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IRRIGATION ALLOCATION PROBLEMS AT TERTIARY LEVEL IN PAKISTAN

M Akhtar Bhatti and Jacob W Kijne

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IRRIGATION ALLOCATION PROBLEMS AT TERTIARY LEVEL IN PAKISTAN

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1 SUMMARY

Limitations are described in the current system of allocation and distribution of canal water at watercourse level in Punjab irrigation systems. It is argued that the rigidity implicit in the warabandi system prevents farmers from managing irrigation water in an optimal way. Alternative water allocation systems should be developed because of larger water supplies, resulting from the use of pumped groundwater, and persistent inequity in water distribution going from head to tail reaches in distributary and watercourse command areas. It is proposed that a new set of rules for allocation and distribution should be flexible and take account of the water quality of pumped groundwater used for irrigation.

2 INTRODUCTION

Because of climatic conditions characterised by low rainfall and high evaporative demand, irrigation is required for most agricultural production in Pakistan. Irrigation is practiced on about 75% of the cropped area, which contributes about 90% of the nation's total agricultural production. The river Indus and its tributaries serve as source of irrigation water for around 86% of the irrigated area in Pakistan.

2.1 Irrigation System of Pakistan

The irrigation system in Pakistan (14.6 M Ha.) is the largest contiguous irrigation system in the world. It comprises the Indus and its major tributaries, 3 major storage reservoirs, 19 barrages/headworks, 43 canal commands and some 89,000 chaks (watercourse command area). The total length of canals is about 56,000 km, with watercourses, farm channels and ditches running another 1.6 million km in length. The first controlled all-year irrigation began in 1859 with completion of the Upper Bari Doab Canal from Madhopur Headworks on the Ravi River. The main objective of the early canal systems was drought protection and since then irrigation systems have been designed to fit the availability of water supplies in the river and to meet the objective of bringing to maturity the largest area of crops with the minimum consumption of water.

Land holdings in the Punjab canal colonies were laid out on a grid system of 25 acres (10 ha.) squares, whereas in the other provinces existing land holdings were of highly irregular shape, which complicated the laying out of the distribution system for irrigation water. The area served by a particular watercourse may range from 40 to 400 ha but the average is around 180 ha. Flow in the cfaak is governed by an open outlet or 'mogha' designed to pass a discharge that self-adjusts in proportion to flow in the parent canal. Design discharges from moghas vary from less than 30 to 120 l/s (1 to 4 cusecs) to enable efficient handling by individual farmers.

Extensive developments in the Indus basin over the last century and lack of appropriate drainage facilities have caused severe waterlogging and salinity problems in large areas of Punjab and Sindh provinces. Public tubewells were first introduced in the 1940s to address these problems, and the first large scale Salinity Control and Reclamation Project (SCARP) with 30 to 150 litres per second capacity tubewells was completed in 1963. The large-scale development of groundwater by the private tubewells started soon after the initiation of the SCARP program. The most recent estimate (1984-85) of groundwater contribution is about 40.66 million acre feet annually.

2.2 Existing System of Irrigation Water Allocation

The rules that serve the irrigation water allocation were developed by the British over a century ago. Under these rules the Irrigation Department delivers a specific amount of water based on a predetermined 'water allowance' and on the size of the cultureable command area of the watercourse. The outlets ('moghas') are constructed such that each watercourse draws its allotted share of water from the distributary simultaneously, when the discharge in the distributary is at design level and the hydraulic design of the channel is maintained.

The present water allocation system within chaks is known as 'warabandi' (wara means turn and bandi fixation). The warabandi is basically a continuous rotation system in which one complete cycle of rotation usually lasts seven days, i.e. each farm receives its water once a week. The duration of the turn is in proportion to the size of the farmer's holdings. During his turn, he is entitled to all the water flowing in the watercourse. Each year the warabandi schedule is rotated by twelve hours to give relief to the farmers who had to irrigate at night under the previous schedule. The water from the public tubewells is also shared according to the warabandi.

There are two types of warabandi system being practiced currently. Under the 'pacca' (official) warabandi system, a weekly rotation is fixed by the canal officer for each farmer at the joint request and by agreement of the cultivators. This becomes binding on all shareholders and cannot thereafter be altered. Under the 'kacha' (temporary) warabandi system, the turns for each farmer are agreed upon by all shareholders and the Irrigation Department does not interfere unless a complaint is lodged. The two systems have been explained in detail by Nasir (1981) and Malhotra (1982).

2.3 Merits and De-Merits of Warabandi System

The main operational objective of the warabandi system is to achieve both high efficiency of water use by imposing water scarcity on every user and social equity through ensured irrigation for many rather than intensive irrigation for a few. According to Malhotra et al (1984), the first and most important single thing to appreciate about the warabandi system is that it is a system of imposed water scarcity. For anyone at all familiar with the social tension and conflict created by scarce irrigation water in these areas, the fact that warabandi has been able to impose such extreme scarcity, over such large areas, for such a long time is little short of miraculous.

The pacca warabandi system has been successful in reducing the opportunities for disputes and conflicts among the farmers as water turns are fixed officially keeping in view the benefits for the community as a whole. The system tends to be self-policing, because the next in turn is waiting and ready to take his turn (Chaudhry, 1986). On the contrary, the kacha warabandi system is considered unsatisfactory because it often leads to disputes among farmers, particularly during periods of peak demands and shortages. Changes from kacha to pacca warabandi in the Punjab are said to have occurred mainly because of concerns for ensuring equitable water supplies to all farmers.

A major disadvantage of the pacca warabandi system, however, is that the volume of water available to a farmer is independent of the stage of a crop growth and he is forced to either take his turn (whether needed or not), or to forego it. This means that the system not only leads to wastage of water but sometimes even results in low crop yields due to over-irrigation. Compensation cannot be obtained from the Irrigation Department nor from other water users for turns one has not received because of lack of water in the distributary (e.g. due to frequent breaches, cuts, etc, necessitating closure of the distributary for repairs). Renfro

(1982) also observed that rigidity of the supply schedule under this system causes periodic shortages and at other times an excess of water supply.

Contrary to this, the kacha warabandi system is more flexible in accommodating the common interests of all farmers. It also ensures that no one suffers from the unplanned and undesired closures as the warabandi turn restarts from the user where it terminated when the lack of water occurred. The warabandi system is too rigid for supplying water according to the current understanding of crop water requirements and for the present levels of water supply. The reliability in supply, both with respect to the timing and its amount, is insufficient (Reidinger, 1971). Gustafson and Reidinger (1971) have proposed that water trading (selling and lending) should be legalised as they observed that farmers who trade water were on average more productive than those who did not.

In addition, Renfro (1982) has pointed out that the pacca warabandi system allows farmers to supplement canal water with tubewell water only if either they have an uninterrupted right to the total flow in the watercourse or when the stretch of watercourse between the outlet to their fields and the tubewell is unused and empty of another farmer's water. Thus rigidity of the system affects the economics of private tubewell installation because of fewer potential users and purchasers of tubewell water. Maass and Anderson (1978) have mentioned that in some parts of the world, e.g. USA and Spain, water rights are actively traded or sold. Their simulation analysis showed substantially higher returns from a distribution system with active cash transactions in water rights than from more rigid systems, including rotational ones similar to the warabandi system.

It is suggested that the rigidity implicit in the warabandi system prevents farmers from maximising private and social net benefits from scarce water. Inflexible allocation of water has serious consequences, especially when new water supplies show high marginal development costs. Moreover, it has been found that equity of distribution cannot be attained along a watercourse by applying water for an equal length of time per unit of land for all farms regardless of their location along the watercourse. Conveyance losses from the watercourse result in smaller supplies per unit of time in tail than in head reaches of the watercourse command area. However, farmers pay an equal amount per acre cultivated with a specific crop, although downstream farmers may receive 20% to 30% less water than those in the head reach, with lower yields for similar cropped areas.

3 FIELD INVESTIGATIONS

Since 1987, IIMI Pakistan has carried out research activities focused on the secondary level (distributary) of canal irrigation systems in Punjab. Several distributaries representing head (Lagar & Manawala) and tail (Pir Mahal & Khikhi) portions of the Gugera Branch of the Lower Chenab Canal were selected for detailed field investigations in collaboration with the Irrigation Department. Early results indicated low reliability of water supply from canals and public tubewells. Therefore, during 1989, a random sample of 89 farms was selected in the command areas of the selected distributaries in Farooqabad sub-division (head) and Bhagat sub-division (tail) to assess the effects of current distribution practices (warabandi system) on water availability at tertiary level during Kharif (summer cropping season). A second sample of 96 farms was studied during Rabi (winter cropping season) 1989-90.

Data collection included the duration of canal turns (sanctioned time and discharge) and the number of turns actually received during the season. Observations on trading of water turns among the sample farmers were also recorded.

4 RESULTS AND DISCUSSION

41 Duration of Canal Turns

Figures 1 present histograms of actual durations of canal turns for 89 sample farms during the Kharif season 1989. About 31% of the sample farms received canal supplies during a period equal to or less than 2.25 hours per week. Irrigation water available for such a short duration simply cannot be managed efficiently considering the distribution network at the tertiary level and surface irrigation practices employed at the farm.

An almost similar pattern was observed in case of the 96 sample farms where detailed investigations were carried out during Rabi 1989-90 (Figure 2). For about 36% of the sample farms, the weekly turn of the canal supply lasted 2.25 hours or less.

Because of the socio-economic environment, major changes have occurred in farm size. A comparison of 1972 and 1980 Agricultural Census data revealed that the number of small farms of less than 2 ha increased from 28% of the total in 1972 to 34% in 1980. Expressed as a fraction of the total cultivated land, the area cropped at small farms also increased. The share of medium and large farms in the total number of farms decreased concurrently. The decrease in farm size affects directly the water rights

FIGURE 1 : DURATION OF CANAL TURNS
89 SAMPLE FARMS (GUGERA CANAL)

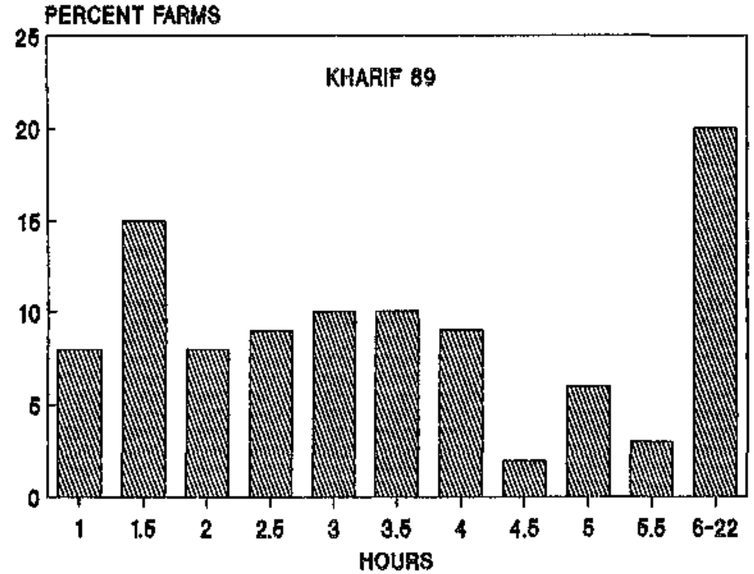
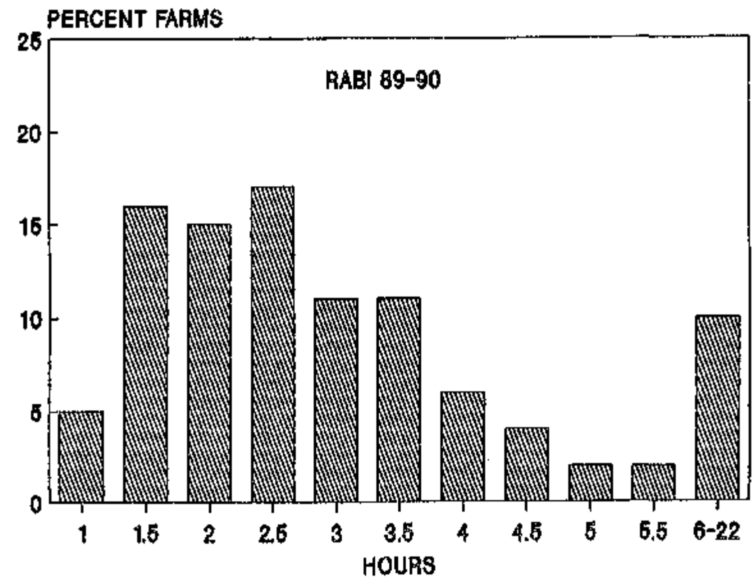


FIGURE 2 : DURATION OF CANAL TURNS
96 SAMPLE FARMS (GUGERA CANAL)



and therefore the duration of the turn in the same proportion. Table 1 presents the comparison between percentages of farms in the various categories as it changed between 1960 and 1980.

Table 1: PERCENTAGE OF FARMS IN VARIOUS SIZE CATEGORIES

Year	1960	1972	1980
Farm Size			
< 3 ha	34.1	43.6	50.9
3 - 10 ha	52.6	45.6	39.9
10 - 20 ha	9.4	7.7	6.5
20 - 50 ha	3.4	2.7	2.4
> 50 ha	0.5	0.4	0.3

The comparison reveals that during one generation (20 years) a large number of farms have been split up between sons to form smaller farms. Since 1980, this process has undoubtedly continued.

4.2 Number of Canal Turns Actually Received

Figures 3 and 4 present frequency distributions of canal turns actually received at the sample farms during Kharif 1989 and Rabi 1989-90. The majority of the farms in both samples received less than 50% of their theoretical share of canal water turns. However, the percentage of turns actually received during Kharif was slightly better than during the Rabi season.

For many farmers the low probability of receiving canal water is certainly an important factor impacting negatively on efficient management and utilisation of irrigation water at the farm. This and the short duration of the water turns appear to be key factors impeding the attainment of higher productivity per unit of irrigation water from the public system.

FIGURE 3 : CANAL TURNS RECEIVED
89 SAMPLE FARMS (GUGERA CANAL)

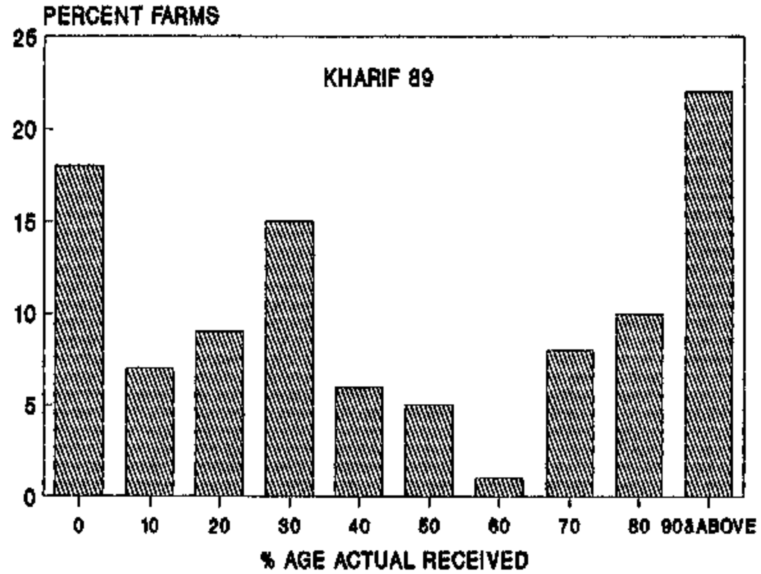
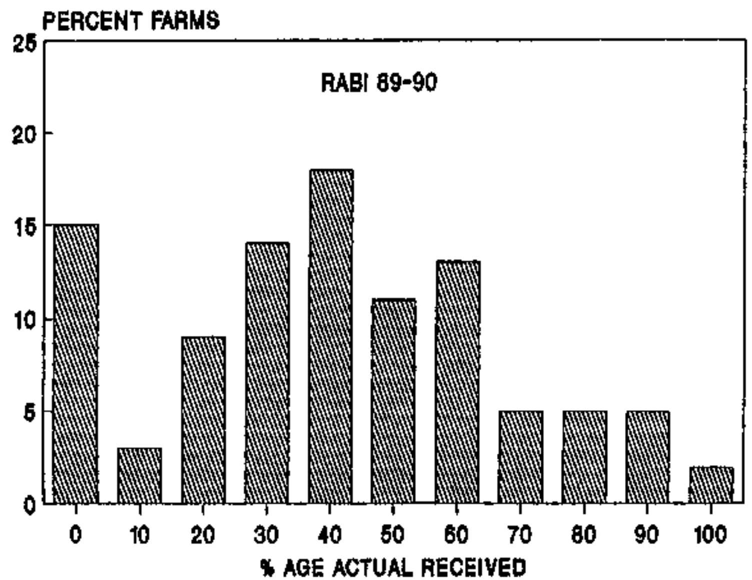


FIGURE 4 : CANAL TURNS RECEIVED
96 SAMPLE FARMS (GUGERA CANAL)



The chance of receiving canal water has a spatial distribution which cannot be discerned from Figures 3 and 4. Field data collected by IIMI field staff have revealed that due to various reasons, equity of distribution is no longer attained in the sample distributaries. Distribution was never equitable when the water supply in the parent canal dropped below 70% of the design level, and this occurs quite frequently in the sample distributaries. Because of increased cropping intensities and, in recent years, a shift toward cultivation of crops with a higher water requirement (i.e. sugarcane and rice), much more is expected from the systems now than ever in the past. Lack of maintenance and the increased occurrence of water stealing in head reaches has complicated the issue of supplying canal water to tail farmers. Inequity of water distribution repeats itself for much the same reasons within watercourse command areas, again the tail farmers receiving less than their share. In as far as many of the public tubewells are located at the head of watercourses, with the pumped water to be distributed through the same network of watercourses and branches, access to water from public tubewells is also restricted for farmers in the tail portions of the command areas.

Table 2: RANGE OF STREAM SIZES

Cropping Season	Sample Size (n)	Stream Size in litres per second								
		Canal			Public Tubewell			Private Tubewell		
		Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Kharif 89	89	35.4 12.9*	11.6	68.0	52.8 13.9*	25.5	73.1	27.4 8.4*	14.7	58.3
Rabi 89 - 90	96	32.9 7.5*	22.9	46.2	54.3 13.3*	38.5	79.3	26.9 7.4*	14.7	58.3

Avg = Average, Min = Minimum, Max = Maximum

* = Standard Deviation

4.3 Stream Sizes

Stream sizes made available for irrigation applications are presented in Table 2. The data show a large diversity in stream sizes used by farmers at the tertiary level. This large variation has been identified as a key obstacle in the application of appropriate water amounts in individual irrigations (Bhatti, 1991). This is particularly true in case of combined canal and public groundwater supply.

4.4 Trading of Turns

To improve water management some farmers trade their turns by selling and lending among themselves. Table 3 presents a summary of the available information on trading of water turns for the sample farmers. Turns were traded depending upon farmers' needs and/or convenience. The data provide reasonable evidence of farmers' lack of satisfaction with the allocation system and proof of their efforts to make the system more flexible in order to improve the management of the available water supplies.

Table 3: PERCENTAGE OF ACTUAL WATER TURNS RECEIVED BY ALL THE SAMPLE FARMERS

Description	Kharif 89		Rabi 89-90	
	Canal	Public Tubewell	Canal	Public Tubewell
Borrowed	11	8	14	28
Lent	20	18	37	51
Purchased	1	1	1	0
Sold	2	1	7	7

4.5 Alternative Water Allocation Systems

The problems associated with the present water allocation system as discussed here require remedial measures. Chaudhry (1986) has presented a brief summary of some of the methods which could be employed to improve the present system.

Relative scarcity of water is said to be the main factor which influences the selection of a specific water allocation mechanism. The complex and elaborate characteristics of Pakistan's warabandi system reflect the initial severe scarcity of water, a shortage which continues to be a critical bottleneck in the desired growth of agricultural productivity. The development of groundwater, first through public tubewells and more recently through a large number of private tubewells has added large amounts of water for irrigation purposes. In some of the sample areas, contributions from groundwater amount to around two thirds of the annual water supply for irrigation. Water distribution from public tubewells, however, takes place according to its own warabandi. As public tubewells are powered by electric motors and electricity is rationed in rural areas especially during periods of peak water demands (e.g. early in the rice growing season), the reliability of water supplies from public tubewells also leaves much to be desired. The desired flexibility in water allocation, therefore, cannot be provided by the public tubewells. However, farmers can use pumped water from their own tubewells whenever they wish, provided electricity is available if the pump is driven by an electric motor.

Recent analysis of water quality from public and private tubewell waters has revealed that the water quality of pumped groundwater shows a spatial variability with deterioration occurring generally towards tail ends of distributary command areas (Kijne and Vander Velde, 1991). This means that farmers in tail reaches of command areas face a double handicap; they receive a far smaller proportion of their share of canal water than do farmers upstream along the same distributary, and the groundwater in these locations which must be used to obtain any crop is of poorer quality than elsewhere.

The provision of either more water, better quality water or better controlled water constitutes a necessary condition for economic growth in the presence of such constraints (Howe, 1976).

Reidinger (1971), and Burnes and Quirk (1979) are among those who have argued the need for added flexibility in the system and suggested that the key factor is the institution of organised water markets. In Pakistan, under the existing set of institutional rules, it will be politically difficult to switch from the warabandi system to a much different set of water allocation rules.

However, certain institutional arrangements can be made within the framework of the existing warabandi system which will add flexibility to the system and, in turn, will make the system economically more efficient and socially more equitable (Chaudhry, 1986).

The present water allocation rule distributes water in accordance with the time specified per cultivated unit of land. An improvement would be to take into consideration the volume of water delivered to make sure that a certain minimum volume is supplied during each season and water charges are collected only if the minimum volume was delivered to the farm. Although it does not ensure delivery of water at critical growth stages of the crops grown on the farm, at least it will make the Irrigation Department more responsible for delivering certain limited quantities during the growing season. It would ensure some reliability and adequacy, which is presently not there. In view of the increased exclusive use of marginal and poor quality groundwater, especially in tail reaches of command areas, it is desirable to consider quality aspects also in the set of allocation rules. This would oblige the Irrigation Department to deliver water of a specified average seasonal quality. Of course, it is realised that this has far reaching consequences in terms of the conjunctive management of surface water and groundwater, which are presently not perceived at all, both in terms of 'hardware' (redesign of distributary canals and gates), and 'software' (operational rules).

5 CONCLUSIONS

Apparently, since the design and introduction of the warabandi system, no effort has been made to see what has happened to the historical water rights granted on the basis of land holdings, despite major physical, political and socio-economical changes which have occurred during the last century. Much has been said about the shortage of water resources in relation to crop water requirements, but little has been done to evaluate its allocation or to find ways and means to improve distribution procedures. Sample data suggest that management procedures to utilise the available irrigation supplies in an optimal way are inadequate.

Optimal water management at farm level requires a flexibility of water allocation that the present warabandi system does not provide. In drawing up a new set of rules for distribution and allocation of irrigation water, consideration should be given to the vastly increased amounts of water available at the farm gate through the development of groundwater. This occurs not only in areas with good quality groundwater; private tubewells have been installed also in areas which are known to be underlain by saline groundwater where farmers tap fresh (or marginal) groundwater from the top of the aquifer by means of skimming wells.

New rotational rules should aim at flexibility in providing each farmer with an ensured seasonal supply as a first step towards more equitable distribution of irrigation water. In addition, rules should not be the same everywhere but they should be appropriate for each environment. For instance, assured supplies should be given to saline groundwater areas (since farmers in those areas cannot respond to uncertainty by pumping: Berkoff, 1987). Similarly, farmers who are using poor quality groundwater which is known to have an adverse effect on soil conditions, should also have priority in the allocation of an ensured amount of good quality canal water.

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