Warabandi as a sociotechnical system for canal water allocation: opportunities and challenges for reform

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Abstract

This paper describes and evaluates the warabandi system of irrigation prevalent in NorthWest India and Pakistan. It argues that warabandi needs to be understood as a composite sociotechnical system comprising a physical infrastructure and a corresponding institutional arrangement for rationing and sharing water. This has implications for efforts at replicating the system in other parts of the region. An understanding of these features is also essential in assessing the prospects and potential for irrigation management reform in the region. The paper concludes by identifying some challenges and opportunities for management reform in the warabandi system.

Keywords: India; Institutions; Irrigation reform; Pakistan; Protective irrigation; Technology; Warabandi; Water policy

1. Introduction

This paper seeks to evaluate the warabandi system of irrigation prevalent in South Asia and assess the major challenges and opportunities for reform in the system. The paper is divided into 4 sections. Section 1 describes and reviews the concept of protective irrigation as a specific form of irrigation prevalent in NorthWest India and Pakistan. This is followed by a description of the warabandi system as designed, in Section 2. Its premises and supposed benefits are described. Its chief organizational, technical and institutional characteristics are discussed. Section 3 describes the practice of warabandi and seeks to assess the system critically. Some of the debates surrounding the warabandi system are reviewed. Section 4 describes the major challenges and opportunities for reform in the system and concludes the paper.


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2. Protective irrigation: concept, evolution and characteristics

Protective irrigation is a specific form of large-scale canal irrigation found in the semi-arid, drought prone areas of the Indian sub-continent (Mollinga, 1998). These irrigation systems are designed and operated such that the available water in the rivers or reservoirs is spread thinly over a large area in an equitable manner. The objective is not to match water supply with crop water requirements. Instead, the goal is to reach as many farmers as possible, and to protect them against famine and crop failure, which would otherwise occur in regions of low and erratic rainfall. This is to be distinguished from the dominant design practice in irrigation engineering, which is to design irrigation systems so that water supply covers the full crop water requirements, either completely by irrigation or in addition to rainfall (Jurriens et al., 1996).

The concept of protective irrigation emerged as an element of British colonial irrigation policy in the 19th century (Mollinga, 1998). At that point of time, protective irrigation undertook to supply limited quantities of water to subsistence-oriented farmers growing traditional food crops. This would protect crops and livelihoods from drought, prevent famine and social unrest, and secure colonial rule. Thus, “Protective works, as their name implies, exist primarily for protection against famine, not to bring revenue to the state” (Narain, 1922: 272). Similarly, as Attwood (1987) put it, when protective irrigation works were constructed in the Deccan in the early 20th century, the ‘protective nature’ of Indian canal systems implied that (1) the canals were intended to protect food crop production against droughts over as wide an area as possible and (2) they were not required to be self-financing. In other words, the authorities did not expect to recover the full interest on capital costs from irrigation charges.

After independence, protective irrigation became part of the government’s policy for agrarian development, with an emphasis both on growth and equity objectives: production and productivity increase and the spread of the benefits of development over different sections of the population and different regions (Mollinga, 1998). It has since guided the construction of canal irrigation projects in the phase of planned economic development. In 1987, the National Water Policy stated thus: “the irrigation intensity should be such as to extend the benefits of irrigation to as large a number of farm families as possible, keeping in view the need to maximise production” (GOI/MOWR, 1987: 9). In evaluating the contribution of irrigation to India’s economic development, it has been argued that irrigation has lived up both to its productive and protective role (Dhawan, 1988).

In its present context, protective irrigation can be understood to be a form of large-scale irrigation, specific to the drought prone areas of the Indian sub-continent, and having particular technical, organisational and socio-economic characteristics, described below.

2.1. Technical design characteristics

Protective irrigation is sought to be realised through operational targets such as low irrigation intensity and high duties (or low water allowances) (Jurriens & Landstra, 1990). By planning irrigation of part of

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1 Irrigation intensity expresses the intensity of the use of the command area of an irrigation system. When irrigation intensity is 60%, 60% of the land is cultivated with an irrigated crop once per year (or 30% is double cropped). When it is 200%, all land is cultivated twice with irrigated crops per year. Duty expresses the area that can be irrigated with a unit discharge of water. It is usually given in acres per cusec (cubic foot per second). It is the inverse of ‘irrigation allowance’, which is expressed in L/s. ha (liters per second per hectare) (Mollinga, 1998).
the irrigable areas under canals only, and by limiting irrigation on a particular piece of land to one crop per year, the water is spread over a large area, and only part of the area commanded by the canal is irrigated. By designing a large area to be irrigated per unit discharge, supplementary irrigation is implied. The intensity of irrigation in many systems is less than 100%, thereby lending them a characteristic of ‘water-constrained systems’ (Tilak & Rajvanshi, 1991: 1).

A further design characteristic is the supply orientation. Water supply into the system is not determined by actual, and fluctuating, demands in the field. Fine-tuning supply to demand, which is needed to maximise yield, is not aimed at. The supply orientation combined with the desire to keep the systems as cheap as possible (because they were unproductive systems yielding little revenue) has led to a minimum of regulating devices for controlling water levels between the intake of the system (weir or dam) and the outlet command areas at the farmers’ level (Mollinga, 1998).

2.2. Organisational characteristics

The above specific technical design characteristics translate into certain organisational and institutional characteristics. Since the aim is not to match supply with demand, control structures are limited. Thus, these systems have a low management intensity as well (Jurriens et al., 1996).

The second organisational characteristic, apart from the low management intensity described above, is that of hierarchy (Mollinga, 1998). The supply orientation of protective systems fits well with the top-down organisational structure of the Irrigation Department. This structure is based on the principle of upward flow of information and a downward flow of instructions.

The third organisational characteristic is the institutional form of the rationing of irrigation water. Since these systems aim to spread water over a large area and number of farmers and the amount of water which a farmer is entitled to receive is insufficient to cover full crop water requirements, implicit in their operation is a system of ‘scarcity by design’ (Jurriens et al., 1996). This ‘designed scarcity’ necessitates a system of institutional rationing of water, spreading out limited supplies over a large number of farmers over a large area, where the objectives of an individual farmer may differ from those of system management.

Where water is too limited to meet the demands of farmers, it may be rationed through controls over supply: by controls over the amount of water which flows to the fields, with the farmers being left to decide which crops they will grow within the constraint of a fixed water supply. This is the Northwest Indian model (Wade, 1976), referred to as the warabandi system. In addition to supply side controls, there may be demand side controls, controls over the types of crops which may be grown, and over the areas on which they may be grown. This demand-oriented method is used in much of the Deccan plateau, including Maharashtra, where the shejpali system of irrigation is practiced. In South India, the control strategy for protective irrigation is localization. Details of the shejpali system are provided in Narain (2003); a discussion of localization can be found in Mollinga (1998). A discussion of the warabandi system is the subject of this paper.

2.3. Socio-economic characteristics

On account of its ability to contribute to the policy goals of equity, maximisation of farm output and agricultural incomes, the concept of protective irrigation has guided the construction and operation
of large-scale canal irrigation systems in the phase of planned economic development in India (Mollinga, 1998). Economically, protective irrigation strives for high output per unit of water. A protective cropping pattern of light crops increases the total agricultural output of the irrigation system, as compared to concentrated irrigation. From a national policy perspective, thus, protective irrigation makes sense because (i) it increases agricultural output given the availability of a limited quantity of water, (ii) it can generate more employment than wet irrigation, and (iii) it spreads the benefits of irrigation over a large number of producers.

3. Design of the warabandi system: warabandi in principle

 Warabandi, prevalent in Northwest India and Pakistan, is a specific form of protective irrigation. It is a system of water distribution which is designed so that every farmer is entitled to receive a predetermined share of water in proportion to the size of his land-holding (Malhotra et al., 1984; Malhotra, 1988; Berkoff, 1990; Bandaragoda, 1998). As a system of water distribution, warabandi covers an area of about 24 million hectares of irrigated land in these two countries (Bandaragoda, 1998). The warabandi system is more than one hundred years old (Malhotra et al., 1984; Malhotra, 1988).

‘Wara’ means turn and ‘bandi’ means fixation. Thus, warabandi means fixation of turns (Bandaragoda, 1998; WALMI, 1998a). It implies a rotational method of water distribution. The cardinal principle underlying the warabandi system of irrigation management is that the available water, whatever its quantum, is intended to be allocated to cultivators in equal proportion to their Culturable Command Area (CCA), and not only to some of the farmers in the command to meet their total demand. This is intended to impose water scarcity conditions in the system.

The theory of the warabandi arrangement is that each cultivator is assigned a turn, represented by the specific period of time—a time share—and the volume of water available during that slice of time is his to use (Coward, 1986). This time share becomes a property right legitimised by the state through the creation of a formal and legal warabandi roster for the delivery channel in question. The warabandi share, as a property right, then serves to organise the social relations of irrigation among the cultivators and between them and the irrigation agency.

3.1. Scarcity by design under warabandi

 Water allowance, capacity factor and irrigation intensity are the expressions of ‘scarcity by design’ in the operation of the warabandi system. Each unit of CCA is allocated a certain rate of flow of water called the water allowance. Its value is a compromise between demand and supply. For instance, in the case of the Bhakra project in North India, the value of this allowance at the outlet to the watercourse is 2.4 cusecs of water per every 1,000 acres of CCA (0.17 L/s.ha) (Malhotra et al., 1984; Malhotra, 1988).

No distributary operates for all days during the crop season: the ratio that the operating period of a distributary bears to the total period of the crop is called its capacity factor. This is again a compromise between demand and supply and is separately designed for each of the sub-periods. For example, in the Bhakra canal system, the designed mean capacity factors for kharif and rabi are 0.8 and 0.72 respectively, which means that during these seasons, each distributary may receive full water for about 144 and 129 days respectively, i.e. for about 273 days a year.
The above values of *water allowance* and *capacity factors* do not ensure irrigation for 100% of the Culturable Commanded Area. The ratio of the irrigated area to the total Culturable Commanded Area is known as the *intensity of irrigation*. Its value in case of the Bhakra canal is 62% per year, or about 30% per season.

When the distributary is running FSL (Full Supply Level), the watercourse draws its full (authorised) discharge. The capacity of the watercourse varies from 1 to 3 cusecs, depending upon the command area (WALMI, 1998b). The value of the water allowance at the watercourse head is 2.5 to 3 cusecs per 1000 acres of the Culturable Command Area.

To ensure that the stream size below the outlet is appropriate for handling by farmers (say 25–40 L/s), outlet commands (*chaks*) are relatively large (100–300 ha). If the *chak* is 100 ha, and allowance is 0.2 L/s.ha, then the farmers receive 20 L/s for 1.68 hours per hectare; if *chak* size is 200 ha, they receive 40 L/s for 0.84 hrs.

Delivery capacity per hectare (allowance) is very low, about 0.10–0.15 L/s.ha at the outlet (300–400 acres/cusec). This is considered insufficient even if given continuously to meet the theoretical crop water requirements for more than perhaps 20–30% of land in *kharif* and 35–45% in *rabi* (Berkoff, 1990). In a study of the Pabra Distributary of the Bhakra Project, in the Hissar district of Haryana, Malhotra et al. (1984) conclude that for an average of 3–4 irrigations per field, the system of *warabandi* and the amount of water available provides adequate irrigation to 25–30% of the CCA; leaving 70% of the CCA as rainfed. This, the authors argue, corresponds to the design objectives of the *warabandi* system.

On the Western Yamuna Canal, where research was carried out by this author, the allowance is 2.4 cusecs per 1000 acres on the Bahlot sub-branch, 2.86 Cusecs per 1000 acres on the Butaana Branch and 2.57 cusecs per 1000 acres on Rohtak Distributary at the level of the outlet (Narain, 2003). The designed irrigation intensity is 60% for the entire year.

An important aspect of the studies of some of these irrigation system is the limited description of their technical design characteristics (Jurriens & Wester, 1994). One problem with documentation of design data in some of the studies is that it is not stated at which level it applies; similarly, when intensities are given, we do not know how they vary across the seasons (Jurriens & Wester, 1994). This limits the usefulness of these studies.

### 3.2. Operation of the *warabandi* system

Since the water supply is inadequate to run the whole system continuously, *warabandi* works through a system of rotation (Malhotra, 1988; Malhotra et al., 1984). This system of rationing works at three levels. First, a main canal carries the water from the source, which may be a river or a reservoir. The main canal feeds two or more branch canals which operate by rotation and may or may not run full supply. This is the primary distribution system and runs throughout the irrigation season with varying supply. Branch canals supply water to a large number of distributaries, which must run at full supply level by rotation. The distributaries operate by eight-day periods. This is the secondary distribution system.

Distributaries supply water to watercourses through ungated, fixed discharge outlets. Watercourses are designed to run at full supply when the distributary is running full supply and its water is allocated by the farmers through the *warabandi* schedule. This is the tertiary water distribution system. A period of seven days (168 hours) is divided among the farmers in proportion to the size of their land-holdings.
An eight-day period for running the distributary ensures a minimum of seven-days running for each watercourse including the most distant from the distributary head. The eighth day is needed for filling the distributary. Water deliveries are controlled by time and are proportional to land.

Main and branch canals are operated with variable flow (e.g. in response to variable river flows), but distributaries and minors are intended to be operated either full ON or full OFF (with reduction in flow to at most 80–90% of design) (Berkoff, 1990). When main and branch canals run full, which is the normal case so long as river flows exceed diversion capacity, all lower channels also run full. When main/branch canals run less than full, lower channels operate in rotation such that the sum of discharges in ON channels equals the branch discharge less losses.

Along the main or branch canals, gates are needed to control changes in flow. At the distributary head, ON/OFF gates are needed to facilitate rotation of channels in response to less than full supply in the main and branch canals but not to modify flow. Below the distributary head, the system is ungated with proportional division. Flow levels are supposed to be monitored twice a day at key points, and when the tail flow falls below full discharge, the supply is considered to be inequitable and appropriate action needs to be taken to increase supply or to close channels to ensure ON channels remain at full supply.

Below the outlet, the warabandi schedule is supposed to be followed by the farmers. The government’s main role is to assist in preparation of the roster and in settling the disputes. Farmers are allowed free use of groundwater and freedom to plant whatever they want following their own assessments of the availability of water.

3.3. The organisational set-up under warabandi

There are two establishments for irrigation management, that is, Engineering and Revenue and both work under a single command (Malhotra, 1988). The Engineering Establishment is responsible for the maintenance and operation of all works relating to the main canal, branch canals, distributaries and outlet. The Revenue Establishment is responsible for recording the area irrigated and the preparation of water bills for individual farmers and passing on the same to the District Collector for realisation. In addition, it helps in deciding all disputes and conflicts relating to the distribution of water, alignment of water courses and transfer of areas from one outlet to another.

The administrative unit under warabandi is known as a Division. It is headed by an Executive Engineer. An average Division has 70,000 hectares of Culturable Commanded Area. A Division comprises 3 to 4 Sub-Divisions, each of which is headed by a Sub-Divisional Officer, who is the junior most officer. A Sub-Division may have 3 to 4 Sectional Officers to help him. For the revenue work, a Sub-Divisional Officer is assisted by 2 to 3 Zilledaars and each Zilledaar is assisted by 10 to 12 Irrigation Booking Clerks. Each Division has one Deputy Collector who supervises the work of Zilledaars in a Division.

Along the canals the gates at the head of distributaries are operated by the Regulation Beldaars. The gates are opened on the basis of a telegram from the office of the Irrigation Department. The Taar Babu (Telegram Officer) delivers this telegram on the basis of an instruction from the XEN (Executive Engineer). The XEN sends the indent to the Regulation Beldaar.

The duty of the Canal Patrollers is to guard the outlets during the day as well as the night time. Each Patroller has a shift of 8 hours. His duty is to inspect the outlets and siphons. Should there be a water theft or tampering with an outlet, he is supposed to report the same to the JE (Junior Engineer). The JE is then
supposed to send a telegram to the SDO (Sub-Divisional Officer), indicating that action needs to be taken. At some places, ghauts have been made to allow people to swim, wash clothes, or to bathe their livestock. When some other place along the canal is used for this purpose, the Canal Patroller is authorised to stop it. The copy of the pucka warabandi schedule is kept with the Nahari Patwaari, who has a direct interface with the farmers. The Irrigation Department gives the task of desilting the canal on contract. This is to be done twice a year.

4. Evaluation of the warabandi system: warabandi in practice

A fall-out of the system of water rationing under warabandi is that the farmer is the master of his water budget. He is supposed to choose his crop profile to suit water availability. Unlike the localisation practices in South India and shejpali of west India, there are no cropping restrictions. Water is allocated in proportion to land and farmers are free to use their allocation as they want (Berkoff, 1990).

The basic characteristics of protective irrigation in general, and warabandi in particular, imply an inherent conflict with the farmers’ objectives. While the design and operation of protective irrigation systems in general and warabandi in particular is guided by the goal of maximizing production per unit of water, in practice, farmers seek to maximize production of cash crops per unit of land (Mollinga, 1998). On account of this inherent conflict, the original objectives of protective irrigation have rarely been achieved in practice.

In North-West India, these systems were designed to irrigate mainly wheat; in recent years, rice and sugarcane have emerged as important crops (Jurriens et al., 1996; Brewer et al., 1999). In the early decades, the combination of a warabandi system with light crops such as wheat allowed the systems to work as designed (Jurriens, 1993). Later, however, with the onset of the green revolution, the introduction of high yielding varieties of seeds and the consequent commercialisation of agriculture, there occurred many changes in cropping practices. Farmers wanted to irrigate in two seasons instead of one. They wanted to irrigate all their land as against the low planned intensities, or at least more than planned. The initial high design duties, thus, became inadequate with the desire for more productive irrigation and the increase in rice cultivation. This was an important factor behind the spurt in tubewell structures to sustain the green revolution in North West India and Pakistan. In field work carried out by this author in two districts of the North West Indian state of Haryana, farmers were found to respond to this designed scarcity by engaging in water thefts along the canal, tampering with outlets, supplementing canal irrigation with tubewell irrigation and engaging in time exchanges (Narain, 2003).

The warabandi system is considered to have some virtues (Gustafson & Reidinger, 1971). The opportunity to receive water is rationed in a way which could be considered ‘fair’, since each piece of land is designed to obtain its proportionate amount. The other possible benefit is that this model of running a distributary and its watercourses involves human control only at the distributary level head, leaving the outlet at the watercourse head automatic. Since the possibilities of human intervention in the operation of the system are small, Gustafson & Reidinger (1971) argue, the possibilities of corruption could be limited. The rules of water distribution are ‘public knowledge’ and each farmer is sure of his rights (Reidinger, 1974). This, however, means little in practice. In research carried out by this author on the Western Yamuna Canal system in North West India, farmers were found to intervene both at the level of the outlets as well as above, to increase discharges by breaking outlets or by inserting siphons on
the canal (Narain, 2003). Similarly, it was common for farmers to bribe the employees of the Irrigation Department to allow them to do so.

The Warabandi system is criticized for unpredictable and unreliable water supply (Gustafson & Reidinger, 1971; Jairath, 1985; Malhotra, 1988; Tilak & Rajvanshi, 1991; Latif, 1993). The physical design of the system, the design of the watercourse outlets, and especially the canal rotations all interact to produce a relatively unreliable water supply from the farmers’ point of view. “Indian agriculture has been described as a gamble with the monsoons; in canal irrigated areas, it could be described as a gamble with the canal as well” (Gustafson & Reidinger, 1971: A-158).

In a system which is entirely centrally controlled, the main weakness of the system is considered to be the lack of predictability, certainty, and controllability of the canal water supply by the farmer and the inability to match water supply with crop water requirements. A major disadvantage of this system, as designed, is that the volume of water available to a farmer is independent of the stage of crop growth and he is forced to either take his turn (whether needed or not) or to forego it. Another drawback is that it does not permit crops with high variations in water requirements in sub-commands. In research carried out on the Western Yamuna Canal system by this author, farmers often complained of an uncertain and unreliable water supply and that they did not have information on canal closure and the dates of water release (Narain, 2003). This hampered their ability to plan irrigation activity, and was a major cause of resentment against the Irrigation Department.

Canal water deliveries in these systems have been known to be unreliable because of a number of factors (Jairath, 1985; Latif, 1993). These include drought conditions, limited storage, breaching, high losses and manual intervention and malpractice. Farmers are confronted with several problems: these include the absence of information about canal closure, illegal canal cuts, and breaches and water thefts by the use of siphons and pipes on the canals and distributaries. An important problem which is cited by Jairath (1985) is that of corruption and inefficiency in addressing irrigators’ problems - such as alteration of the size of outlets and their level. The actual state of maintenance of the canals is also found far from satisfactory. The bureaucratic functioning of the Irrigation Department, Jairath (1985) argues, takes up a high proportion of the funds for the organisational working, leaving a small proportion for the operation of the system.

Another drawback of the system is that there is no knowledge as to how much water each farmer receives (Malhotra, 1988). Further, there is no provision in the system to compensate any individual farmer who does not receive water in his turn, even when it is for factors for which he is not responsible (Malhotra, 1988; WALMI, 1998b). If for any reason a farmer is unable to receive his share of water, this system does not provide a method of compensating him for the loss. Similarly, if the flow of water is less than the authorised flow because of a technical defect, the loss suffered on this account, too, is not compensated. Thus, “A primary virtue of the rationing system is that all recipients apparently share both water and insecurity equally” (Reidinger, 1974: A-100).

The responses of farmers to a system of scarcity take three main forms: digging of tubewells, intra-seasonal and inter-seasonal exchange or sale of time turns, and intervening along the canal or the distributary (Gustafson & Reidinger, 1971; Reidinger, 1974, 1994; Jairath, 1985; Bhatti & Kijne, 1990; Meinzen-Dick, 1996, 2000). In research carried out by this author, the most common response to this problem was in terms of time exchanges, that is, farmers exchanged their time slots to suit their convenience. When a farmer did not need water during his turn, he would lend his turn to another farmer in need, and then take it back on a future date. This time exchange was based on a system of mutual understanding and social relations, captured in the term ‘bhaichaara’ (literally meaning brotherhood).
Thus, while water rights were defined through the *warabandi* schedule, that is, through state law, they were realized through another normative system, that of ‘*bhaichaara*’ based organization. Water rights were defined through one legal system, and realized through another, pointing to the existence of legal pluralism in water distribution (Narain, 2003).

An important response of farmers to this system in the sub-continent has been the increase in the number of tubewell structures, particularly after the onset of the green revolution in the 1960s. The opportunities for more intensive agriculture in the wake of the green revolution and increasing population pressure created demand for more water and more flexible deliveries (Meinzen-Dick, 2000) than could be provided through the *warabandi* system. In contrast to rigid *warabandi* schedules, farmers with tubewells could irrigate their fields more frequently in periods of peak demand throughout.

The increase in water supplies made possible through ground water development at the watercourse level means that the designed low cropping intensities described in Section 2 of this paper can be overcome. Even considering breakdowns, tubewell operators in Pakistan reported that pump or engine failures made ground water unavailable for an average of 1–2 weeks per season, which was still better than the reported unavailability of canal water for an average of 4–5 weeks per season (Meinzen-Dick, 2000). In research on the *warabandi* system conducted by this author, farmers were found to supplement canal irrigation with tubewell irrigation (Narain, 2003). When farmers needed water outside their turn, a common practice was to operate their tubewells. Tubewell irrigation supplemented canal irrigation both in terms of volume as well as the timing.

Another response of farmers is the exchange or sale of turns among themselves (Reidinger, 1974, 1994; Jairath, 1985). In research carried out by this author, this response was somewhat limited. Farmers preferred to lend their time share instead of selling it, since a time share lent created a basis for a future claim. A water turn sold, on the other hand, was a turn gone forever (Narain, 2003).

A third response is the interference of farmers directly at the level of the distributary by modifying the dimensions of the outlets, the use of flexible siphoning pipes at night and cuts in the banks of the distributaries (Jairath, 1985; Rinaudo *et al.*, 1998; Wahaj, 2001). In research carried out by this author, this was a very common occurrence (Narain, 2003). This culminated in the deprivation of tail-enders and an over appropriation of water by farmers at the upper reaches of the canal. As shall be argued later in this paper, improving the management of the main system in order to check over appropriation of water by head-enders and for securing more equitable distribution of water at the tail reaches is an important priority for reform in the *warabandi* system.

Criticisms of the *warabandi* system also relate to actual patterns of equity in water distribution (Malhotra *et al.*, 1984; Bhatti & Kijne, 1990; Khan, 1991; Bhutta & Vander Velde, 1992; Kijne & Vander velde, 1992; Latif, 1993). There are wide variations between the discharges actually realised between head and tail reaches (Bhutta & Vander Velde, 1992). These variations occur at the level of the main canal and distributary as well as along the watercourses.

A criticism of the system from an equity perspective is that this system delivers an amount of water among irrigators which is unequal along tertiary channels. Under the existing rotational system, transmission losses along the channel are not considered. A constant time per unit area is allocated to the farmers regardless of their locations along the watercourse. This results in decreasing amounts of water delivered to the downstream farmers (Latif, 1993). Farmers receive proportionate running time, but not necessarily proportionate quantities of water. This makes the water distribution system inequitable. Losses tend to increase towards the tail reaches. Thus, it is argued that the system rations time, or the opportunity to receive water, rather than water itself (Reidinger, 1974).
Absorption losses in watercourses below the outlets have been found to be as much as 25% of the supply at its head (Malhotra et al., 1984). Drawing upon a study in Pakistan, Khan (1991) estimated that the irrigation efficiencies in the watercourse command range from about 55 to 65%. Bhatti & Kijne (1990) report that farmers pay an equal amount per acre cultivated with a specific crop, though downstream farmers receive 20–30% less water with lower yields for similar cropped areas. Lining of watercourses is seen as one remedy but some losses would still remain (Malhotra et al., 1984). In research carried out by this author, absorption losses between the head and tail reaches at the watercourse level were found to be of the order of 25–30% (Narain, 2003).

There have been some proposals to modify the warabandi system on equity and allocative efficiency grounds (Chaudhry & Young, 1990). Chaudhry and Young propose a modification of the standard warabandi practice to attempt to account for losses in the watercourse so that an equal supply of water could be achieved per acre. They call it “warabandi by quantity”. A more fundamental critique of the system from an equity perspective, is that it ties rights to water expressed in terms of the time for receiving water to acreage of land ownership. By conferring rights in water in proportion to rights in land, it strengthens the existing patterns of inequality in land ownership.

5. Implications for irrigation management reform

As a form of protective irrigation, since warabandi implies a system of rationing water which is scarce relative to demand, instead of matching water supplies with crop water requirements, the management concerns relating to Indian canal irrigation, especially in terms of their productivity, need to be appreciated in this backdrop (Gustafson & Reidinger, 1971; Reidinger, 1974; Jurriens et al., 1996).

In current debates on irrigation management reform in India, an important point of discourse relates to the applicability of the warabandi system of North India to the West, where shejpali is followed. In fact, the adaptability of the warabandi system was studied in the old Bombay state (Lele & Patil, 1994). However, it was found unsuitable because of the variation in ground water availability due to rocks underlying the soils, the changing soil conditions within the canal commands which necessitated different frequencies and doses of water supply, the resulting variation in crops and cropping systems followed by the farmers and the preference of farmers for high value, high water consuming crops like sugarcane and banana (Lele & Patil, 1994).

As a matter of fact, Warabandi, notwithstanding its limitations as discussed in the preceding section of this paper, has come to be treated as a magic buzz word, and efforts have been made to implement it in many other states (Malhotra, 1988). This discourse became very popular in the 1970s and 1980s. States like Andhra Pradesh, Karnataka, Maharashtra and Gujarat introduced this system on an experimental basis. However, the point which has been missed in these discourses is a consideration of the fit of the organizational system with the type and standard of the physical infrastructure- especially the distributary, its outlets and watercourses.

In these discourses, warabandi has been understood simply as a system of water distribution at the tertiary level through a system of rotation and fixation of turns. On the other hand, warabandi, as a system of water distribution, needs to be supported by a set of physical and institutional conditions which form the broader environment of warabandi, transcending the boundaries of the tertiary system in which it is applied (Bandaragoda & Rehman, 1995). Warabandi is a composite sociotechnical system, with a
physical infrastructure as described in Section 2 of this paper accompanied by an organization set-up and institutional arrangement for distributing the scarce water at different levels of the system.

Another issue relates to the relevance of *warabandi* under present circumstances, especially after the introduction of the green revolution. The introduction and rapid spread of high yielding varieties after the mid-1960s generated a demand for assured irrigation. Under these circumstances, *warabandi* has been criticised for the total lack of control which irrigators are confronted with and the fact that it limits the participation of the farmers in the green revolution. The groundwater boom in India’s agrarian economy has been explained chiefly in terms of a policy environment promoting the cheap availability of power, subsidized credit for tubewell structures, the absence of a legal framework for regulating groundwater withdrawals and the absence of a property rights structure which defines water extraction limits (Shah, 1993; Saleth, 1996; Narain, 1998, 2000). The implications of technology - in terms of the design of canal irrigation which creates a system of scarcity by design – have been overlooked. The groundwater boom in India needs to be appreciated in this context, as a response of farmers to overcome the constraints posed by a regime of designed scarcity which would have hindered their participation in the green revolution.

As noted earlier in this paper, one fall-out of the limited flexibility in irrigation conferred by *warabandi* which constrained the farmers’ ability to take part in the green revolution was the increase in tubewell structures. In the early 1970s, northwest India experienced a “tubewell explosion” in response to the commercial gains that accrued to farmers from the introduction of the new technology in wheat production. In fact, in Punjab, the increase in area devoted to paddy cultivation and the development of groundwater occurred at the same time (Chopra & Bathla, 1997).

At present, reforms in Indian irrigation are being carried out primarily under the buzzword of Participatory Irrigation Management, entailing the formation of water users associations at the tertiary level. The point which is being missed in these efforts is that in the *warabandi* system, at the tertiary level there already is a form of organization for carrying out water distribution and management functions. Within the overall framework of the *warabandi* schedule, farmers share water through time exchanges based on their mutual convenience. This has led to very little difference in water management and distribution functions at the field level through the formation of water users associations, whose role has been confined to supervising the construction of lined watercourses.

This is similar to what Byrnes (1992) established with regard to his study of water users associations in Pakistan’s World Bank Assisted On-Farm Water Management Programme. “Generally, the establishment of legally-authorized WUAs on the W/Cs (watercourses) has not resulted in farmers drastically changing or going beyond what they traditionally accomplished through their informal khal committees” (Byrnes, 1992: xiv). Further, “the underlying reason for this problem lies in the failure of the design of World Bank-assisted irrigation projects to include an effective strategy, and to provide the necessary resources to implement that strategy, for WUAs to function as the farmers’ own vehicle for investing and sharing in the benefits of development. Much work remains if WUAs are to evolve from short-lived paper organizations for improving watercourses to self-sustaining organizations active in promoting agricultural and rural development” (Byrnes, 1992: xv).

Reforms are needed above the outlets, to prevent tampering of outlets and water thefts. Further, the manner in which *warabandi* is organized as a system which is centrally operated and controlled rules out the possibility of devolution to user groups unless control is transferred at the distributary level (Narain, 2003). At that level, the formation of water users groups will be strategically very difficult,
given the large geographical spread of systems and the coordination across several villages which this will entail.

Within the current pattern of organization of the warabandi system, three interventions are crucial. Firstly, there is a need to improve information flow to the farmers in terms of announcements on the timing of water distribution and canal closure. Secondly, reforms are needed above the outlets in order to curb illicit practices and water thefts and tampering of outlets. This is important from an equity perspective in order to make water available downstream to tail-enders who are often deprived of water. Thirdly, donors and academics interested in analyses of the study of social capital in North-West India and Pakistan need to appreciate warabandi as a potential for mainstreaming institutional development activities. Warabandi provides a social glue at the tertiary level for the conduct of water management and distribution activities. It is built on a premise of bhaichaara, implying a system of social relationships and mutual cooperation (Narain, 2003).

Warabandi needs to be understood as a sociotechnical system with an institutional arrangement for water distribution accompanying the physical infrastructure. Typically, the word warabandi has come to acquire a connotation of simply an arrangement of sharing water at the tertiary level, around a myth that it is equitable and effective at the same time. This myth needs to be unshackled to understand the system as a composite of technology and institutions, in order to understand its implications not only for reform in the states where it is prevalent, but also where policy makers are keen to replicate it.

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