COMPLICT AND INEQUALITY IN SURFACE IRRIGATION: A SOCIO-ECOLOGICAL PERSPECTIVE

Prem S. Vashishtha[1] and Dalbir Singh[1]

Abstract

This paper attempts to understand the role of institutions and governance, in explaining unequal access to canal water under different rules of the game. Two states at different levels of agricultural productivity with different rules of distribution of canal water are chosen to study the problem at project level. While Bihar, at low level of agricultural productivity, represents absence of scientific method of distribution of water, Punjab offers high level of agricultural productivity with the warabandi system. The two case studies offer interesting similarities and dissimilarities in terms of unequal access to water by the tail enders and mechanisms needed to mitigate this inequality. Some similarities are: (a) the tail enders suffer the most with low access to water forcing them to adopt only low water intensive crops in comparison to the head reach and mid reach farmers; and (b) the farmers supplement canal water with ground water. The dissimilarities noticed are: (a) while over exploitation of ground water in Punjab has reached levels beyond natural recharge of aquifers in several places; in Bihar, with low withdrawal of ground water and natural endowment of high water table, such a situation has not arisen; (b) the breaking of canal and water courses for own benefit by the powerful with political clout is rampant in Bihar, rarely attracting a penalty from the irrigation department; (c) the water market for tubewell water (Rs.70 to 80 per hour) has developed in Bihar partly mitigating inequality in access to canal water by the tail enders; no such phenomenon is common in Punjab. The plausible reason for the low density of tubewells in Bihar in contrast to Punjab is low incomes making affordability of tubewell an issue, and (d) cooperative efforts by farmers to lay down pipes through neighbors' plots to minimize loss of water has succeeded in Punjab; in Bihar such efforts succeeded initially at a small scale but could not sustain without government assistance. The absence of scientific rule for distribution of canal water and the weak canal governance system aggravates the misery of tail enders. In such a scenario, the mitigation of unequal access to water by the tail enders is facilitated by the development of water markets at high cost in a complex situation with tiny holdings and lack of cooperation among the farmers.

1. INTRODUCTION

Expansion of surface irrigation in seventies and eighties was followed by a rising gap between the potential created and the utilization of potential of irrigated area. The degree of utilization of irrigated potential varies across schemes with different scales (large, medium and minor). One feature is common to states at different levels of agricultural development, i.e., despite expansion of irrigation potential, the gross irrigated area in most states declined in the nineties and continues to decline. The increasing inefficiency of the canal irrigation system is also associated with highly unequal distribution of water between the head reach and the tail end farmers (Shah, 2001). This inequity and inefficiency manifests in supply of excess water at the head reach leading to waterlogging and salinity and high scarcity of water at the tail end (Vashishtha, 2007). In fact, the scarcity at the tail end is very severe at some locations not just for a season or two but for several consecutive years threatening the very livelihood of the tail end farmers. In that situation, the tail-enders depend highly on ground water, many of whom buy tube well water from their resourceful neighbors to save their crops (Meinzen-Dick, 1996; Palmer-Jones, 1994). It is also observed in the literature that while the buy-sell phenomenon of ground water is beneficial to both the buyer and the seller in financial terms in the short run, excessive dependence on ground water resulting in lowering of water table could pose a major threat to all jeopardizing the

[1]Professor and Fellow respectively at the Institute for Human Development, New Delhi. Emails: premsv@rediffmail.com / sdalbirsingh@gmail.com

ground water balance in the long run (Morris, 2007). The above scenario raises several questions that need probing:

(i) What steps has the local community (mainly farmers in the command area) taken to mitigate unequal distribution of canal water, especially when the state irrigation authorities have virtually failed to take corrective measures?

(ii) Do farmers operating under different rules of distribution of water (in different regions) react differently against unequal access to water by the tail enders? Are farmers prepared to invest/contribute to the common pool to take corrective steps to improve local access to water?

(iii) Are tail-enders able to mitigate the suffering inflicted by lack of access to canal water through purchase of tube well water from neighbors?

This study aims at examining the above questions with the help of evidence collected from the field and is organized as below. Section 2 outlines the main objectives of this study and the methodology of conducting the field study. Section 3 describes the main features of sample locations. The field observations are presented in section 4. The last section 5 presents the concluding observations and policy implications.

2. OBJECTIVES AND THE METHODOLOGY

2.1 Objectives

Keeping in view the issues discussed, the paper, in a socio-ecological perspective, focuses on the following objectives:

1. To discuss the relative access of tail enders vs. head reach farmers to surface water in a canal command area, the nature of conflicts arising thereof and the socio-ecological problems associated with it.
2. To explore the role of local community (group of farmers in the canal command area) and other institutions in mitigating the impact of unequal access to surface water under diverse institutional arrangements of distribution of canal water.
3. To discuss whether the emergence of water markets has helped mitigate inequity in access to canal water and also the consequences associated with external diseconomies (declining water table), if any.

2.2 Methodology

Given the nature of research issues, it was decided to focus on 2 states for a comparative study, the main criteria of selection of states being (i.) they represent different levels of agricultural development, and (ii) they have different sets of rules for distribution of canal water at the village/water course level. As regards the choice of irrigation project, it was guided by prior knowledge about the nature of inequality and the conflict involved in the distribution of canal water. Whether or not the farmers took initiative to mitigate the intensity of conflict arising due to unequal access to canal water also featured in the choice of projects. Coming to the choice of village, it was dictated by the location. One village from each location (head, middle and tail end) was selected for field visits for intensive observations and discussion with the village leaders (well-informed individuals) and a group of farmers at each location. Although we did not conduct a farmer level survey, we did draw upon other studies based on farmer level data. It may be pointed out that the main insight relating to the existing water institutions and their functioning came from village level information and focused group discussions. Interaction with different stakeholders helped understand the ground reality on conflict and its resolution by the community. All this information was supplemented by secondary data of villages and districts selected for the study. This exercise is expected to share regional experiences for improving water access to the deprived groups and also form the basis for initiating an effective dialogue at different levels.

The 2 states viz. Bihar and Punjab were selected for a comparative study. These 2 states are at different levels of per capita state domestic product and agricultural productivity. While Punjab is in the top level of agricultural productivity, and high value of per capita state domestic product, Bihar is in the category of bottom level of states in respect to both these parameters. The per capita income (at 1993-94 prices) of Punjab is about

four times that of Bihar. As regards poverty ratio (percentage of population below poverty line), Bihar has 42.6% for rural and 42% for the entire State in comparison to Punjab's poverty ratio of only 6.33% and 6.2% for rural and entire state, respectively. Even compared to the all India situation, Bihar fares poorly in terms of poverty ratio (Table 1). The physical yield of major food grain crops gives a good idea of the relative agricultural productivity levels in different states. Punjab's yield of rice and wheat is more than 2 times that of Bihar. Even for maize, the yield of Punjab is more than one-and-a- half times that of Bihar (Table 2).

Table 1: Income and Poverty Level in Bihar, Punjab and India

	Bihar	Punjab	India
Per Capita income (Rs.)			
2003-04	3,776	18,364	11,799
2004-05	4,159	19,354	12,416
Poverty Ratio (2004-05)			
- Rural	42.59	6.35	28.29
- Urban	32.42	5.75	25.62
- All	41.99	6.16	27.62

Poverty ratio refers to percentage of population below poverty line as taken from Planning Commission, GoI, New Delhi.

Table 2: Productivity of Major Food grain Crops, 2003-04: Bihar, Punjab and India

(kg/ha)

S. No.	Crop	Bihar	Punjab	India
1	Rice	1386	3694	1978
2.	Wheat	1903	4200	2696
3.	Course cereals	1816	2675	1107
4.	Maize	1682	2982	1875

The 2 states have very different system of canal water distribution. Punjab's *warabandi* system is designed to have an equitable distribution of canal water, at least by design. Bihar does not have such a scientific system at all. The turn of head-reach and tail end farmers for distribution of canal water is not scientifically worked out by the state irrigation department. Discussion with Bihar government officers and local scholars indicates that since initially there was no water shortage in Patna, the efforts to develop an equitable system did not receive attention. After deterioration in the maintenance of the canal system, the issue of equitable distribution has assumed importance. In the absence of a *warabandi* system, the decision of the irrigation department to discharge water in the distributaries is influenced by the pressure exerted by different interest groups (stakeholders) for favoring their constituency.

3. SAMPLE SITES

Having chosen the 2 states for this study, the choice of site for intensive study involved the following steps: one irrigation project-within each state; a canal or distributory within a project; village (and district) in each project; and some stakeholders in each location of the distributory. Appropriate projects and sites were selected in district Jalandhar of Punjab and district Patna of Bihar. The basic information on the sample sites is contained in Table 3.

Table 3: Irrigation Project and the Sample Sites

Zone	State	Irrigation project	Reach/Location at the distributory	Village corresponding to reach/location
North	Punjab	Bist Daob canal (district: Jallandhar)	- Head - Middle - Tail	Mullah Bediyan Khanpur Sarali
East	Bihar	Sone Canal Maner distributory (district: Patna)	- Head - Middle - Tail	Dhanesar Pura Datiana Korhar

3. 1 Punjab

Cropping Pattern: In *Bist Doab* canal command area, the farmers grow three crops in each season - wheat, sugarcane and green fodder in kharif, and paddy, maize and vegetable (potatoes) in rabi. Some farmers also allocate land in limited proportion to grow mint during zaid season. The cropping pattern in the mid reach and tail end villages is quite similar to that observed is the head reach villages (Table 4). It is obvious that in both the crop seasons, the present cropping pattern is water intensive. The irrigation water requirement is met from canal as well as groundwater sources.

Table 4: Cropping Pattern of Villages located at different reaches: Jalandhar (Punjab)

Sl. No	Season	Crops at different reaches		
		Head	Middle	Tail end
1	Kharif	Wheat, Sugarcane & green fodder	Wheat, green fodder	Wheat, green fodder
2	Rabi	Paddy, maize & Potato	Paddy, maize	Paddy, maize
3	Zaid	Mint	Not specified	Not specified

Source: Group Discussion with village leaders / other stakeholders

3.1.1 Source of Irrigation

Groundwater is the major source of irrigation in all the selected villages. The area of head reach village is spread on both the sides of the canal with undulating topography, rendering one side of the canal unfavorable for gravity irrigation. The area under canal irrigation varies at different locations from one-fourth to one-half of the irrigated area. The major proportion i.e. 50-75% water requirements is met from groundwater. In the mid reach village, the irrigation water requirement is fulfilled by canal and groundwater sources in equal proportion. Because of insufficient supply of canal water at the tail end, it meets only less than one-fifth of the total irrigation requirement (Table 5).

Table 5: Source of irrigation at different locations: Jalandhar (Punjab)

S. No.	Source	Proportion (%) of irrigated area		
		Head	Middle	Tail
1	Canal water	25-50*	50	15-20
2	Groundwater	50-75	50	80-85

Source: Field Observations

(* This case is rather unusual due to undulating topography of the head reach village)

3.1.2 Groundwater Table

The discussion with the village elders and knowledgeable individuals shows that the depth of groundwater varies from location to location. According to the village leaders the water depletion has been faster in the last five years than in the previous years. The decline in the water table at the tail end (25 to 30 feet) is far greater than that observed at other reaches. Relatively higher decline in the water table at the head reach (10ft) than at the middle reach (2 to 3ft) is an uncommon phenomenon arising due to the peculiar undulating topography of the head reach village (Table 6).

Table 6. Depth of and Decline in Groundwater Table at Different Location. Jalandhar (Punjab)

Particulars	Location of selected villages		
	Head	Middle	Tail
Depth of Water Table (ft)	200-220	200-230	250-270
Decline in water table is the last 5 years (ft)	10	2-3	25-30

3.2 Bihar

3.2.1 Cropping Pattern

At the head reach villages, farmers grow paddy in kharif, and wheat in *rabi* season. In the middle reach paddy, maize and groundnut in kharif, and wheat and vegetables in the rabi season are grown. At the tail end, paddy, maize and green fodder in Kharif and wheat, gram and green fodder in rabi are the main crops (Table 7).

Due to the availability of sufficient water at the head reach the farmers allocate their land to water intensive crops such as paddy in kharif and wheat in rabi season. The cultivation of less water intensive crops like gram and mustard was absent. At the middle reach, the farmers allocate certain proportion to other crops such as maize and groundnut in kharif and vegetables in the rabi season. At the head and middle reach, the farmers also grow less water intensive crops (e.g; gram and green fodder). The proportion of agricultural land allocated to different crops varies significantly even within a location.

Table 7: Cropping Pattern of Villages located at Different Reaches: Patna (Bihar)

Sl no.	Season	Crop at different reaches		
		Head	Middle	Tail end
1	Kharif	Paddy, green fodder	Paddy, maize and groundnut	Paddy, maize, green fodder
2	Rabi	Wheat, green fodder	Wheat, vegetables	Wheat, gram and green fodder

3.2.2 Source of irrigation

A very clear pattern of relative use of surface and ground water across different reaches is noticeable. The contribution of surface (canal) water declines drastically as one moves from the head reach village to the middle reach, and finally to the tail end. Canal water meets more than 90-95% of irrigation requirement at the head reach, 40-50% requirement at the middle reach and none at the tail end (Table 8). The canal maintenance is so poor and the tail enders are almost totally deprived of canal water. Obviously, the dependence on ground water increases as one moves from head to the middle and then to the tail end. Since the availability of electricity is extremely limited and voltage fluctuations are high, the farmers have to reply mainly on diesel pump sets for lifting ground water. This is why tail end villages have quite a good number of diesel pump sets (approx 50). It was noticed that the problem of water scarcity has increased in recent years and almost 8-10 tube wells have been added at the tail end every year in the last three years.

Table 8: Main Source of Irrigation at Different Reaches / Location: Patna (Bihar)

S. No.	Source	Proportion (%) of Irrigated area		
		Head	Middle	Tail end
1	Canal water	90 - 95	40 - 50	Zero
2	Ground water	5 - 10	50 - 60	100

Source: As in table 1.

3.2.3 Ground Water Table

It is observed that the groundwater table varies across different reaches (Table 9). The fluctuation in the level of groundwater across seasons is relatively low at the head reach village. Low availability of canal water helped recharge groundwater at head reach and prevented decline in water table. In the villages located at mid and tail reaches the aquifer depleted at a fast rate in the last five years; example, by 10 ft in the middle reach and by 15 - 20 ft at the tail end.

Table 9. Depth of and Decline in Ground water Table at Different sites: Patna (Bihar)

Particulars	Location of selected villages		
	Head	Middle	Tail
Depth of water table (ft) 100-150	100-150	120-180	
Decline in water table in the last 5 years (ft)	Nil	8-10	15-20

4. DISCUSSION ON FIELD OBSERVATIONS

4. 1 Punjab

The main observations made on the basis of field visits are:

4.1.1 Unequal Access to Canal Irrigation

The accessibility to canal water at different locations varies significantly. Although it may be attributed partly to undulating topography, the major factor is the lack of accountability of irrigation department for maintenance of tributaries and water courses. Further, the rotational procedure of canal water distribution that is supposed to be revised every year[2] has not been changed for the last one decade. It is surprising that the local farming community has not taken up this issue with the irrigation department.

4.1.2 Concentration of Water Intensive Cropping Pattern

Water intensive crops like paddy and wheat are common in all locations in spite of canal water being scarce at the tail end. The shortage of canal water is compensated through ground water lifting.

4.1.3 Emergence of Alternative Institutional Arrangement

The irrigation department has failed in its responsibility of maintaining and developing the irrigation structures (Stephen, 2002). The void is being filled on a limited scale by an alternative institutional arrangement in the form of users' cooperation. Farmers took initiative to organize themselves to repair and construct water courses leading to improvement in accessibility of water. Those who did not participate in this venture did not benefit. This led to differences between the farmers' group. The farmers sorted the issue by making the process

[2] In certain areas, the rotation takes place on Diwali.

more inclusive. Farmers have succeeded in laying down cemented pipe lines in the fields to help eliminate potential disputes over water access. This collective effort was attempted at the minor irrigation level as well. The neighboring villages have also made similar arrangements. It is noteworthy that this has been achieved through farmers' own resources without any direct support from the irrigation department.

4.1.4 Absence of Canal Water Theft

In the sample sites, the incidences relating to water theft (or siphoning of canal water) were non-existent. It may be attributed to the spirit of vigilance among the farming community. This sends a strong signal that breaking water course and/or siphoning off water will be reported to irrigation authorities inviting stringent punishment.

4.1.5 Non-existence of Water Markets

In the selected villages, there is hardly any buying and selling of ground water. In a few cases if water is sold, it is because of social considerations, not for financial gain.

4.1.6 Charges for Canal Water and Electricity Use

In Punjab, as per the announcement made by the then government, the canal water and electricity used in agriculture were available without any charges or at very little cost. This has resulted in several adverse situations such as: (i) overdrawing of groundwater even beyond recharge capacity; (ii) revenue deficit and lack of resources for improving transmission expanding capacity for electricity board because of zero or small cost of electricity; and (iii) higher price of electricity for domestic use due to cross-subsidization (from Rs. 1/unit to Rs. 4/ unit in couple of years). The farming community has its own perceptions regarding such political concessions (Dubash, 2007; Kumar, 2005). They feel that free power is of no use to them in the long run. Since power is not available for more than 8 hrs/day, they would be willing to pay for power used for extraction of groundwater for improved quality and quantity.

4. 2 Bihar

The following main findings are based on field observations:

4.2.1 Unequal Access to Canal Water

It is obvious from Table 6 that the dependence on canal water for irrigation declines sharply from head reach to middle reach and tail end. The situation at the tail end is so bad that water has not reached there at all for the last so many years. In contrast, the head reach farmers' dependence on ground water is only 5-10% as they get a major part of their water requirement from canal water. As a result, the head reach farmers are able to devote a much higher proportion of their cultivated area to paddy and wheat.[3]

4.2.2 Extension of Command Area Causing More Scarcity ofWater

The village leaders mentioned that there was substantial water in Maner canal until 1964-65. Water from Sone river was diverted to the newly constructed canal that caused reduction of water in the Maner canal affecting the farmers adversely in its command area. Some of the farmers reported that they had taken up the matter of restoring the share of water in this canal with the irrigation department. It did not give any results due to lack of effective leadership and political support in favor of farmers in the command area of newly con-

[3]Figures on area under paddy and wheat are not given in Table 5 but this phenomenon was confirmed by the village leaders and panchayat functionaries. However, as a part of food security and survival strategy farmers at the tail end do grow paddy and wheat even though they obtain much less yield than obtained by the head reach farmers.

structed canal.[4] The expansion of canal network without commensurate increase in discharge of water has aggravated the difficulty of farmers, especially tail enders.

4.2.3 Negligence of Maintenance, Blockage of Canal and Conflicts

The canal has not been cleaned properly since almost 25 years. Whenever cleaning was undertaken it was done only in small segments which failed to maintain a free flow of water to farmers at different reaches. Water courses are also poorly maintained (Gulati et al., 2004). In certain cases, canals had eroded completely and resulted in unchecked water flow from one field to the other, leading to accumulation of excess water near the outlet. Farmers reported that such unregulated water flow causes loss of fertilizer applied in the fields located near outlet. Because of undulating land, the farmers with higher level of land tend to block distributory to raise water level and attempt to siphon it off to meet their water requirement. Influential and powerful farmers, mainly big land-lords with political clout are more likely to be involved in the blockage of canal irrigation than small and marginal farmers (Saleth, 2004).[5] This kind of activity on the part of some influential individuals in the area has provided too much of water at the mid reach village resulting in over-irrigation at those sites (interestingly, head reach farmers are not involved in it) and led to severe scarcity of canal water at the tail end villages.[6]

4.2.4 Emergence of Water Markets

During the summer, the shortage of water reaches up to one-third to one-half of the total requirement even at the mid reach. As mentioned earlier, since the canal water does not reach at the tail end, the farmers depend entirely on the ground water. The resourceful farmers have installed pump sets (mainly diesel) which enables them to draw ground water not only for their own use but also for sale to others. Well owners charge Rs.70 – 80/hr for water. It is observed that even poor farmers, including the marginal ones, manage to irrigate their land by buying water from other farmers. This of course, is done at a high cost in the absence of availability of canal water. The emergence of water market does help poor farmers to mitigate the extreme shortage of water partly (Barah, 1993; Meinzen-Dick, 1996; Vashishtha, 2003).

4.2.5 Emergence of Informal Institutional Arrangement

Certain informal institutional arrangements evolved to help the system from complete collapse. A group of farmers restored some water courses. This phenomenon is not prevalent in the entire village. This group was informal and included different category of farmers – big as well as small. Most of them had contiguous piece of land. However, it could not expand its base in the entire village. This group also approached the irrigation department, government of Bihar, for financial help to repair and maintain the channel and water courses but without success.

4.2.6 Encroachment on Canal Area

The villagers of tail end reported that since 1977, there was no availability of water in the canal. Taking advantage of this situation, some individuals encroached the land area. Surprisingly, a group used it even for construction of shelters. Due to unlawful activities at the tail end the canal bed area has shrunk and is now converted into a small drain.

4.3 Comparative Picture

No doubt, Punjab and Bihar case studies present a contrasting picture, they also have some broad similarities in respect of inequality in access to canal water and canal administration. Some of these aspects are presented below:

---

[4] Similar evidence was noticed in Haryana in Hansi-Bhutana link canal which was constructed in the recent past. The farmers in the adjacent canal command area protested and asked for restoring their original share of water prior to the construction of canal.

[5] A similar phenomenon is observed in Haryana by Vashishtha (2003).

[6] It was also reported that part of the scarcity is due to diversion of canal water for use in non-farm activities.

4.3.1 Tail Enders are the Most Deprived Lot

In both Punjab and Bihar, access to canal water is very low as compared to the head reach and mid-reach farmers. In Bihar, however, the tail enders are pushed to the extreme situation of almost complete deprivation in terms of access to water. The unchecked siphoning off of water from canal by powerful elements reflects the status of socio-political milieu in rural Bihar.

4.3.2 Neglect of Canal Maintenance and Watercourses

This aspect is common to both the states. In the case of Bihar, this neglect is pushed to a desperate level due to the virtual financial bankruptcy of the irrigation department. Irrigation rates are very low in both states and the state governments do not intend to offend the farmers by raising irrigation tariff. In Bihar, an additional factor is the low agricultural productivity and high rural poverty, which discourages the state government to face risk involved in raising tariffs. In Punjab, the level of productivity and poverty per se is not the major issue. However, the stagnant productivity and declining profit levels in agriculture production may be an important deterrent for the state government to raise tariff levels.

4.3.3 Socio-ecological Problems

Certain features common to both Bihar and Punjab may be noted: (i) availability of excess water and raising of water intensive crops at the head-reach irrespective of the overall shortage of water; (ii) significant decline in ground water table, especially at the tail end (decline in water table at the tail end is much sharper in Punjab than in Bihar). Since, the ground water table is already too low in Punjab and over-exploitation of groundwater has gone beyond the recharge capacity of aquifer in many places (Singh, 2006), the environmental consequences of decline in water table are more serious and imminent in Punjab than in Bihar; (iii) minor encroachment in canal and distributory takes place in Punjab too but in the case of Patna, (Bihar) encroachment in the form of settlement in the canal bed at the tail end is extreme; (iv) the political economy of very low power tariff (or zero tariff) for lifting ground water is quite similar in both states. However, the environmental negative externalities of power tariff policy are more serious and imminent in Punjab as compared to Bihar due to (a) the extent of over exploitation of ground water that has already taken place in Punjab; and (b) continuing incentives favoring water intensive crops (e.g. paddy) and discouraging crop diversification (Singh, 2007).

4.3.4 Water Markets

There is little evidence of water markets in Punjab. In contrast, in Bihar there exists market for ground water and the pump set owners charge Rs.70-80 per hour for supplying ground water to their neighbors. A plausible reason for absence of ground water markets in Punjab may be the widespread ownership of tube wells and pump sets by many farmers. This is facilitated by the reasonably high level of agricultural productivity (vis-à-vis all India), relatively larger average land holdings and consolidation of land holdings (Shah, 1993). In contrast, in Bihar, the productivity level is too low, average landing is small, and holdings are fragmented rendering installment of tube well and pump sets unaffordable by individual farmers. The ground water market in Bihar helps partly mitigate inequality in access to canal water even for the marginal farmers (Singh et al. 2007).

4.3.5 Informal Institutional Arrangement

In Punjab, the farmers managed to evolve an informal cooperative mechanism and pool their resources for repairing damaged water courses and laying down pipes through fields of different plot owners to minimize waste of water and avoid potential conflict. Siphoning off canal water is rare and there is respect for running the *warabandi* system. This is not observed in Bihar. The farmers attempted, on a very limited scale, to organize themselves and restored a few water courses. However, this experiment could not be extended to the entire village. The tiny land holdings, low productivity, fragmented society on caste basis and the apathy of the state

government machinery to the problems and difficulties of the people made the cooperative venture difficult to sustain. Further, lack of respect for allowing free flow of water by the unscrupulous and powerful elements is a big challenge to the poor and fragmented units to organize themselves into an effective and cohesive group. It is important to emphasize that a combination of factors (economic, social and institutional) poses a big problem for restoring a credible governance system for canal administration.

5. CONCLUSIONS

Poor distribution of canal water to the middle and tail end users has lead to sever and unsustainable withdrawal of ground water in Punjab and creation of water markets in Bihar. Addressing local institutions, the size and distribution of land holdings and support from public authority are a pre-requisite to bringing about any improvement in canal water distribution, preventing water losses and conserving ground water.

In case of Punjab, the environment is already conducive to surface water management since the size of landholdings is large, farmers have sufficient revenue to undertake repair, the *warabandi* system or system of taking turns for access to water already exists. If local institutions are more active and work with communities, they can have equitable distribution of water to the tail end users as well. In case of Bihar, the small size of land holdings and poor income of farmers act as major deterrents. Further, the institutions set up for management of canal water are inefficient and partial. The first step towards addressing distribution in Bihar would thus be reforming the institutions and making them more accountable.

Reasonably good level of agricultural productivity coupled with relatively large and consolidated land holdings do provide incentive for return in investment of a joint venture for repair of water courses and laying down of pipes to avoid wastage of water, the factors that are missing in Bihar.

ACKNOWLEDGEMENT

This paper is a part of the study 'Unequal Access to Canal Water and Options for Conflict Resolution: An Exploratory Study' conducted in 2007 with financial support from India Water Partnership.

REFERENCES

Barah, B.C; V. Narsimha Reddy, B. Ratna Reddy; B. Gopi; J. Ramdas Reddy; K. Chadersekhar Reddy and Srinivas Rao (1993), Economics of Water Sharing in Drought Prone Area (Part-I), department of Economics, University of Hyderabad (mimeo).

Dubash Navroz K (2007), The Electricity-Groundwater Conundrum: Case for a Political Solution to a Political Problem, *Economic and Political Weekly,* Vol. 43 (52).

Gulati, Ashok, Ruth Meinzen-Dick, K. V. Raju (2004), Institutional Reform in Indian Agriculture, SAGE Publication, New Delhi.

Kumar, M. Dinesh (2005), Impact of Water Prices and Volumetric Water Allocation on Water Productivity: Comparative Analysis of Well Owners, Water Buyers and Shareholders, IWMI-TATA water Policy Program, Vallabh Vidyanagar, Gujarat.

Meinzen-Dick, Ruth (1996), Groundwater Markets in Pakistan: Participation and Productivity, International Food Policy Research Institute Washington, DC.

Merrett, Stephen (2002), Water for Agriculture: Irrigation Economics in International Perspective, Spon Press, London.

Morriss Andrew P (2007), Incentives Matters: The Case for Market Valuation of Water in Baru Mittra, Kedra Okonski and Mohit Satyanand (Eds.) Keeping the Water Flowing, Academic Foundation, New Delhi.

Palmer-Jones, Richard (1994), Groundwater Markets in South Asia: A Discussion of Theory and Evidence in Marcus Moench, Selling Water: Concept and Policy Debates over Groundwater Markets in India, VIKSAT, Pacific Institute, Natural Heritage Institute.

Saleth, R. Maria (2004), Strategic Analysis of Water Institutions in India: Application of a New Research Paradigm, Research Report 79, International Water Management Institute, Colombo.

Shah, Anil C (2001), 'The Deprived in a Command Area of an Irrigation System', Development Support Centre, Ahmedabad (mimeo)

Shah, Tushaar. (1993), Groundwater Markets and Irrigation Development: Political Economy and Practical Policy, Oxford University Press, Bombay.

Singh, Karam (2006), Groundwater in Punjab, Government of Punjab.

Singh, Ashish Kumar, A. K. Chaudary and D. K. Sinha (2007), Groundwater marketing in Nalanda District of Bihar: A socio-economic Appraisal, Agricultural Economics Research Review, Vol. 20 (2).

Singh, Dalbir (2007), Who Gains and Who Loses in the Game of Groundwater Markets in Water-scarce Regions, Agricultural Economics Research Review, Vol. 20 (2)

Vashishtha, Prem S (2003), Tail Enders and other Deprived in an Irrigation System in Haryana, Research Study No. 2003/1, Agricultural Economics Research Centre, University of Delhi, New Delhi (Mimeo).

Vashishtha, Prem S (2007), Tail Enders and other Deprived in an Irrigation System in Haryana - Executive Summary, in Jharwal and R. S. Deshpande (Eds.), Glimpses of Indian Agriculture, Academic Foundation, New Delhi.