commanded hectares **on** this watercourse, only about 200 hectares, or 70 - 75% of the total is irrigated.

Until **1961,** the rotation **on** this watercourse was an unofficial kachcha *warabandi*. There is no record available today of how this rotation worked. Informants say that if the canal water stopped for some time. the person in line for the next turn would be the first to get the water. Thus, rotations were not necessarily on fixed days. Similarly, specific data are unavailable on the level of conflict over water or on the level or effectiveness of maintenance. Informants made general statements that there used to be many quarrels, usually over rotation times (attributed to the lack of preciseness of thepehr system), and sometimes over water theft, but they insisted these did not lead to major problems and did not affect the ability of the farmers to cooperate in channel maintenance. They claim the channel was better maintained before the installation of the SCARP tubewell, as before that water was short and frequent cleaning was essential to get water.

Developments Since 1960. Conflicts within and among biradaris in Gondalpur became intense in the late **1950s.** culminating in a double murder in **1962** (Merrey **1983).** Conflicts and tensions have continued since then, and two members of the Kharal family in Chak Aziz have also been involved. All of the land owning parties in these conflicts have their major holdings on this

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[6] Lowdermilk et al. (1979[III]:26-33) found an average of 2.6 *nakka* (field turnout) cuts hectare in a survey of 40 water courses in Pakistan.

[7] Some of the non-irrigated land is waterlogged, but is cultivated with paddy once a year.

watercourse. It is not surprising that watercourse politics have become intertwined with the larger political conflicts in Gondalpur. Several other factors have had an impact on the operation of the watercourse and biradari politics.

One factor is the increase in population, leading to subdivision of land holdings, necessitating more minute subdivision of water rights. This subdivision makes it difficult to maintain an informal rotation, and has led throughout Punjab to appeals to the Irrigation Department to create official rotations. Related to this subdivision is a second factor, the purchase of land by people of other biradaris, leading to an increase in the mixture of biradaris on the watercourse. For example the Kharal of Chak Aziz village have acquired small plots of land here and there in Gondalpur; Pindi village people have bought land from some of the Khudaya involved in the 1962 murder; and in recent years two Rajeane Bhatti have bought land in several locations on the Khizarane branch. These purchases have complicated the rotation and made cooperation for maintenance more difficult to enforce.

A third factor is the intensification of cultivation, partly a result of increased population pressure and facilitated by the introduction of higher yielding varieties of crops: these are far more water-sensitive, placing a greater premium on amount and timing of irrigation water. Related to this is the fourth factor, the installation of the SCARP tubewell in 1965 which in effect doubled the water supply. Increased water supply has led to an increase in double cropping and in the area of crops requiring large amounts of water, especially rice and sugar cane (Merrey 1983). It also led to an increase in the wastage of water: as on other watercourses supplemented by public tubewells, this one was not enlarged to accommodate the enhanced flow, leading to erosion, overtopping, leaking, and washouts. Further, since there was far more water than farmers were accustomed to using, the frequency and effectiveness of watercourse cleaning declined. As the watercourse deteriorated from both these factors (lack of maintenance and water flow greater than channel capacity) the distribution of water became increasingly inequitable: farmers at the tail were probably getting half to a third of the amount available at the head by 1977 (farmers' statements; Lowdermilk et al. 1978[III]:97-99).

As on other watercourses in Gondalpur, there is a five rupee fine for non-participation in periodic cleaning; but while many do not cooperate, I could not find one example of a fine actually collected. On the branch passing through Chak Aziz village and Gondalpur to Pindi village, biradaris have assigned shares to clean based on the amount of land irrigated. This cleaning is done about twice, a year; but the head cultivators, the Kharal of Chak Aziz village, not only avoid their share but often sabotage the cleaning of others. On the other branches farmers work together beginning at the head, and stop when the section up to their individual plots are clean. With this system those near the tail do more'work; and there were many complaints that the ditches are not cleaned often or well enough.

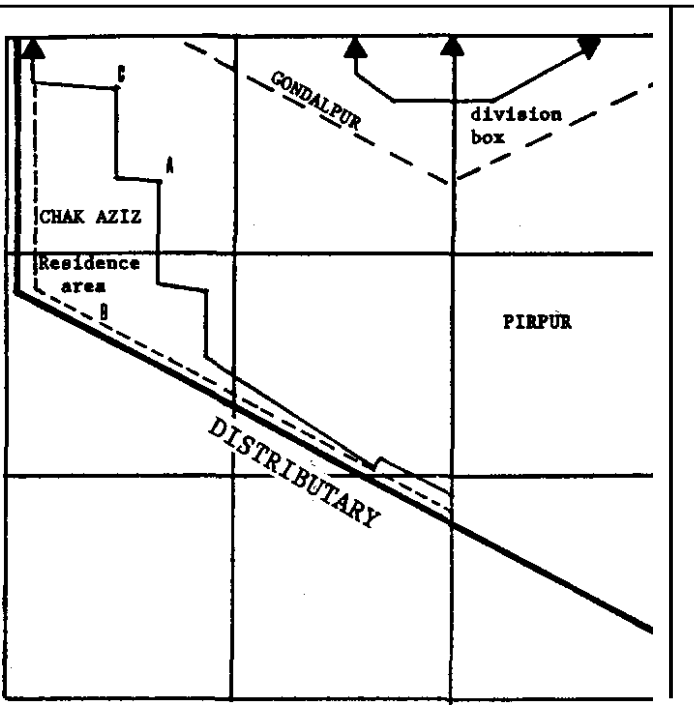
All of these factors have led to three inter-related responses on this watercourse: attempts to change the route of the official watercourse to better fit perceptions of the needs and realities of social relationships; changes in the rotation of water; and more recently, demands for government-aided watercourse rehabilitation. The route changes are also related to the attempts of some to use a favorable location on the watercourse as a political weapon.

## Route Changes

1. Chak Aziz *and dingi* branches. The unauthorized ditch built about 40 years ago by a Langah man to irrigate his land in squares 41 and 42 has been mentioned above. Informants say this route was shorter, and therefore more efficient. However, both this and the legal route pass

through land owned by the *numbardar*[8] family, a relatively powerful group within the Khudaya biradari. Several years before the 1962 murder of the previous numbardar, a Langah biradari man was suspected of having been involved in the attempt to burn him and his cousin to death (Merrey 1983). Therefore, the numbardar destroyed the sections of the Langah ditch passing through his land; for two years the Langah man got no crops as he had no water. Later the numbardar allowed it to be rebuilt when he discovered the Langah had not been involved in the plot.

Until the early 1960s. the *dingi nali* route remained as shown in Map 2. It ran though land owned by the numbardar and Fazal Kharal, of Chak Aziz village; it cut across squares and *killas*, rather than running along the ridges between the fields. Then Fazal arranged a land trade with the numbardar to consolidate his land. To facilitate cultivation of his newly consolidated land with a tractor, Fazal then convinced the other people on the branch to agree to a major change in the route. This was an extension of the previous Chak Aziz branch to replace the *dingi nali*, and runs along the ridges between squares, and then along the distributary, as shown in Map 3.




Map **3.** Changes in Route *of* Chak Aziz Watercourse Branch.

**Key**

A. Route of Watercourse branch until rehabilitation project. 1977.

**B.** Route of watercourse as built during rehabilitation project, 1977. which probably reflects the route actually sanction by the irrigation deparment in the mid-1960s.

C. Before mid-1960s this watercourse stopped here, irrigating only Chak Aziz land; it was extended from here to Gondalpur when the route was changed and the ***dingi nali*** abandoned.

[8] ***Numbardar*** (from the English word "number") refers to the village resident selected by the Government as its contact point in the village. He collects land revenue and irrigation fees from individuals, based **on** the revenue and cnal clerks' assessments. The position is normally hereditary (father to **son),** subject to Government confirmation.

The Langah biradari's land is located just downstream of Fazal's land. Langah informants say now that they made a mistake in agreeing to the change in the route, and accuse Fazal of fraud, Since Fazal's land is high, and the new route is also higher, he gets more water than before. However, he and his relatives refuse to de-silt the channel regularly because the silt helps raise the water level, facilitating irrigation to their fields. The Langah are forced to de-silt the Kharal's share as well as their own to get water--but they claim the Kharal then often refill the channel with silt again. The Langah can do little as the Kharal are far wealthier and politically more powerful.

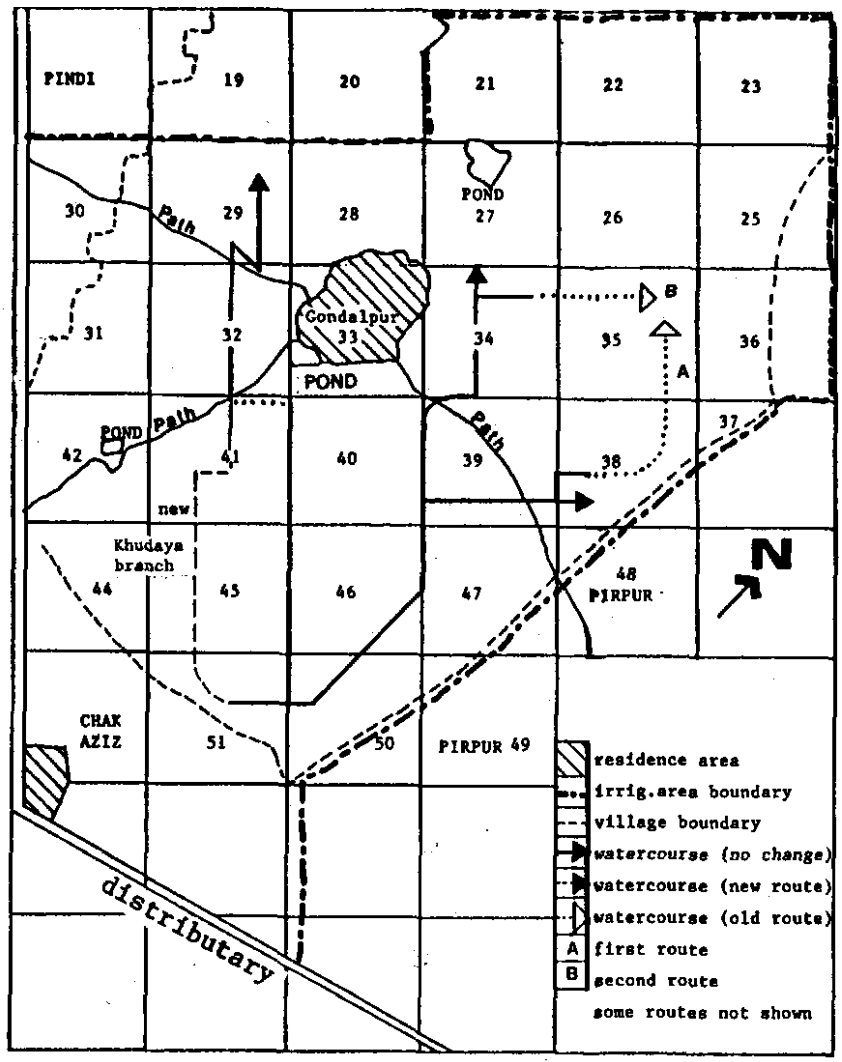
The Langah claim that Fazal got the Irrigation Department's sanction after a new ditch had been built. but instead of getting sanction for the route just constructed, he got yet another route sanctioned along the distributary, behind the residential area of Chak Aziz, and continuing downstream along the distributary. The Langah say they did not realize this change had been made when they agreed to its sanctioning; after it was authorized; they had no choice but to go along with its reconstruction again, along the distributary downstream of the Chak Aziz residential area (the section through this residential area was sanctioned but not built until the watercourse reconstruction program in 1977; Merrey 1982). The Langah probably agreed to these changes out of both powerlessness to oppose the Kharal, and faith in their kinship tie with Fazal, whose mother is a Langah. The Langah today have acute water problems, and in 1976-77 were among the most enthusiastic supporters of a proposed watercourse reconstruction program.

2. ***The Muradke and Khudaya branches.*** As is shown on Map 2, the Khudaya and Miane biradaris' land in squares 45, 41, 32, 33, 28, 29, 19-21, etc. used to be irrigated from the center (vichali) branch. Today it is shorter, and primarily irrigates Muradke land and some Awan land. The Muradke and Awan were initially accused along with the Langah in the first attempt to kill the numbardar and his cousin, though they were later exonerated. Nevertheless, several informants date the tension between the Khudaya and Muradke from that incident. The tension continued after the murder of the numbardar and his cousin (both Khudaya biradari). The new numbardar and his brothers were young and weak then, and other Khudaya feared they would get into trouble while irrigating since the water passed through Muradke land while irrigating. They also feared the Muradke would attempt to deny them water. Other informants attribute the heightened tension to the effect of the first "Union Council" election under the "Basic Democracy" system. in 1960, when a Muradke opposed a Khudaya for Gondalpur's seat (the Khudaya won).

About a year after the murder, about the time the new Chak Aziz branch was under construction. the Khudaya built a new watercourse branch, now called the Khudaya branch (see Map 4). This new branch utilizes part of the former dingi branch in square 51, and runs northwest through the land owned by the Khudaya and Miane (squares 45, 41), to link up with the old section through squares 32, 29, 28, and beyond. No survey was done, and the ditch was made the same depth throughout regardless of land height. A few years later, about 1966, the numbardar got the new route sanctioned by the Irrigation Department.

Not everyone is happy with the new route: the Miane biradari, whose land is relatively high, complain they get less water than before, while the numbardar's poor relatives at the tail say they also get less water. Nevertheless, the new route accomplished its purpose: the Khudaya now have their own channel, which they control right from the division box; they are no longer dependent on the Muradkes'good will, and no longer have to pass through their land. Perhaps as a result, the Khudaya-Muradke tension has not led to any overt conflict since the early 1960s.

3. ***The tail of the Khizarane branch.*** At its tail, the Khizarane branch is supposed to irrigate land in parts of squares 23, 25, 26, 35, and 36. The land furthest from the head of the watercourse is relatively high and sandy land, while the intervening land, parts of squares 38-39, 34-35, 26-27, and 21, are low and waterlogged. Thus the watercourse must pass through this waterlogged low land in order to reach the higher sandy land. Much of this higher land is owned by Muradke, Rajeane Bhattis, and an urban landlord. The lower land is owned by various people, including

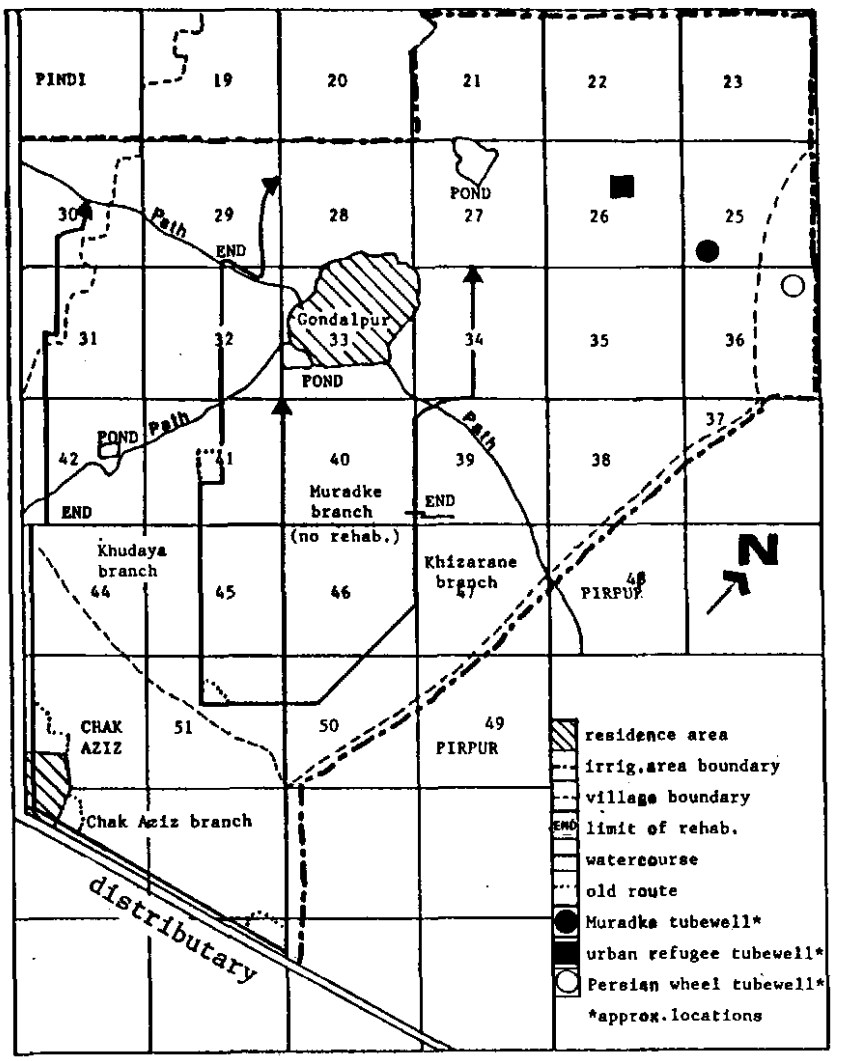



**Map 4.** Modification in Route, Khudaya/Muradke and Khizarane Branches, Gondalpur.

Khudaya, Muradke, and Khizarane, as well as the urban landlord. According to informants, originally there was a watercourse (A on Map 4) carrying water to this high land. At one time parts of this high land were very productive. However, some decades ago, perhaps in the 1920s when waterlogging in this portion of Gondalpur became severe, this channel was ruined. Two factors were responsible: on the one hand it was difficult to maintain a functioning channel through a waterlogged, sometimes flooded area (which had become uncultivable); and the sandy area itself became saline.

However, after the construction of a drain by the government north of this area in the late 1920s, the water table declined and it became possible to build a channel through the still rather waterlogged area. Through leaching of salts, some of the high sandy soil was also reclaimed. I do not know when this channel was rebuilt, but estimate it was sometime in the late 1950s. Its route was different from the previous one (B on Map 4). This land is included in the official rotations established since 1961 (see below).

During the interim, a Persian wheel well was constructed in the 1930s just beyond the village *(mauza)* boundary on Pirpur land. This irrigated some of the sandy land and is still functioning (Map 5). In addition, the urban landlord installed a diesel-powered tubewell on his sandy land about 10 - 12 years ago, and the Muradke built another one about 1974 (Map 5). In 1977, the landlord had stopped running his tubewell because his tenants refused to pay for its use, while the Muradke ran theirs occasionally, but at great expense.




**Map 5.** Main Watercourse Routes after Rehabilitation, and Modern Wells, Gondalpur, 1977

About 1974, the new watercourse channel running through the waterlogged land to this higher land (B on Map 4) was knocked down again and was still not operating in 1977. Informants gave several explanations: first, it was difficult to keep the channel in repair, as the waterlogging and periodic flooding of the land tended to obliterate it. Second, informants say it was deliberately knocked down by the Muradke so that the Rajeane Bhatti and the landlord's tenants would be forced to buy water from their tubewell (this has not happened, however). The third and major reason is the Muradke knocked it down after a dispute over a marriage with a Rajeane Bhatti man.

Summary. This section has shown how the routes of the watercourse branches have been manipulated by more powerful people to gain control over, or to punish, others on the watercourse. In only one case, the modifications in Chak Aziz village, was an economic benefit also important: the changed route enabled Fazal Kharal to better cultivate his land with a tractor, and possibly to improve his water supply. However, in the process the Langah supply was reduced, and Fazal and his relatives' power over the Langah enhanced. In the case of the Khudaya. they were able to separate themselves from having to cooperate with the Muradke, with whom relations were tense; but this was at the expense of a reduced water supply for at least some people. On the Khizarane branch, the watercourse was used by the Muradke as a weapon to hurt a person of another biradari who had slighted them, i.e., struck a blow at their honor *(izzat)*, even though their action was at their own expense as well. All of these changes in the route of the watercourse are inseparable from changes in the rotation, the subject of the next section.

## Changes in the irrigation Rotation: **1961** to **1977**

No record is available today on the informal rotation in operation on the main watercourse until late **1961.** Informants say it was broken when people who had acquired land found they did not get water,' and applied to the Irrigation Department to institute a formal rotation (*pakka warabandi*). The first formal rotation, established in late **1961,** apparently preceded most of the route changes discussed above. There is no indication in the canal clerk's register that this rotation included extra lead time for filling the watercourse, suggesting it may have been technically deficient. This rotation lasted less than five years. It had to be replaced for two reasons: its gross inequity, and the changes in watercourse routes, especially the separation of the Khudaya and Muradke branches.

One informant told me that people began complaining almost immediately after the establishment of this first formal rotation, because of its inequity. He alleged the canal clerk had been "influenced" by certain farmers. His major example was from his own biradari: several holdings which were still together in the record books as one holding were given a total of **9** hours of water, which was reduced to a more reasonable total of 2.5 hours in the next rotation. I had thought this an exaggeration, but examination of the rotations of **1961** and **1966** in the canal clerk's register confirmed this. There were other similar anomalies, but this was the most obvious one; in each case the inflation occurred by including in the rotation schedule land not actually irrigated by this watercourse.

The other factor necessitating the revision of the rotation was the construction of two new branches discussed above: the Chak Aziz branch, which was lengthened and replaced the *dingi* branch; and the creation of a new Khudaya branch separate from the Muradke channel. This new rotation was sanctioned in August **1966** and was the basis for the rotation in operation in **1977.** It includes lead time for filling the channel and extra time for citrus orchards; and it was on this rotation that the annual twelve hour shift of time was introduced: every April **1** the rotation shifts **12** hours alternately backward and forward, so that people who irrigate at night one year, irrigate during the day the following year.

This rotation has been slightly revised twice since **1966.** In March **1971,** it was changed to reflect the division of land between the numbardar family and his cousin. In August **1975.** another revision occurred when an absent Khudaya family sold a small piece of its land. Table **2** presents the revised rotation. Notes are based on observations of, and informants' statements concerning, actual practices where they differ from the official rotation.[9]

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[9] **Unfortunately, through an oversight. I failed to get detailed data on tenancy on this watercourse. Most owners are self-cultivators. Some of the landowned by the Kharal is cultivated by tenants, both Gondalpur and Chak Aziz residents. Some of the land owned by the Miane and Several Khudaya is also cultivated by Sayid and Rhani tenants in Gondalpur.** In **these cases, the internal distribution of the water is decided by the owners in consultation with his tenants.**

***Table 2.*** Current Irrigation Rotation on the "Main" Watercourse. Gondalpur.

| Branch' Owner[2] | Square[3] numbers | Area (ha) | Starting time |
|---|---|---|---|
| ***Khizarane Branch*** | | | |
| | | | ***Monday*** |
| 1. Mumtaz, Mirza, Khizarane[4] | 25, 34. 39, 46, 47. 50, 51 | 7.0 | 6:00 |
| 2. Abdul, Khirarane | 23, 25, 26, 34, 38. 46 | 2.1 | 10:39 |
| 3. Mirza, Ghulam. Khizarane | 25, 26, 32. 45, 46, 50, 51 | 3.1 | 11:35 |
| 4. Lal Shah (Pirpur) | 50 | 0.9 | 13:44 |
| 5. Nawab Shah, Sayid[5] | 24, 33, 34, 46, 49, 50 | 4.3 | 14:17 |
| 6. Khushi, Khirarane[6] | 34. 39, 46, 50 | 6.7. | 16:59 |
| 7. Raja etc., Khizarane & Sardar Machchi[7] | 23, 25, 33. 34, 39.46, 47 | 2.7 | 20:58 |
| 8. Salabat. Hayat, Sahll, Khizarane[8] | 23, 24, 25, 38, 46 | 4.3 | 22:46 |
| | | | ***Tuesday*** |
| 9. Nadar & Sardar Shah, Sayid | 46 | 3.1 | 1:18 |
| 10. Murad etc. Dhudhi (Pindi) | 47.48.49, 50. 51 | 1.5 | 3:07 |
| 11. Din & Dost, Khizarane | 33, 38, 46, 47, 50 | 4.2 | 402 |
| 12. Sher. Khizarane[9] | 25. 26, 34, 47 | 2.9 | 6:32 |
| 13. Khan, Khizarane | 34.39.40.47 | 1.8 | 8:14 |
| 14. Jahana & Rahman. Khizarane | 34.38. 39 | 2.3 | 926 |
| 15. Shabu (urban refugee) | 34, 38, 39 | 5.7 | 1046 |
| 16. Fateh (urban refugee) | 25, 26 ,33, 36, 39, 40 | 9.5 | 1409 |
| 17. Rahman. etal. Musalli | 39 | 1.0 | 19:48 |
| 18. Saghir Shah, Sayid | 40, 46, 50 | 2.7 | 2023 |
| 19. Raja, Muradke[10] | 29, 33, 40 | 1.7 | 22:00 |
| 20. Wali, Rajeane[11] | 23, 26, 34 | 6.1 | 23:00 |
| ***Khudaya Branch*** | | | |
| | | | ***Wednesday*** |
| 21 Ali, Khudaya[12] | 21, 22, 27, 34 | 7.3 | 3:02 |
| 22 Sher. Khudaya | 21, 27, 38, 34, 41 | 10.6 | 7:21 |
| 23. Baksh & Malik, Khudaya | 28, 42, 44, 45 | 1.7 | 1332 |
| 24 Baksh, Khudaya[13] | 30, 40, 42, 45 | 1.8 | 14:48 |
| 25 Akbar (nambardar). et al., Khudaya[14] | 39-42, 44, 45, 51.52 | 27.3 | 15:52 |
| | | | ***Thursday*** |
| 26. Ghulam. et al., Miane[15] | 21.29.33.40.41.42 | 13.8 | 8:39 |
| 27. Qaim, et al., Khydaya | 28.29 | 3.9 | 1705 |
| 28. Nuri, Khudaya[16] | 21.27.30.31.32.45 | 15.1 | 19:25 |
| | | | ***Friday*** |
| 29. Dost. Khudaya | 28.29 | 3.9 | 422 |
| ***Muradke Branch*** | | | |
| | | | ***Friday*** |
| 30. Sardar. Khudaya[17] | 42, 44, 45 | 4.1 | 6:22 |
| 31. Sada. Muradke[18] | 22. 26, 40, 41, 45 | 7.8 | 8:55 |
| 32. Ahmad, et al.,[19] | 22. 23.26. 32-34, 40, 41, 45 | 22.7 | 13:48 |

| Branch[1] Owner[2] | | Square[3] numbers | Area (ha) | Starting time |
|---|---|---|---|---|
| *Muradke* | | | | |
| | | | | Safurdey |
| 33. | Sher, et al., Kasise | 32. 33, 40. 41 | 0.9 | 3:17 |
| Khizarane Branch | | | | |
| 34. | Sardar. et al., Awan[20] | 25, 26, 27, 33. 34.40 | 4.5 | 4:05 |
| Chak *Aziz* Branch | | | | |
| 35. | Rahim. Fazal, Hafeez, Kharal (Chak Aziz)[21] | all the land in Chak Aziz | 35.6 | 6:26 |
| | | | | Sunday |
| | "water tank"[22] | ? | ? | 424 |
| | Rahim. et al. again[23] | 21. 22. 26-28. 33, 38, 39, 41, 42, 46, 47, 50-52 | 11.4 | 5:45 |
| 36. | Zaman, Langah[24] | 42.44 | 1.2 | 12:39 |
| 37. | Ghulam. Langah[25] | 42 | 0.5 | 13:32 |
| 38. | Lala, Khudaya | 29.44 | 1.9 | 14:01 |
| 39. | Hayat & Sardar, Langah[26] | 41, 42, 44 | 4.4 | 15:08 |
| 40. | Moulu & Hariana (Pindi) | in Pindi | 5.3 | 17:46 |
| 41. | Sahli. Randhavah[27] | 31.32 | 4.7 | 21:11 |
| | | | | Monday |
| 42. | Rehman. et al., (Pindi)[28] | in Pindi | 11.1 | 12:00 |
| | | totalirrigafed: 275.1<br>water returns *fo*Khizarane branch at *6:00* | | |

Notes Sources; Official rotation given in canal clerk's register, with notes on present practices from informants.

[1]See Map 1 for location of watercourse branches. [2]Owners' names, biradari. and village in () if not Gondalpur. [3]See Map 1 for locations of square numbers where land is located. [4]Informants include their fraternal nephew; 30 min. lead time. [5]His son now cultivates; 9 min. lead lime. [6]Mumtaz Khizarane cultivates this land on lease. [7]Raja is in Sind: his brothers cultivate; 12 min. lead time. [8]Informants say Hayat takes water at 22:35; then Sahli at 23:25; the Salabat at 00:15 Tuesday. [9]Sher, Kahn. Jahana. Raman (No. 12-14) are deceased; informants say Phule and Gula s/o Khan take water at 6:32; then Dost s/o Jahana at 8:14. Sher's sons are not mentioned but presumably taka water. 6 min. lead time in Khan's time. [10]Deceased; son Ahmad cultivates. Square 29 is not on this branch; previous rotation lists squares 26, 33, 34, 40. [11]Mostly sandy area not irrigated. Informants list this land as owned by Wali's son Anar, who cultivates. [12]Official time is on Khizarane branch, but actually used on Khudaya branch. [13]Deceased; son cultivates. [14]Includes 1.1 ha orchard, which gets extra time. 35 min. lead. Akbar deceased. [15]Deceased; sons manage land now; 15 min. lead time. [16]Nuri's land includes 1.0 ha orchard. [17]Lead time is 6 min. [18]Deceased: 2 sons now cultivate; 15 min. lead time. [19]Ahmad is deceased and succeeded by a son. Four households each take 3 hrs, and rotate who goesfirst. second. etc. weekly. [20]This land is in fact minutely subdivided. [21]Rahim, deceased, is succeeded by 2 half brothers of the other two. 48 min. lead time. [22]I know of no such tank, and informants never mentioned one. It may be a ruse for the Kharal to increase their supply. [23]Rahim's sons' (the troublemakers) araa, "enemies" with the other two, but they have an informal internal rotation. Dost Rajeane bought 2.8 ha of this land, and rented another .4 ha from 2 Kharal men. but has not yet obtained separate water for his land. Times listed are on Chak Aziz branch - but the land is on Khizarane branch. Each week Dost informally arranges for water. [24]Lead time is 11 min. [25]Lead time is 10 min. [26]Hayat is deceased, and succeeded by brother's son. All these Langah and Lala Khudaya work together and share water. [27]Sahli deceased and replaced by son. [28]Informal internal rotation.

One striking characteristic of the official rotation is that many of the holdings are still listed in the names of persons who were deceased even in 1966 when it was established. This reflects the legal position according to the records, since the rotation is based on the official record of rights. but shows people are evading the legal prescription to subdivide land when the owner dies. As a result of these demographic changes, the record does not reflect actual practice, and informal arrangements have been made among the successors for internal sharing of the water. This gap between the official rotation and social reality is a major force behind recent pressures to apply for another revision of the rotation.

Another striking feature, as noted above, is that water is allocated to people, not specific pieces of land. A comparison of the square numbers in which people hold land with the watercourse map shows that the plots belonging to one holding are widely scattered; in some cases they must even be irrigated by separate branches of the watercourse. If during one turn a man must move water from one branch to another, a great deal of water is likely to be wasted. In fact this is often done; but in addition there is also a lot of informal trading of water to adjust to the problem. Another result of this single allocation of irrigation time for scattered plots of land is that those owning land in the sandy or waterlogged areas have extra water that can be applied to their cultivable plots, This too has a consequence pointed out by several informants: it reduces the incentive for those farmers to participate in cleaning and maintenance, since they have more water than most.

The allocation of water to people instead of land also creates a problem when land is purchased. After purchasing land, it is necessary to apply to the Irrigation Department for separate time for one's land, a lengthy and somewhat expensive, process. For example, Dost Mohammad, a Rajeane Bhatti, purchased about 2.8 hectares of land from Fazal Kharal of Chak Aziz. The land is actually located in the middle of the Khizarane branch, far from Fazal's main holding. Thus. every week Mohammad must make an arrangement with Fazal to get water, including bringing it from the Chak Aziz branch to the Khizarane branch, a long distance. He has a similar problem with land he rents from another Kharal on the same branch. During the field work he was attempting to get separate rotation time, but despite paying a number of informal "fees," had not succeeded before I left.

Another important characteristic of the rotation schedule given in Table 2 is the exactness of the times allotted to begin or finish irrigating. Times are given to the minute, such as 10:39 or 1:44. This leads to frequent disagreements, since watches often do not agree, and a man's field may not be completely irrigated at the exact time when his neighbor is scheduled to take the water.

Finally, the designers of the irrigation system (and the rotations) assumed holdings in multiples of at least 5.1 hectares, the smallest original colony allotment, which entitled the holder to nearly three hours of water per week on this watercourse. Effective irrigation under the constraints imposed by the low water supply per hectare requires planning irrigation for a holding of at least this size. However, many holdings are now far smaller than reflected in the official rotation because of de facto divisions. The smallest holding listed in the official schedule is 0.5 hectare belonging to a Langah. His watercourse has a poor water supply, so that it takes about two hours to irrigate .4 hectare of land. With 19 minutes plus 10 minutes lead time to fill his irrigation ditch, a total of 29 minutes. this man could not manage within this schedule. Fortunately for him, his is a relatively cooperative biradari, so that with judicious exchanges and trading he is usually able to irrigate his crops adequately. However, it is questionable how long such a formal rotation can work, if it becomes even more detailed and subdivided, in the absence of informal cooperation, trading, and sharing.

The present rotation schedule is already losing its legitimacy, as the processes of land subdivision, land transfers, and increasing conflicts among people who had previously cooperated, continue. During the field work period, a land consolidation program and a watercourse

reconstruction program simultaneously raised hopes and led to an increase in tension, and many people expressed the opinion that it was time to break this rotation schedule and create a new one (Merrey **1982, 1983).**

## Conclusion

**In 1977** a Government research organization offered to assist in implementing a reconstruction program on the main watercourse. In this program, the Government provides engineering assistance and materials, including concrete outlet gates (pakka nakka); the farmers provide the labor. Most people reacted enthusiastically to this program, but it soon bogged down in disagreements over shares of work, and disputes with some who were attempting to sabotage the program. As reported in detail in Merrey (1982), the villagers apparently had seen this as yet another opportup ity to solve the underlying social problems, but it was not successful.

Other writings have explored various sociological problems and their historical roots in irrigation management in Pakistan (Merrey **1982, 1983, 1986).** Here I wish to note a feature of rural Pakistani social structure that has not been emphasized previously. Even after about **80** years of adapting to an imposed irrigation system, no specialized irrigation management roles have evolved separate from the larger social structure at the local level. It would not be correct to say that there is no irrigation management organization; rather, the roles and norms through which irrigation tasks are carried out are imbedded in the larger local social structure, especially the kinship-based biradari system.

However, the social structure has no legitimate cultural mechanisms to insure that irrigation functions are fulfilled, i.e., that irrigation tasks requiring cooperation with others are done. Rather, as I have shown in this paper, the irrigation system has become yet another weapon, as it were, in the conflicts endemic in rural Pakistani society.

What lessons can be drawn from this case? It is not possible to offer a simple panacea, to solve all the complex organizational problems faced in designing and managing irrigation systems. But it is clear that when an irrigation system is still at the planning and later at the design stage, it is essential to make serious use of local social data, as well as the usual technical considerations., These data must be gathered systematically by social scientists trained to understand what types of data are appropriate and necessary, to avoid overloading the designers with extraneous data.

Irrigation planners and designers cannot assume that people will adjust themselves to the technology, or by themselves evolve satisfactory solutions to what are often deeply imbedded sociological, political, and economic problems. An integral component of the design, construction, and operation processes must therefore be the development of appropriate organizational capacities so that the users can make the best use of the system. This would apply to rehabilitation and modernization projects on existing systems, as well as to new systems.

Regarding Pakistan specifically, the case reported here is not unique. For example, Mirza and Merrey **(1979;** Merrey **1982)** show that similar problems characterized all of the recently rehabilitated watercourses studied to varying degrees. The minute subdivision of land and therefore irrigation times; the absence of an indigenous local capacity to ensure cooperation on collective tasks; and the "embeddedness" of irrigation management tasks in a highly fragmented and competitive social structure are serious and deep-rooted problems not amenable to standard types of social tinkering usually recommended by social scientists.

The implication is that the continuing implementation of watercourse rehabilitation programs, even including recent efforts to organize water users associations will be problematical from a long term perspective in the absence of more fundamental changes in system design and the organization of irrigation-related tasks.

## REFERENCES


Adams. Robert McC. 1974. Historic Patterns of Mesopotamian Irrigation Agriculture. In Theodore E. Downing and McGuire Gibson (eds.). *Irrigation's Impact on Society.* Tucson, AZ: Anthropological Papers of the University of Arizona No. 26. pp1-6.

Alavi. Hamza. 1972. Kinship in West Punjab villages. *Contributions to Indian Sociology* 6:1-27.

Asian Development Bank (ADB). 1980. *Irrigation Development and Management.* Manila, Philippines: ADB pub.

Bennett, John W. 1976. *The Ecological Transition: Cultural anthropology and human adaptation.* Oxford, UK: Pergamon Press.

Bottrall, Anthony F. 1978. *Field study in Pakistan: Lower Jhelum Canal and SCARP II Circles, Sargodha District, Punjab.* World Bank Research Project No. 671/34. Report No. 7.

Bottrall, Anthony F. 1981. *Comparative Study of the Management and Organization of Irrigation Projects.* Washington, DC: World Bank staff working paper No. 458.

Campbell, J. H. 1964. *Honor, Family and Patronage.* Oxford, UK: Oxford University Press.

Clibborne, J. 1924. *Irrigation Work in India.* Uttar Pradesh, India: Roorkee University.

Clyma. W., A. Ali. and N. Ashraf. 1975a. *Irrigation Practices and Application Efficiencies in Pakistan.* Mona Colony, Bhalwal, Water and Power Development Authority.

Clyma, W., A. Ali, and N. Ashraf. 1975b. *Watercourse Losses: Annualprogress report.* Fort Collins, CO: Water Management Research Project, Colorado State University.

Corey, G. L. and W. Clyma. 1975. *Improving Farm Water Management in Pakistan.* Fort Collins, *CO:* Water Management Research Project, Colorado State University. Water Management Technical Report No. 37 (Pakistan Field Report No. 1).

Coward, E. Walter, Jr. 1980. Irrigation development: Institutional and organizational issues. In E. Walter Coward, Jr. (ed.). *Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences.* Ithaca and London: Cornell University Press. pp15-27.

Department of Water Resources (DWR). 1983. *Statewide Alpha Listing of Water Service Agencies. California,* USA. June.

Development Alternatives, Inc., (DAI). 1984. *Funding Requirements for Adequate Irrigation System Operation and Maintenance - Pakistan: Report to USAID.* Washington, DC: DAI, May.

Doherty, V.S. and N. S. Jodha. 1977. *Conditions for Group Action Among Farmers.* Hyderabad, India: International drops Research Institute for the Semi-Arid Tropics (ICRISAT), Economics Program Occasional Paper No. 19.

Douie, Sir James McC. 1960. *Punjab Settlement Manual,* 4th ed. Chandigarh: Punjab: Controller for Printing and Stationary.

Eckert, J., N. Dimick, and W. Clyma. 1975. Water Management Alternatives for Pakistan: A tentative appraisal. Fort Collins, CO: Water Management Research Project, Colorado State University. Water Management Technical Report No. 43.

Fernea, Robert A. 1970. Shaykh and Effendi: Changing patterns of authority among the El*Sha*bana of Southern *Iraq*. Cambridge, MA: Harvard University Press.

Flannery, Kent V. 1972. The cultural evolution of civilizations. Annual Review of Ecology *and Sys*tematics 3:399-426.

Foster, G. M. 1965. Peasant society and the image of the limited good. American Anthropologist 67:293-315.

Gibson, McGuire. 1974. Violation of Fallow and Engineered Disaster in Mesopotamian Civilization. In Theodore E. Downing and McGuire Gibson (eds.) Irrigation's *Impact* on Society. Tucson, AZ: Anthropological Papers of the University of Arizona No. 26. pp7-20.

Gustafson, W.E. and R. B. Reidinger. 1971. Delivery of canal water in North India and West Pakistan. Economic and Political Weekly (special issue: Review of Agriculture) 6(52):A-157-62.

Hailey, W. M. 1907. Assessment Report of the Area Commanded by the Lower Jhelum Canal in the *Shahpur* District. Lahore, Pakistan: The Civil and Military Gazette Press.

Hardin, G. 1968. The tragedy of the commons. Science 162:1234-1248.

Jacobsen, Thorkild. 1958. Salinity and irrigation agriculture in antiquity. Diyala Basin archeological project report on essential results, 1 June 1957 to 1 June 1958. Unpublished mimeo.

Jahania, Ch. M. H. 1973. The *Canal and Drainage* Act, *1873* (with Rules), 3rd ed. Lahore, Pakistan: Mansoor Book House.

Johnson, Sam H. III, A. C. Early, and M. K. Lowdermilk. 1977. Water problems in the Indus Food Machine. Water Resources Bulletin 13:1253-1268.

Johnson, Sam H., III. 1982. Large-scale irrigation and drainage schemes in Pakistan: A study of rigidities in public decision making. Food Research *Institute* Studies 18(2):149-180.

Korten, David C. and Norman Uphoff. 1981. Bureaucratic Reorientation for *Participatory* Rural Development. Washington, DC: National Association of Schools of Public Affairs and Administration Working Paper No. 1.

Lees, Susan H. 1974a. The state's use of irrigation in changing peasant society. In Theodore E. Downing and McGuire Gibson (eds.). Irrigation's Impact on Society. Tucson, AZ: Anthropological Papers of the University of Arizona No. 26. pp123-128.

Lees, Susan H. 1974b. Hydraulic development as a process of response. Human Ecology 2:159-175.

Lieftinck, P., A. R. Sadove, and T. C. Creyke. 1969. Water and Power Resources of West Pakistan - A Study in Sector Planning, (3 volumes). Baltimore, MD: John Hopkins University Press.

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 farmer's responses. Fort Collins, CO: Water Management Research Project, Colorado State University. Water Management Technical Report No **42.**

Lowdermilk, Max **K.,** David M. Freeman, and Alan C. Early. **1978.** Farm Irrigation Constraints and Farmers' Responses: Comprehensive field survey in Pakistan **(6** volumes). Fort Collins, CO: Water Management Research Project, Colorado State University. Water Management Technical Report No **48.**

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

Malik, Bashir A. **1978.** Some aspects of concept and practice of land reclamation. The Pakistani Times (Lahore Edition), October **24, 1978.**

Merrey, D. **1979.** Irrigation and Honor: Cultural impediments to the improvement of local level water management in Punjab, *Pakistan.* Fort Collins, CO: Water Management Research Project, Colorado State University, Water Management Technical Report No. **53** (Pakistan Field Report No. 9).

Merrey, D. **1980.** Problems of farmer organization in an "appropriate technology" project: Lessons from the Water Course Improvement Project in Pakistan. In New Dimensions of Appropriate Technology. Ann Arbor, MI: University of Michigan, International Association for the Advancement of Appropriate Technology in Developing Countries.

Merrey, Douglas J. **1982.** Reorganizing irrigation: Local level management in the Punjab (Pakistan). In H. **S.** Mann and B. Spooner (eds.). Desertification and Development: *Dryland* ecology in social perspective. London, U K Academic Press. pp83-109.

Merrey, Douglas J. **1983.** Irrigation, Poverty and Social Change in a Village of Pakistani Punjab: An historical and cultural ecological analysis. Ph.D. dissertation, University of Pennsylvania, Dept. of Anthropology. Ann Arbor, MI: University Microfilms.

Merrey, Douglas J. **1986.** The local impact of centralized irrigation control in Pakistan: A socientric perspective. In Peter D. Little and Michael M. Horowitz (eds.), Lands at Risk in the Third World: Local *level perspectives.* Boulder, CO: Westview Press.

Merrey, Karen. **1983.** The *Punjabi* Wedding as an Ethnosociological Model. Ph.D. dissertation, University of Pennsylvania, Department of Anthropology. Ann Arbor, MI: University Microfilms.

Michel, Aloys Arthur. **1967.** The Indus Rivers: A study of the effects of partition. New Haven, CT Yale University Press.

Mirza, Ashfaq Hussain, and Douglas J. Merrey. **1979.** Organization Problems and their Consequences on Improved Watercourses in Punjab. Fort Collins, CO: Water Management Research Project, Colorado State University. Water Management Technical Report No **55.**

Nulty, L. **1972.** The Green Revolution in West Pakistan: Implications of technological change. New York, NY: Praeger Publishers.

Olson, M. **1965.** The Logic of Collective Action - Public Goods and the Theory of Groups. Cambridge, M A Harvard University Press.

Peterson, Dean F. 1984. Pakistan USAID long-range strategy options for water resources. Unpublished paper.

Peristiany, J. G. (ed.). 1966. ***Honor and Shame.*** Chicago, IL: University of Chicago Press.

Planning Commission, Pakistan. 1978. ***The Report of the Indus Basin Research Assessment Group.*** Islamabad.

Radosevich, G. E. 1975. ***Water User Organizations for Improving Irrigated Agriculture: Applicability to Pakistan.*** Fort Collins, CO: Water Management Research Project. Colorado State University. Water Management Technical Report No. 44.

Rappaport, R. A. 1969. ***Sanctity and Adaptation.*** Paper for Wenner-Gren Foundation Symposium on the Moral and Esthetic Structures of Human Adaptation. New York, NY. (Cited in Flannery 1972).

Rappaport, R. A. 1971. The sacred in human evolution. ***Annual Review*** of ***Ecology and Systematics*** 2:23-44. (Cited in Flannery 1972).

Reidinger, R. B. 1974. Institutional rationing of canal water in Northern India: Conflict between traditional patterns and modern needs. ***Economic Development and Cultural Change*** 23:79-104.

Reuss, J. O. and W. D. Kemper. 1978. Water management affected by size of holding and cropping systems. In ***Improving Irrigation Water Management on Farms.*** Fort Collins, CO: Water Management Research Project, Colorado State University.

Reuss, J. O., G. V. Skogerboe, and D. Merrey. 1979. Watercourse improvement strategies for Pakistan. ***Water Supply and Management*** 4:409-422.

Rudkin, D. G. 1911. ***Revised Assessment Report of the Area within the Limits of the Lower Jhelum Canal in the Shahpur District*** (2 volumes). Lahore, Pakistan: Punjab Government Press.

Singh, K. K. (ed.). 1980. ***Warabandi for Irrigated Agriculture in India.*** New Delhi, India: Central Board of Irrigation and Power. Publication No 146.

Spooner, Brian. 1984. ***Ecology in Development: A rationale for three-dimensional policy.*** Tokyo, Japan: The United Nations University.

Trevaskis, Hugh Kennedy. 1931. ***The Punjab of Today*** (volume one). Lahore, Pakistan: The Civil and Military Gazette Press.

Uphoff, Norman, Ruth Meinzen-Dick. and Nancy St. Julien. 1985. Getting the process right: Farmer organization and participation in irrigation water management (draft). Ithaca, NY: Cornell University.

Water and Power Development Authority (WAPDA). 1979. Revised action programme for integrated agriculture. Master Planning and Review Division.

Water Management Research Project, 1976. ***Institutional Framework for Improved On-Farm Water Management in Pakistan.*** Fort Collins, CO: Water Management Research Project, Colorado State University.

Whitcombe, Elizabeth. 1972. The United Provinces under British rule, 1860-1900. In ***Agrarian Conditions in Northern India.*** Berkeley, CA: University of California Press. Vol. 1.

The White House-Department of Interior Panel on Waterlogging and Salinity in West Pakistan. 1964. Report on Land and Water Development in the *Indus* Plain. Washington, DC: Superintendent of Documents, US Government Printing Service.

Wittfogel, Karl A. 1957. *Oriental Despotism:* A comparative study of total power. New Haven, CT: Yale University Press.

World Bank. 1985. The World *Bank* Atlas, 1985. Washington, DC: The World Bank.