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WATER MARKETS IN THE FORDWAH/EASTERN SADIQIA AREA

An Answer to Perceived Deficiencies in Canal Water Supplies?

Pierre Strosser
and
Marcel Kuper

IIMI

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

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Information Office
International Irrigation Management Institute
P. O. Box 2075
Colombo
Sri Lanka

Contents

Figures

Tables

Abstract

THIS PAPER PRESENTS the results of a study on water markets in the Fordwah/Eastern Sadiqia Irrigation System, which is located in the southeastern portion of the Province of the Punjab, Pakistan. Based on primary data collected by IIMI-Pakistan, the study stresses and quantifies the importance of water markets in the area. The sale and purchase of groundwater pumped by private tubewells are the major activities in these markets. Other forms of water transactions are the exchange of full or partial canal water turns, the exchange of canal water for tubewell water, and the sale and purchase of canal water.

Canal water supply, seasonal variations in crop water requirements, groundwater quality and tubewell operation costs (related to the source of power) are important factors influencing the type and level of water transactions. Farm characteristics (for example, holding size and tenure status) influence the participation of farmers in water trading activities as well.

A first attempt is made to evaluate the impact of water markets on the quality of irrigation services. Via surface water and groundwater markets, the flexibility and adequacy of the irrigation water supply are improved. The purchase of groundwater enhances the equity in access to irrigation water, increasing the quantity of water supplied to non-tubewell owners who are mainly small farmers and tenants. At the same time, it makes a more efficient use of the existing tubewell capacity. Tubewell owners, however, retain the largest share of the groundwater pumped, which is translated into a higher cropping intensity and larger areas under wheat and rice. The analysis of crop yields, however, did not show any clear difference between groups of farmers characterized by different degrees of control on the irrigation water supply.

Policymakers and funding agencies are currently advocating the privatization of the water sector and the development of water markets in Pakistan. However, further research is a prerequisite to any institutionalization and further development of water markets in Pakistan, to fully understand the impact of water markets on the quality of irrigation services, agricultural production and environmental sustainability.

Introduction

WITH MORE THAN 15 million hectares (ha) annually irrigated, the Indus Basin represents one of the largest irrigation systems in the world. Built by the British during the second half of the 19th century, the system was designed to spread the scarce available water over as large an area as possible on an equitable basis. The irrigation system was not designed for flexibility in operation. A constant discharge at the main and secondary levels of the irrigation system was to be distributed proportionally to tertiary offtakes (watercourses), according to the officially commanded area.

Within the watercourse command areas, farmers receive water for a specific period of time (water turn), following a weekly or ten-day schedule referred to locally as *warabandi* (*wahr*=turn, *bandi*= fixed). With this system, each farmer's turn is roughly proportional to the area of his land (Bandaragoda and Firdousi 1992). The actual crop water requirements were not accounted for in this supply-driven distribution system, thus reducing the managerial input. A hundred years later, the main operational objectives of this vast surface water irrigation network are still directed towards an equitable and supply-based distribution of water among farmers.

At present, system reality is at variance with these policy objectives. Research undertaken by IIMI on several canals in the Punjab has highlighted two important features of the current canal water supply: inequity and unreliability. The quantity of canal water distributed decreases from the head to the tail of both secondary canals (distributaries) and watercourse commands, while the unreliability in the water supply follows the opposite pattern, increasing from the head to the tail of both the distributary and watercourse command areas (see for example Vander Velde and Kijne 1992 or Kuper and Kijne 1993). These problems are well recognized by officials and policymakers, as evidenced by motions no.75 and no. 174 presented before the Punjab Provincial Assembly in October 1992, *regarding tail shortage and depressed feelings of the farmers about the actual performance of the (irrigation) system.*

Farmers have reacted to the perceived deficiencies of the surface water irrigation system by investing in tubewells to tap groundwater resources, thus augmenting their water supply and enhancing the flexibility in their irrigation application. Conservative estimates indicate that 40 percent of the total irrigation water supply at the farm gate in Punjab is derived from private tubewell supplies (Vander Velde and Johnson 1992).

A few groups of small farmers have invested commonly in tubewells, sharing the operation and maintenance costs and managing their tubewells jointly. However, tubewells have mainly remained an attribute of larger farms (see WAPDA 1980; Johnson 1989; GOP 1991). Small farmers have been mostly involved in the use of groundwater through water transactions. Water markets, which involve an important part of the farming community (see for example Khan 1986, 1990), do not relate only to tubewell water but also to canal water, even though the Canal and Drainage Act of 1873 forbids farmers to trade their canal water turns.

Water markets in Pakistan are mentioned in several publications, but studies specifically focused on water markets in Pakistan are still rare (see Renfro and Sparling 1986; Bajwa and Ahmad 1991; Meinzen-Dick and Sullins 1993), in absolute terms as well as compared to the literature describing and analyzing water markets in other South Asian countries like India and Bangladesh (for a more comprehensive literature review, see Meinzen-Dick and Sullins 1993). Moreover, most of the studies focus only on groundwater markets and are based mainly on interviews obtained in farm surveys.

The main objectives of this paper are to describe water markets and estimate their importance in the Fordwah/Eastern Sadiqia area, and to correlate their characteristics and functioning with the main features of the irrigation system (surface water and groundwater). The impact of water markets on irrigation services and agricultural production is considered. Recommendations for policymakers as well as a methodology for further research are proposed and discussed.

Research Locale

GENERAL

THE FORDWAH/EASTERN Sadiqia Irrigation System is situated on the left bank of the Sutlej River and is confined by the Indian border in the east and by the Cholistan Desert in the Southeast (see map, Appendix I). It commands a gross area of 301,000 ha, out of which 232,000 ha are culturally commandable.

The climate is semiarid and the annual evaporation (2,400 mm) far exceeds the annual rainfall (260 mm). The area is located in the cotton-wheat agro-ecological zone of the Punjab, with cotton, rice and forage crops dominating in the *kharif* (summer season), and wheat and forage crops in the *rabi* (winter season).

The Fordwah Canal and the Eastern Sadiqia Canal both originate from the Suleimanki Headworks on the Sutlej River (see map, Appendix 1) and were developed under the Sutlej Valley Project (1932). This project was launched to increase the reliability of the water supplies, during the kharif season, to the lower areas along the Sutlej River that were already irrigated by inundation canals, and to supply water to the higher-lying lands towards the Cholistan Desert.

Low river flows in rabi limited irrigation supplies in this season to only part of the system. The area that was heretofore irrigated through inundation canals, where farmers had a right to water in kharif, was, for the largest part, labeled non-perennial (i.e., only served during kharif, from April to October). The higher lands were made perennial (with a year-round supply). Water duties for the non-perennial channels are higher (0.5 l/s/ha or 7.0 cfs/1,000 acres) than for the perennial canals (0.25 l/s/ha or 3.6 cfs/1,000 acres).

In the study area, located in the northwest of the Fordwah/Eastern Sadiqia Irrigation System, two transects were drawn going perpendicular from the Sutlej River towards the Cholistan Desert, cutting across the Fordwah, Azim and Fateh distributaries. The Fordwah and Azim distributaries both divert water from the tail of the Fordwah Branch of the Fordwah Canal, whereas the Fateh Distributary offtakes from the Malik Branch of the Eastern Sadiqia Canal. Along these three distributaries, five sample watercourses were selected, located along the transects. The main features of the three distributaries and the characteristics of the five sample watercourses are presented in Appendix II.

There are no public tubewells in this area, unlike in other parts of the Punjab. However, especially towards the river, a large number of private tubewells have been installed. The exploitation of groundwater in these command areas varies widely, influenced by the access to canal water supply, and limited by the quality of the groundwater.

The riparian tract, traditionally commanded by the inundation canals, was inhabited long before implementation of the Sutlej Valley Project. The farmers in this area, often referred to as "locals," can be categorized as having larger landholdings, a higher use of external labor and a more wheat-cotton-oriented farming system. The general perception of these locals is that they are noncooperative (see van Waijjen 1991). The command area of the Azim Distributary falls in this area. In the higher areas (the Fordwah Distributary and the Fateh Distributary), developed after the introduction of a more reliable irrigation water supply, farmers, locally known as "settlers," are usually viewed as being cooperative and more "progressive."

RESEARCH METHODOLOGY

The analysis is mainly based on a comprehensive set of primary data collected from June 1991 to June 1992 in the study area. Surface water flows were monitored by collecting daily stage readings at strategic locations in the canal distribution system from June 1991 onwards. Discharges were recorded at the main system level, at the head of the Fordwah and Azim distributaries, and at the tertiary intakes of sample watercourses. Cropping intensities and cropping patterns for the sample watercourses were obtained through crop surveys (one per season). The predominant role of tubewell water in water transactions warranted a focus on tubewell owners and their participation in water sales. A tubewell census in the 5 sample watercourses was first undertaken in 1990 and has been regularly updated since. Location, age, type of tubewell, operational status, ownership characteristics (single owner or shareholders) and other basic information were collected for all of the private tubewells. Information on tubewell operation and groundwater transactions has also been recorded since June 1991.

Sixty farmers (12 in each sample watercourse) were interviewed using a formal questionnaire during kharif 1991. The objective of this survey was to better understand the farming system and its socioeconomic environment. One section of the questionnaire focused on farmers' management of irrigation water and on water markets. Thirty tubewell owners, already monitored by IIMI for irrigation application data, formed the base of the sample. Thirty additional farmers were selected mainly within the non-tubewell owner population, according to their position along the watercourse (head, middle or tail). Out of 60 sample farmers, 41 are tubewell owners or tubewell shareholders, with direct access to groundwater for irrigation purposes. The sample has a higher percentage of tubewell owners than the average of the total farmers' population in the area. The bias introduced has to be recognized in the interpretation of the data and results presented in this paper.

Tubewell owners were specifically interviewed during rabi 1991/92 on their relation with their buyers, water prices and constraints on their water sales. Discharge measurements and analysis of the quality of the water supplied by the tubewells have complemented the tubewell data set.

The Irrigation Environment

THE FORDWAH/EASTERN Sadiqia area represents a conjunctive use irrigation environment, where canal water supplies are augmented by a range of private tubewells. The present study mainly focuses on tubewell operation and groundwater transactions, constituting the major component of water markets. However, since farmers have installed tubewells as a reaction to perceived deficiencies in canal water supplies (see Kuper and Strosser 1992), a closer look at the surface irrigation system is required to better understand the farmers' management of tubewells.

THE SURFACE IRRIGATION SYSTEM

The analysis of the surface irrigation system is focused on the distribution of canal water at the secondary and tertiary levels, as the water allocation and distribution at these levels have a direct bearing on farmers' tubewell operations. The impact of the performance of the main system on canal supplies at the distributary and watercourse levels has been reported by Essen and Feltz (1992) and Kuper and Kijne (1993).

Access of farmers in watercourses to canal water is site-specific, as it varies between distributaries and depends on the location along the distributary. In this paper, water delivery to the sample watercourses has been evaluated against the design criteria of the irrigation system.[1] The total volume of water delivered as a percentage of what was intended to be delivered is appraised in the Delivery Performance Ratio (DPR). A DPR of 100 means that the volume supplied equals the intended volume. The Coefficient of Variation (CV) is used as a proxy for the reliability of the flow. As the CV increases, the reliability decreases. The analysis was carried out separately for the kharif season and the rabi season, since the water supply to non-perennial canals (i.e., Azim) is discontinued in the rabi season. Results are presented in Table 1.

The sample watercourses in the Azim Distributary received significantly less water than those in the Fordwah and Fateh in kharif 1991. This was mainly caused by an operational preference for the Fordwah, with a DPR of 90 percent for the whole Fordwah Distributary versus only 60 percent for the Azim Distributary. At the same time, the reliability of water supplies to the Fordwah and Fateh watercourses was much greater than that to the Azim watercourses. This is evidenced by the fact that the Azim Distributary experienced 75 dry days at the tail (55% of the total number of kharif days), whereas the Fordwah had only 36 dry days (26%).

1 The design criteria—an equitable water distribution with fixed 'design' discharges for offtakes—are still considered valid by system managers. Crop water requirements, whether inter- or intra-seasonal, are not taken into account in the present system operation and it is assumed that farmers will manage available canal supplies optimally by adapting their cropping pattern. Cropping intensities, originally fixed at 70 to 80 percent, for non-perennial and perennial canals, respectively, have increased dramatically. Presently, Punjab Irrigation and Power Department (PID) data indicate intensities of 115 percent for Fordwah Division and 120 percent for Eastern Sadiqia. A comparison between these data and IIMI data for the sample watercourses suggests that actual intensities may well be even higher than the official PID data.

Table 1. Assessment of water delivery to sample watercourses—kharif 1991 and rabi 1991/1992.

Watercourse	Kharif 1991		Rabi 1991/1992	
	DPR (%)	CV (%)	DPR (%)	CV (%)
Azim 63-L	57	42	–	–
Azim 111-L	17	96	–	–
Fordwah 62-R	106	16	74	59
Fordwah 130-R	87	53	97	75
Fateh 184-R	162	31	138	44

Constraints in the water distribution at the secondary level impede the water supply to tail watercourses. Illegal irrigation, outlets with dimensions at variance with design values, and siltation (resulting in higher water levels in the first reach of distributaries) are taken to be responsible for the inequity in water distribution at the secondary level.

Fateh 184-R draws water in excess of the design discharge with a DPR of 162 percent. Farmers have succeeded in changing the dimensions of this outlet to obtain higher canal supplies, mainly to improve their cropping intensities and counter the poor groundwater quality in this command area that restricts tapping of the aquifer using tubewells. In kharif 1991, the dimensions of the outlet were changed back and forth a few times in a struggle between the PID and the farmers, thus increasing the variability of water delivery to this watercourse.

In rabi 1991/1992, only the watercourses in the Fordwah and Fateh (perennial) distributaries received water regularly. Azim 63-L received water only when the Azim was used as an escape in case of excessive discharges in the main system, and Azim 111-L did not receive any water during this rabi season. Fordwah 130-R received relatively more water in rabi 1991/1992 than Fordwah 62-R. A heavy desilting of the distributary, coupled with a large-scale remodeling of head-end outlets, ensured a higher supply to the tail, taking away water from head watercourses. Stage readings, taken by farmers at the tail of the Fordwah Distributary, show that supply to the tail was considerably better than it has been for the last 7 years. Observations from field staff indicate further that, in rabi 1991/1992, very few interventions by farmers (illegal irrigations) occurred because of a lower water scarcity, ensuring a more equitable distribution of canal water within the watercourse command area in rabi 1991/1992 than in kharif 1991.

The variability of canal supplies is generally greater in rabi. This is partly brought about by the uncertainty in supplies following the annual closure. In rabi 1991/1992, for instance, the annual closure was extended from the originally envisaged 3 weeks to a period of 7 weeks.

The existing farmer-established warabandi in the 5 sample watercourses was confirmed and made official by the Irrigation Department between 1960-1970. Ip has not been updated since, even though land has been divided among family members (typically after the demise of parents), and parts of land have been sold. Therefore, farmers frequently have 2 or even 3 different water turns in this 7-day period.

The warabandi system is perceived by the farmers to be a fair though rigid way of distributing water, with a high variation in the number of turns that cultivators actually secure. The main causes for deprivation of water turns (for which farmers are not compensated) are the large fluctuations in the water supply at the higher levels in the irrigation system. More turns were lost in the Azim watercourses than in the Fordwah ones, due to the operational preference for the latter distributary. The variation in the number of turns secured is even more pronounced within watercourse command areas. Farmers in Azim 63-L, for instance, reported losing their turn as often as 23 times during kharif 1991 (out of 26 turns), while other farmers lost their turns only 6 times.

The distance of the farm to the *mogha* (watercourse outlet) is an important factor influencing the canal water supply at the farm level. With a discharge at the mogha below a certain fraction of the design flow, conveyance losses in the watercourses prevent farmers in the middle and tail of the tertiary unit from irrigating. In the sample watercourses, the length of the main channel varies from 3 to 8 kilometers. In the case of Azim 63-L, for instance, the discharge was below 70 percent of the design discharge for almost 45 percent of the total number of days in kharif 1991.

Stealing of water at the tertiary level has not been reported as a major cause for losing water turns. Only occasional cases of water theft were reported by interviewed farmers, occurring mainly during the periods of high irrigation water demand. Differences, however, exist between watercourses, with Fordwah 130-R farmers estimating, on average, 7 cases of water theft per year whereas in Fateh 184-R, no such event has been reported by farmers.

CONJUNCTIVE USE OF GROUNDWATER AND SURFACE WATER

Farmers have reacted to these perceived deficiencies of the canal water supply by installing private tubewells and pumping groundwater, thus augmenting their irrigation water supplies. In the riparian tract along the Sutlej River, farmers traditionally have tapped groundwater for agricultural purposes, mainly by Persian Wheels. From 1960 onwards, these were replaced by mechanical pumps. The development rate of tubewells has increased dramatically over the last 10 years. Tubewell densities in the 5 sample watercourses monitored by IIMI range now from 28 tubewells per 1,000 ha of Culturable Command Area (CCA) in Fateh 184-R to 95 tubewells per 1,000 ha of CCA in Azim 63-L, depending on the quality of the groundwater, the access to canal water supplies, and the socioeconomic characteristics of the farmers.

Three different types of tubewells can be distinguished, Power-Take-Off (PTO), diesel and electric tubewells, constituting 45 percent, 38 percent and 17 percent, respectively, of the total number of tubewells in the sample watercourses. The choice of the source of power is influenced by the investment capacity of the farmers, their landholding size, and their expected utilization rate. Investment costs are relatively high for the installation of electric tubewells, for example, while their operation and maintenance costs are less than half of the expenses for diesel and PTO tubewells.

On average, tubewells in the sample watercourses were operated 620 hours for the 12-month period considered (June 1991 to May 1992), equivalent to a utilization rate of 10 percent only. Utilization rates vary tremendously, depending on the source of power and the availability of canal water. This is related to the watercourse in which the tubewell is located and the position of the tubewell along this watercourse (Kuper and Strosser 1992).

The temporal variability in the operation of tubewells is large, with different inter- and intra-seasonal crop water requirements and canal water supplies. Not surprisingly, the pumping rates of tubewells are higher in the kharif season than in the rabi season, and higher for the Azim Distributary than for the Fordwah Distributary with its more favorable water supply. Finally, tubewells located in the command areas of tail watercourses are usually utilized more than those located in the command areas of head watercourses. The contribution of groundwater to the total irrigation supply at the field level is considerable, ranging from 11 percent in Fateh 184-R to 93 percent in Azim 111-L as presented in Table 2.

Table 2. Irrigation application for sample watercourses in 1991/1992.

Watercourse	Surface water		Groundwater		Total
	mm	%	mm	%	mm
Azim 63-L	320	35	592	65	912
Azim 111-L	80	7	1,145	93	1,225
Fordwah 62-R	885	82	190	18	1,075
Fordwah 130-R	695	58	503	42	1,198
Fateh 184-R	815	89	101	11	916

Table 2 emphasizes the fact that the degree of access to canal water determines the share of groundwater in the total irrigation application with the Azim watercourses using relatively more groundwater than those of the Fordwah, and tail watercourses more than head watercourses. The relatively small share of groundwater in the irrigation application in Fateh 184-R is related to the low quality of the groundwater resources in this area.

Private tubewells have evidently augmented the quantity of irrigation water available for farmers. At the same time, they have increased the flexibility of farmers to manage their irrigation water supply at the field level, which is especially important at the vital stages of crop development.

These advantages are not restricted to the tubewell owners, but appear to be shared by other cultivators as well. All non-tubewell owners interviewed in the sample watercourses indicated that they had purchased tubewell water from other farmers, disclosing the existence of an active and extensive water market. Although this water trade mainly deals with groundwater pumped by private tubewells, canal water is also transacted. Farmers are combining canal water turns, exchanging them or even buying and selling these turns. The next section describes water markets in the 5 watercourse command areas, based on data collected in interviewing farmers.

General Characteristics of Water Markets

TYPE AND INTENSITY OF WATER TRANSACTIONS

DIFFERENT TYPES OF water transactions can be identified in this part of the Fordwah/Eastern Sadiqia Irrigation System, ranging from an informal exchange of water turns to a more market-oriented sale of tubewell water. Table 3 shows that it is mainly tubewell water that is transacted by farmers, with an average number of tubewell water sales and purchases of 9.4 and 7.2 per farmer, respectively.

Table 3. Average number of transactions per farmer in 1990/1991.

Transactions	Number of transactions per farmer
Partial canal turn exchange	4.4
Full canal turn exchange	0.4
Tubewell water for canal water	0.6
Canal water purchased	1.2
Canal water sold	0
Tubewell water purchased	7.2
Tubewell water sold	9.4

Farmers trade tubewell water more often than canal water, usually through selling and buying, while exchanges are the main type of activities involving canal water. The importance of transactions with canal water, however, is far from being negligible. On average, 15 percent of the water turns of the rigid warabandi system are transacted (various types of exchange and canal water sale) by the irrigators.

In the sample of 60 farmers, 58 participate in water markets and 43 of them are also involved in water sale and purchase stricto sensus.[2] The two farmers who do not participate in transactions are both Azim 111-L farmers (reported as less cooperative and with larger landholdings) and tubewell owners (with sufficient water supply). It is an interesting fact that only 1 farmer claimed that he was selling canal water, against 12 saying they had purchased canal water during the 2 seasons. The fear for fines for the selling of water (canal water sales are forbidden under the Canal and Drainage Act of 1873) could be a factor influencing the response of the farmers. However, the current low level of enforcement of the Act by the Provincial Irrigation Department does not support this argument very strongly.

2 Since tubewell owners are overrepresented in our sample, extrapolation of the results given in Table 2 would overestimate actual activities related to farmers for the Fordwah/Eastern Sadiqia area. At the same time, canal water trading activities may be underestimated where tubewell owners are less interested in canal water trading than non-tubewell owners.

Exchange of partial canal turns is a more common practice in the Fordwah watercourses than in the Azim and Fateh watercourses (for the average level of transaction per watercourse, see Appendix III). Tail watercourses (Fordwah 130-R and Azim 111-L) manifest a higher activity than the head watercourses, essentially due to a high level of tubewell water sales.

The Azim farmers turn out to be the most active in exchanging full canal water turns, especially those in Azim 111-L due to the higher number of tail farmers who do not receive cajal water during certain periods of the year. The same phenomenon applies for canal water purchases. Those farmers, often located at the tail of the watercourses, prefer to sell their water turns when they see (or predict) that the discharge in the distributary is too low for canal water to reach their farms. They trade the water with farmers located at the head of the watercourse who can use these small water flows in a more effective way.

Although farmers located at the tail of Fateh 184-R have a very poor canal water supply, they do not sell or exchange full canal water turns. Even small quantities of good quality canal water are of prime importance to them to leach a fraction of the salts accumulated in the soil due to the use of poor quality groundwater.

Several factors influence the intensity of groundwater markets. Farmers located in tail watercourses report a higher involvement in tubewell water sales and purchases, due to a lower canal water supply and a higher percentage of electric tubewells (with lower water prices, see next section) in these watercourses. Two electric tubewells of Fordwah 130-R were managed as commercial enterprises, being operated continuously and selling water to more than 15 farmers each. In contrast, farmers of Azim 63-L participate far less in groundwater markets, using most of the tubewell water pumped on their larger landholdings.

A further analysis of the data shows that, on average, water markets are more active during the kharif season for all types of transactions but tubewell water sales. However, differences exist between watercourses: transactions in tail watercourses are more important during the rabi season than in head watercourses. As could be expected, canal-water-related activities are less intensive in the Azim (non-perennial) than in the Fordwah (perennial) during the rabi season. But the opposite tendency is found for the kharif season. When all transactions are taken into account for the entire year (exchange, sale and purchase of canal water or tubewell water), no difference is found between the Azim watercourses (non-perennial) and the Fordwah watercourses (perennial).

Fateh 184-R has a much lower water market intensity than the 4 other sample watercourses for each of the kharif and the rabi seasons; less people participate in water transactions and participants record a lower number of activities. The relatively good canal water supply (in terms of quantity and reliability, as highlighted in the presentation of the irrigation environment) and poor groundwater quality limiting the number of tubewell water sales and purchases are probably the main causes for this situation.

It is important to note that while describing water markets, only the number of transactions and not the quantities of water sold, purchased or exchanged, have been compared so far. The degree of correlation between the intensity of the transactions and the quantity of water transacted remains to be assessed. Moreover, a larger number of watercourses should be analyzed to complement these initial results.