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Tradable Water Rights and Efficient Water Allocation: Results from a Field Experiment in Bhavani River Basin, Tamil Nadu, India.

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Abstract

This paper is based on a study which aimed at exploring the feasibility of introducing a market-based economic instrument namely, the tradable water rights, for efficient surface water allocation within the agriculture sector in the Indian context. Focusing on a 'water scarce' river basin namely, the Bhavani River Basin in Tamil Nadu state in India, the study attempts to estimate willingness to pay (WTP) and willingness to accept (WTA) values of the respective buyers and sellers of 'excess' water available with the latter, in order to assess the potential gains from water trade under the proposed tradable water rights regime in the basin. Based on the WTP and WTA values derived from a contingent valuation-based field experiment conducted within a repeated interaction framework, the study found that the average WTP values of the buyers exceeds the average WTA values of the sellers thereby paving way for market exchange on excess water at least among sixty percent of the farmers across different canal systems in the basin. The study concludes that introducing the tradable water rights as an alternative institutional mechanism will lead to more efficient allocation of water, generating substantial efficiency gains in the agriculture sector. The policy and other institutional arrangements required for implementing the tradable water rights system are also underlined.

Key Words: tradable water rights, efficient water allocation, willingness to pay/willingness to accept compensation, Bhavani river basin, India

1. Introduction

The problem of ever increasing relative scarcity of water puts a substantial amount of economic and environmental constraints on achieving the development objective of efficient, equitable and sustainable agriculture (Bjornlund, 2004). One of the major policy challenges, in developing countries like India, is how to efficiently reallocate the scarce water within agriculture since the scarcity induced social costs impose extra marginal welfare loss to the already 'distressed' farmers. Of late, the causal relationship between over-extraction of water and unsustainable agricultural development has been recognized as to arise from an 'institutional failure' in the relevant sectors (Young, 1986). Such a failure arises from the fact that: a) the already existing formal institutions (such as, policies, laws, constitution, etc) and informal institutions (such as, attitude, perception, etc) governing water management are not conducive for efficient allocation of water and these institutions, in certain cases, constantly interact with each other to produce significant amount of welfare loss (see Dixit, 2004); b) those transaction cost minimizing, efficient institutions (Brewer *et al*. 2007) that are assumed to bring in efficiency in water use do not usually emerge in the scenario because of various reasons that include existence of imperfect information, imperfect competition and pervasive negative externality (Dixit, 2004) in the water sector. In recent years, researchers have identified economic agents to adopt 'boundedly rational behavior' (Camerer *et al*. 2005) which implies that inefficient use of water in agriculture sector may become robust if there exists a substantial number of boundedly rational water users in that sector; again, the underlying institutions are identified to be instrumental in influencing such a behavior. Hence, water sector reforms with more emphasise on incentive-based institutional arrangements have been proposed as well as implemented in some of the developing countries in recent past (Saleth and Dinar, 2004) and the results of these reforms are mixed in nature. Though the phrase 'institution matters' (North, 1994) has been successfully incorporated as part of developmental policies, carving out an 'appropriate institution' for addressing a particular development issue has not yet been so successful; the uncertainty, complexity and heterogeneity of institutions in the water sector pose a great challenge for the researchers to explore 'site-specific' appropriate institutions for efficient water allocation. This paper is an attempt towards that end.

2. Institutional Reforms -Background

The early reforms in the water sector were based on the slogan of 'getting the price right' (see Sampath, 1992). Real world experiences suggest that 'pricing' of irrigation water runs into many different problems embedded in economic and political arena. On the economic front, the pricing decision is not based on the scarcity value of water use (i.e. the opportunity cost of water use which reflects the total economic value (see Freeman III, 2003) so that water can be transferred to its highest value in use. Rather, such a decision is based on arbitrary methods due, in many cases, to difficulty in scientifically measuring such value; the price does not reflect the actual preferences of the farmers ultimately resulting in an anomaly between the price and the farmers' willingness to pay for water. On the political front, any effort to put a price on water is constantly opposed by the farmers' organisations and political lobbies and hence, the indented objectives of pricing (such as, revenue generation and optimal water use) may not adequately be realized if the policymakers are more inclined towards these political concerns. Moreover, mere pricing without improving service delivery and institutional arrangements for the willing farmers to transfer water to other users will not yield any fruitful result. Another approach that was adopted in the irrigation reforms was, 'getting the property rights right'. Measures that transfer certain important responsibilities from the governments to the farmers, such as, Participatory Irrigation Management (PIM), are considered to fall within this broader approach. However, the empirical studies that looked into the performance of such measures in some of the canal systems in India suggest that this approach has also not been effective in brining desirable outcomes in the irrigation sector (see Durba and Venkatachalam, 2010; Marothia, 2005).

Since many experiments attempted with narrow, supply-side orineted approaches have failed in the past, an institutional approach with a slogan of 'getting the institutions right' is being attempted in recent years. A substantial part of this approach deals with how to exploit the market-based instruments (MBIs) to allocate surface water across different uses, provided a 'facilitating' role is being played by other institutions such as, government, river basin authority and water user associations. Empirical evidences from different parts of the world suggest that out of all MBIs, the 'tradable water rights' (TWRs) are found to be more efficient in allocating water among competing uses (Griffin, 1998; Thobani, 1998; Thobani, 1997). They are more incentive-based and the price mechanism which navigates the exchange of TWRs does reflect the preferences of the farmers influenced by the underlying factors, including level of water scarcity. It is found that this approach, if appropriately regulated, provides adequate incentives for the farmers to: a) make use of the water that they are entitled for more efficiently, b) develop efficient infrastructure on their own, and c) explore innovative technologies to sustain water use efficiency on a long-term basis (see Bruns *et al*, 2005; Bjornlund, 2004; Thobani, 1998; Rosegrant and Binswanger, 1994; Rosegrant and Gazmuri, 1994). Nevertheless, there are skeptics who cite existence of large number of small farmers and huge transaction costs involved in monitoring informal water extraction to be curbing the trade in water rights (see Shah and Koppen, 2005). Despite these skepticisms, we in the present study empirically demonstrate that with appropriate institutional arrangements, one could achieve potential Pareto improvements in water use efficiency from introducing ‘tradable water rights’ system for surface water in the Indian context; this is reflected in terms of farmers’ willingness to pay (WTP) and willingness to accept (WTA) compensation for transferring water from less productive use to more productive use within the agriculture sector in the context of Bhavani River basin, Tamil Nadu, India.

3. Description of the Bhavani River[1]

River Bhavani, though perennial, experiences the problem of relative scarcity of water due to both intra-sectoral and inter-sectoral demand for limited amount of water. The river originates from the Silent Valley forests of Kerala, flows towards south-eastern direction up to Mukkaliyar and then after running for 217 kms east-ward, it confluences with river Cauvery at a town called, Bhavani. Its major tributaries are the Siruvani, Pykara, Kundah, Kallar and Moyar. The river gets flood water during the south-west monsoon period since it originates in the Western Ghats. The Bhavanisagar dam is the largest dam constructed in the Bhavani River. It provides irrigation for about 2,47,243 acres in its command area through four canal systems namely, Arakkankottai, Thadappalli, and Kalingarayan which come under the ‘Old Canal System’ (hereafter, Old System) and the Lower Bhavani Project (LBP) canal coming under the ‘New Canal System’ (hereafter, New System).

[1] The information used under this heading is extracted from a report entitled, History of the Lower Bhavani Project (Volume II- Canals) prepared by the Government of Madras in 1966.

Table-1: District-wise Catchment Areas of the Bhavani Sub-basin in Three States.

State/Districts	Catchment Area (in Sq. Km.)	Percentage to the Total Area
Tamilnadu State		
1. The Nilgiris District	1,881	31
2. Coimbatore District	1,002	16
3. Erode District	2,469	40
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Total	5,332	87
Kerala State		
Palaghat District	562	9
Karnataka State		
Mysore District	240	4
Total	**6,154**	**100**

Source: National Water Development Authority, Water Balance Study of Bhavani Sub-Basin, New Delhi in 1993

3.1 Old Canal System

Four hundred years back, a Rayar King of the then Mysore State built up the Kodiveri anicut on the downstream of the now Bhavanisagar dam to divert water to Thadappalli canal (on the right-side of the anicut) and Arakkankottai canal (on the left-side). The Thadappalli canal was constructed in the year 1855; it was renovated and sluice gates were installed in the year 1919. The length of the Tadapalli canal including the branches is 90 miles and it has an ayacut area of 17,500 acres. It has two branch canals namely Singiyam canal and Kugalur canal. Arakkankottai canal was constructed during 1870-1877 and it is 34 miles long and irrigates about 7000 acres. It has also got two branch canals namely, Vaniputhur canal and Perumugai Atthani canal. Water in the main canals is opened for irrigation from April 15 to February 15 (a period of 10 months) to facilitate three crops during a crop year. Kalingarayan canal was constructed by a local philanthropist called, Kalingaraya Gounder, 600 years back at the confluence point where the Bhavani River joins with Cauveri. The total length of the canal is 56.2 miles and was designed to irrigate 8000 acres. Later on, it was extended to irrigate a total area of 15743 acres. Water in this canal is opened for irrigation from the month of June 16 to April 30 (a period of ten and half months) irrigating three crops per crop year. Altogether, the old canal system consists of an irrigated area of 32500 acres and the farmers in this canal system have the senior appropriation right to use the water.

3.2 New Canal System

The LB is the first major irrigation project completed after India's Independence. The work started in the year 1947 and completed in the year 1955. The purpose of establishing the LBP was to divert the excess water available within the catchment area during the flooding season, to the dry areas of the downstream region. Total ayacut area of the LBP irrigation system is 2,07,000 acres. In the LBP, a 'turn system' is being followed to regulate the scarce water available for cultivation. A total quantity of 24 TMC (thousand million cubic feet) of water is being released for the 'wet crops' such as paddy and sugarcane during the first turn and the irrigation period starts usually in 15th August and ends in 15th December. During the 'first turn', only half of the total ayacut area (i.e. 1,035,000 acres) of the canal is being irrigated. During the 'second turn', which starts from 16th December and ends in 15th March, a total quantity of 12 TMC water is being released for cultivating 'dry crops' such as, turmeric, cereals and oil seeds, etc in the remaining half of the ayacut area.

Water in the Bhavani basin has become a scarce commodity because of constantly increasing opportunity cost of water use in different sectors such as, agriculture, domestic and industry sectors. Within the agriculture sector, unresolved conflicts over water, especially between the farmers in the Old System and the New System, have come to occupy the centre stage of the water management in the Basin. Similarly, upstream-downstream conflicts and head-reach and tail-reach conflicts are well known phenomena within each canal system (see Lennerstad and Molden, 2009). This means that small changes in water use efficiency in an area with less water use efficiency have the potential to significantly reduce water scarcity and the associated social costs in other parts of the basin. The research question here is, why despite potential Pareto improvements the water is not being transferred to its most efficient use within the basin? There are two reasons: a) the command-and-control method being followed by the government in allocating water in the basin is not conducive for putting scarce water in its most efficient use; and b) the farmers in the Old System have their 'senior appropriation rights' over irrigation water and therefore, they resist any reduction in its supply even though the entire amount of water released to their canal system is not fully utilized. Though the changes in land use and cropping pattern have been favourble for saving significant amount of water in the Old System, the existing institutions do not provide any incentive for them to transfer water to the New System where water-productivity is relatively higher than other systems in the basin (Palanisamy and Ramesh (n.a)).

4. Methodology

In order to estimate the potential gains from water transfer under our proposed tradable water rights regime, the 'contingent valuation' (CV) survey (Venkatachalam, 2004) was used to elicit the farmers' WTP and WTA values for possible water transfer. Voluntary exchange in water will take place only when: (a) there are potential buyers and sellers in the basin, who would prefer to transfer some portion of their irrigation water through 'voluntary' market exchange; and (b) the average WTP value of potential buyers is greater than the average WTA value of potential sellers. Through primary survey, we identified potential sellers and buyers of 'tradable' water across different canal systems in the river basin. The potential sellers are those farmers who are: a) not willing to use their entitled water for cultivation, temporarily; b) willing to use lesser amount of their entitled water for a given crop which will leave them with some amount of excess water; c) willing to switch over from a high water intensive crop to a less water-intensive one; and d) willing to adopt water conserving technology generating 'tradable water'. The buyers are all those who are willing to pay for additional water for irrigation. The selling and buying decisions of the farmers are *ex-ante* decisions and taken at present for the immediate, next season of cultivation (i.e. January 2008 to April, 2008 season).

In order to estimate the WTP and WTA values, we have used CV experiment within a 'repeated game theoretic framework[2]' (Plott and Zeiler, 2005; Shogren *et al.* 1994; Taylor, 2006). From the buyers and sellers identified, we elicited, in the first round, their initial WTP and WTA values for specific amount of additional water to be purchased and sold, respectively. This initial round was conducted as a 'one-shot game' where the respondents were asked to state their maximum WTP value/minimum WTA value, based on the CV scenario[3] communicated to them; in this round, the respondents had no idea about the bid

[2] This is explained in the analysis part in the subsequent section.

[3] In the CV scenario, the potential buyers of water were asked to state their maximum WTP for water equivalent to 10 irrigations for the next cropping season in case the irrigation water will be supplied to them under the condition of payment. Similarly, the potential sellers were asked to state their minimum WTA compensation for selling water equivalent to 10 irrigations, in case they could save such amount of water without affecting crop growth. Prior to asking the WTP and WTA questions, the farmers were told that a new 'tradable water rights system' will be introduced in the Bhavani River Basin and a River Basin Board, consisting of representatives

values stated by other respondents and whatever the value that they stated was based on their own individual preference. We recorded all these values.

In the next round, we conveyed[4] to 'all' the buyers the minimum WTA value of that respondent whose WTA value was the highest among all the sellers. All the buyers then were asked whether they would be willing to revise (both upwards and downwards) their WTP bid based on the WTA bid made known to them. The answer was recorded properly. Similarly, the WTP value of that respondent whose bid was the lowest among the buyers was communicated to the sellers and the sellers were asked to revise their WTA values accordingly. In the third round, we repeated the same procedure with the 'new' highest WTA and lowest WTP values. We stopped with three rounds since none of the farmers were willing to revise their bids any more. The values in all the rounds have been derived by using a 'scientifically' conducted CV survey[5]. The CV scenario consisted of the good under valuation (i.e. five rounds of irrigation on per acre basis), payment vehicle (i.e. in terms of tradable permits equivalent to five irrigation per acre), institutional mechanism through which water trade will take place (i.e. a centralized authority who coordinates buying and selling of permits), frequency of trade (i.e. once prior to start of cultivation season) and debriefing questions and 'cheap talk' information to ensure that the respondents are giving valid answers. In this way, we ensured the overall validity of the CV results. The results of our study are discussed in the following section.

4.1 Sampling

For the present study, we have selected a sample of 310 farmers across all the canal systems in the Bhavani basin. Using 'purposive sampling', around 52 percent of the farmers (162) were selected from the Old System that consists of Arakkankottai Canal, Kalingarayan Canal and Thadappalli Canal and the remaining 48 percent of the farmers were selected from the New System (i.e. the LBP Canal). Out of 162 sample farmers selected from the Old

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from all the stakeholders, will be created for coordinating the water trade between buyers and sellers. The farmers were told very clearly that their current entitlement for water will never get affected under the tradable rights system; their decision on whether to make use of the entitled water for their own purpose or sell it to others (or buy the water from others) is purely their own private decision.

[4] The initial interview of all the farmers was conducted through 'personal interview'. But the subsequent rounds were conducted through 'telephonic survey' where we conducted the interview through mobile phones. During the first round, we informed the farmers that we would get back to them over their mobile phones with further questions on the WTP/WTA values that they had stated during the first round. Since all the sample farmers own mobile phones, we could minimize the transaction cost conducting the repeated experiments with the farmers.

[5] Scientifically used CV survey is the one which takes all possible measures - as much as possible - to reduce biases and errors that could potentially infect the true values.

System, around 46 percent of the farmers belongs to the Arakkankottai Canal, around 13 percent belongs to Kalingarayan Canal and the remaining 41 percent belongs to Thadappalli Canal. Out of the total sample farmers selected, the largest number of sample farmers (148 or 47.7 percent) have been selected from the LBP canal, while the smallest number of them (21 or 6.8 percent) have been drawn from the Kalingarayan Canal. The number of sample farmers representing the remaining two canal systems is more or less equal, with the sample farmers representing the Arakkankottai Canal being slightly greater (by 2.30 percent) than that of the Thadappalli Canal. Though the distribution of sample farmers across different canal systems is unequal, for fulfilling the major objective of the study –namely, to analyse the possible ‘voluntary exchange’ of water between potential sellers and buyers -we have ensured equal distribution of sample farmers across the Old System and New System (see Table below).

Table -2: Canal-Wise Distribution of Sample Farmers.

Canal System		**Number of Sample Farmers**	**Percentage**
Old System	Arakkankottai	74	23.90
	Kalingarayan	21	06.80
	Thadappalli	67	21.60
New System	LBP	148	47.70
Total		**310**	**100.00**

Source: Computed from Primary Data.

5. Results and Discussion

Before going into the details of the WTP and WTA results, let us discuss the general information about the agriculture and water related aspects of the sample farmers.

Table -3: Landholding Size of the Sample Farmers across Different Canal Systems –Reach-wise.

Canal	Reach	Mean	Median	Std. Deviation	Minimum	Maximum
Arakkankottai	Middle	8.11	5.00	7.46	1.00	37.00
	Tail	10.38	10.00	5.73	4.00	22.00
	Overall	**8.45**	**6.00**	**7.24**	**1.00**	**37.00**
Kalingarayan	Head	3.57	2.00	2.63	1.00	7.00
	Middle	2.04	2.00	1.07	1.00	5.00
	Tail	3.50	3.50	2.12	2.00	5.00
	Overall	**2.69**	**2.00**	**1.88**	**1.00**	**7.00**
LBP	Head	7.09	6.00	5.19	0.50	25.00
	Middle	2.50	2.50	00.00	2.50	2.50
	Tail	6.79	5.00	7.08	1.00	40.00
	Overall	**6.96**	**5.00**	**5.82**	**0.50**	**40.00**
Thadappalli	Middle	3.94	2.25	3.29	1.00	10.00
	Tail	5.81	3.00	8.79	0.75	45.00
	Overall	**5.07**	**2.75**	**7.16**	**0.75**	**45.00**
All	Head	6.86	6.00	5.13	0.50	25.00
	Middle	6.26	4.50	6.52	1.00	37.00
	Tail	6.72	4.50	7.69	0.75	45.00
	Overall	**6.62**	**5.00**	**6.48**	**0.50**	**45.00**

Source: Computed from Primary Data.

The average land holding size of the sample farmers in the basin is estimated to be at 6.62 acres (see Table-3). In terms of size of land holding, the Arakkankottai farmers stand first with 8.45 acres, followed by the LBP farmers with 6.96 acres. Farmers in the Kalingarayan canal own smaller size of land on an average, compared to the farmers in other canals. It should be noted that the size of land holding does not differ much across different reaches of the canal system. Altogether, the land holding size of the sample farmers suggests that many of the farmers in the Bhavani basin belong to the ‘medium’ farmers’ category. For example, the frequency distribution of the land holding size of the sample farmers reveals that around 54 percent of them own land between 5 acres and 10 acres while another 20 percent farmers owning land between 2.5 acres and 5 acres. Remaining 24 percent of the sample farmers belong to 'marginal farmers' category, owning less than 2.5 acres of land. Out of all the sample farmers, only 2.6 percent of the farmers own land exceeding 25 acres.

Table-4: Major Crops Being Cultivated by the Farmers at Present –Canal-wise.

		Canal System				
		Arakkankottai	**Kalingarayan**	**LBP**	**Thadappalli**	**Total**
Crops Cultivated	Paddy	**46** (38.33) (62.16)	**3** (2.5) (14.28)	**40** (33.33) (27.02)	**31** (25.83) (47.69)	**120** (100.00) (38.96)
	Sugarcane	**9** (07.89) (12.16)	**2** (01.75) (9.52)	**70** (61.40) (47.29)	**33** (28.94) (50.76)	**114** (100.00) (37.02)
	Banana	**8** (44.44) (10.81)	**2** (11.11) (9.52)	**8** (44.44) (5.40)	**0** (00.00) (00.00)	**18** (100.00) (05.84)
	Other crops	**11** (19.64) (14.86)	**14** (25.00) (66.66)	**30** (53.57) (20.27)	**1** (01.78) (01.53)	**56** (100.00) (18.18)
Total		**74 (100.00)**	**21 (100.00)**	**148 (100.00)**	**65 (100.00)**	**308 (100.00)**

Source: Computed from Primary Data.

Table-4 explains the details about the primary crops being cultivated by the sample farmers in different canal systems during the cropping season–i.e. April –August, 2008. Out of 310 sample farmers, 308 farmers cultivate at least one primary crop during the reference period. The cropping pattern in the Bhavani basin at the time of the study suggests that paddy and sugarcane –the highly water intensive crops -are those two crops being cultivated by majority of the farmers (76 percent). Banana is being cultivated by around 6 percent of the farmers, constituting third single largest crop being cultivated in the basin. Around 18 percent of our sample farmers cultivate one of the 'other crops' namely, turmeric, oil seeds, etc, as the primary crop.

As far as paddy growers are concerned, a larger percentage of them are in the Arakkankottai canal (38.33), followed by LBP (33.33 percent) and Thadappalli (25.83 percent) canals. Out of 120 sample farmers cultivating paddy as a primary crop, only 2 of them (i.e. 2.5 percent) are in the Kalingarayan canal. In the case of sugarcane farmers, a larger percentage of them (i.e. 61.40 percent) are located in the LBP, than in other canal systems. Around 29 percent of the sugarcane farmers are in the Thadappalli canal system, followed by Arakkankottai (07.89 percent) and Kalingarayan (01.75 percent) systems. In the case of farmers cultivating banana, around 44.00 percent of them are in the Arakkankottai canal and an equal percentage of them in the LBP system. Only 11.11 percent of the banana growers are found in the Kalingarayan canal, while no sample farmer in the Thadappalli canal cultivates banana. In the case of farmers cultivating ‘other crops’, we found that a larger percentage of farmers in this category belong to the LBP canal (53.57), followed by Kalingarayan (25.0 percent), Arakkankottai (19.64 percent) and Thadappalli canal (1.78 percent) canals.

Let us now see the distribution of sample farmers cultivating different crops ‘within’ a canal system. In the case Arakkankottai canal, around 62 percent of the sample farmers cultivate paddy followed farmers cultivating ‘other crops’ (14.86 percent), sugarcane (12.16 percent) and banana (10.81 percent). In Kalaingarayan canal, a large number of farmers (around 67 percent) primarily cultivate ‘other crops’ while 14.28 percent farmers cultivating paddy, and 9.52 percent cultivating sugarcane and banana each. In LBP, a majority of sample farmers cultivate sugarcane as the primary crop (i.e. 47.29 percent), followed by paddy growers (27.02 percent), cultivators of ‘other crops’ (20.27 percent) and banana cultivators (05.40 percent). In Thdapalli canal, the farmers are dominated by the sugarcane growers with 50.76 percent, followed by paddy cultivators (47.69 percent). There is only one sample farmer who cultivates ‘other crop’ as a primary crop, in this canal.

What lesson one can learn from the above analysis? On an average, majority of the farmers in the Bhavani basin cultivates those two major crops namely, paddy and sugarcane that are ‘relatively high water intensive’ in nature. In the LBP canal where there was a restriction for cultivating water intensive crops like paddy and sugarcane, around three fourth of the farmers do indeed cultivate these two crops as primary crops. This has larger implications on the use of already scarce water in the LBP canal system. This means that since these farmers will not easily switch over to less water intensive crops due lack of incentives provided by the present system, their demand for water in the future is expected to be at least at the current level. Moreover, sugarcane cultivation requires water continuously for at least 10 months and the ‘regulated water supply’ (‘Odd Sluice’ versus ‘Even Sluice’) in the LBP system should have discouraged the farmers to cultivate sugarcane. However, nearly 47 percent of the farmers cultivate sugarcane and this suggests that despite the ‘turn system’ being follwed in the LBP at present, the farmers in this canal are somehow able to get constant supply of irrigation water to grow sugarcane. The LBP farmers incur substantial amount of transaction costs to get continuous water supply especially, for long term crops. If the tradable water rights are introduced, the LBP farmers will have incentive to buy additional water required for growing long-duration, water-intensive crops from those farmers with excess water at a relatively lower level of transaction cost. Another important aspect to be noted is that even during the 'wet crop' season, a significant number of farmers cultivate 'other crops' which are mainly dry irrigated crops in nature. This means that these farmers 'voluntarily' forego certain portion of their entitled water during this season. So, proper incentives would make them to save this excess water properly and transfer it to the needy ones. Again, the 'turn system' followed in the LBP canal is not an incentive compatible one –though it is claimed to be a desirable 'adaptation strategy' devised by the farmers (Lennerstad and Molden, 2009). For example, during a particular season where the 'odd sluice farmers' are supplied with water, the farmers under the 'even slices' are not able to cultivate their land even if they are willing to pay a very high price for water. So, the present system of water allocation is not highly efficient since the water is not allocated to its 'most efficient use'.

Table-5: Annual Net Farm Income Received by the Sample Farmers across Different Canal Systems –Reach-wise.

Canal	**Reach**	**Number of Farmers**	**Mean**	**Median**	**Std. Deviation**	**Minimum**	**Maximum**
Arakkankottai	Middle	63	118333.33	75000.00	149205.85	10000.00	768000.00
	Tail	11	125454.54	50000.00	186204.92	10000.00	500000.00
	Overall	**74**	**119391.89**	**65000.00**	**153830.79**	**10000.00**	**768000.00**
Kalingarayan	Head	7	75714.28	40000.00	90895.02	10000.00	260000.00
	Middle	12	83416.66	57000.00	81745.12	10000.00	322000.00
	Tail	2	60000.00	60000.00	14142.13	50000.00	70000.00
	Overall	**21**	**78619.04**	**50000.00**	**78836.84**	**10000.00**	**322000.00**
LBP	Head	101	94742.57	50000.00	110261.38	10000.00	500000.00
	Middle	1	25000.00	25000.00	-	25000.00	25000.00
	Tail	46	70119.56	50000.00	80031.88	10000.00	500000.00
	Overall	**148**	**86618.24**	**50000.00**	**101919.39**	**10000.00**	**500000.00**
Thadappalli	Middle	26	75125.00	47500.00	100366.85	10000.00	500000.00
	Tail	41	88395.12	30000.00	144407.62	10000.00	750000.00
	Overall	**67**	**83245.52**	**40000.00**	**128439.46**	**10000.00**	**750000.00**
All	Head	108	93509.25	50000.00	108846.92	10000.00	500000.00
	Middle	102	102296.56	60000.00	131678.44	10000.00	768000.00
	Tail	100	83497.00	50000.00	123049.60	10000.00	750000.00
	Overall	**310**	**93170.80**	**50000.00**	**121156.83**	**10000.00**	**768000.00**

Source: Computed from Primary Data.

The details of annual 'net farm income' obtained by the sample farmers are available in Table-5. The correlation between landholding size and the net farm income is highly significant. This means that larger size of land holding is associated with larger farm income. The average net farm income for all the sample farmers is estimated to be at Rs. 93170 per annum. As in the case of average land holding size, the average net farm income of the farmers in the Arakkankottai canal is also found to be greater than the overall average; for the farmers in the other three canal systems, it is found to be lesser than the overall value. However, the median values of the net farm income for Kalingarayan and LBP canals that the net farm income derived by majority of the farmers in the basin is more or less equal to what the farmers in the LBP and Kalingarayan canals are getting. The median value for the Arakkankottai farmers is greater than the overall median value, while that of the Thadappalli farmers is lesser.

Table-6: Per Acre Net Farm Income Received by the Sample Farmers across Different Canal Systems –Reach-wise.

Canal	Reach	Mean	Median	Std. Deviation	Minimum	Maximum	Range
Arakkankottai	Middle	18296.31	10555.55	17653.31	2000.00	80000.00	78000.00
	Tail	12360.44	5000.00	17085.45	2000.00	60606.06	58606.06
	Overall	**17401.86**	**10000.00**	**17582.46**	**2000.00**	**80000.00**	**78000.00**
Kalingarayan	Head	28367.34	10000.00	45001.55	6666.67	130000.00	123333.33
	Middle	42750.00	40000.00	29102.09	5000.00	107333.33	102333.33
	Tail	19500.00	19500.00	7778.17	14000.00	25000.00	11000.00
	Overall	**35741.49**	**25000.00**	**33930.25**	**5000.00**	**130000.00**	**125000.00**
LBP	Head	18180.05	10714.28	24454.04	2000.00	160000.00	158000.00
	Middle	10000.00	10000.00		10000.00	10000.00	.00
	Tail	15992.59	10000.00	16855.53	2500.00	100000.00	97500.00
	Overall	**17444.89**	**10166.66**	**22252.71**	**2000.00**	**160000.00**	**158000.00**
Thadappalli	Middle	30852.41	14125.00	51958.84	4000.00	250000.00	246000.00
	Tail	17365.79	10833.33	14680.36	2222.22	62500.00	60277.78
	Overall	**22678.70**	**12458.33**	**34810.29**	**2222.22**	**250000.00**	**247777.78**
All	Head	18840.34	10523.80	26053.54	2000.00	160000.00	158000.00
	Middle	24351.82	15000.00	32165.10	2000.00	250000.00	248000.00
	Tail	16214.70	10000.00	15782.25	2000.00	100000.00	98000.00
	Overall	**19803.72**	**11013.88**	**25775.53**	**2000.00**	**250000.00**	**248000.00**

Source: Computed from Primary Data.

In the case of annual net farm income per acre, we get a different picture (see Table - 6). The farmers in the Kalingarayan canal are getting highest level of annual net farm income per acre (with Rs. 35741.49). While the farmers in the Thadappalli canal obtain net income per acre exceeding the overall average value of Rs. 19803.72, the farmers in LBP[6] and Arakkankottai get lesser income than the overall average. The median values of income also support these findings. Another interesting aspect is that some of the farmers obtain a net income of Rs. 2000.00 per acre per annum, which is a very small amount. In many cases, it is the 'tail reach' farmers who get the lowest per acre income while the 'middle reach' farmers getting the highest level of income per acre. Around 5 percent of the sample farmers obtain

[6] It should be noted that the LBP farmers get irrigation only for two seasons in a year while the farmers in other canals get irrigation for three seasons. However, the average net farm income of the LBP farmers is comparable with that of the farmers in other canal system. This is because of the fact that the productivity in the LBP canal is grater than that of other canal systems.

an annual per acre income of less than R. 2500.00, while 18 percent getting more than Rs. 25000.00. Since cultivating water intensive crops generates more amount of farm income, the farmers who are assumed to be rational in their decision would be expected to cultivate largely the water intensive crops pushing the demand for irrigation water in the coming years.

6. Analysis of WTP/WTA Values for Water

If the new institutional arrangement in the form of tradable water rights has to be introduced in the Bhavani basin, then a necessary condition is that the WTP for tradable water by the potential buyers should exceed the WTA compensation for the same by the potential sellers. To identify such buyers and sellers, we have used a specific technique during our field survey. Each one of the sample farmers was asked to provide details such as, crops cultivated in the past season, crops to be cultivated in the coming season, water availability for the crops to be cultivated, current irrigation practices being followed, best irrigation practices that they intend to follow in future, awareness about the minor irrigation systems, etc. Based on these information, each farmer was asked whether he would be willing to generate ‘excess water’ (which can be ‘tradable’) from the irrigation water they are currently entitled for and sell it or he would prefer to buy additional amount of water for cultivation, during the next cropping season (i.e. January –April, 2008). Those who said they would be willing to generate excess water and sell it were identified as potential sellers and those who wanted to have additional water have been identified as potential buyers. All the potential sellers were specifically asked through a CV survey that in case they could save ‘ten irrigations’[7] during the next cropping season and sell it to potential buyers within the basin, what is their ‘minimum WTA compensation’ for the water they are willing to trade. Similarly, the potential buyers were told to state their ‘maximum WTP’ for obtaining ‘ten irrigation’ during the next cropping season.

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[7] During the pilot survey, we have asked those farmers who said they could generate excess water by way of reducing the ‘number of irrigations’ per season to tell us how many irrigations that they could ‘reduce’ during the January- April season (i.e. four months period) in order to generate excess water without affecting the growth of the crop that they cultivate, and in what way they could reduce. The results suggested that on an average each potential seller could save that amount of water equivalent to ‘ten irrigations’ during the four months period, irrespective their size of land holding. Different farmers reported different types of methods of saving water during the next season: some farmers said they were planning to cultivate less water intensive crops (such as, oil seeds), instead of paddy or sugarcane; some farmers said they would adopt ‘drip’ irrigation method which is becoming popular among the farmers in the basin. This method is becoming popular because farmers could save not only water but also labour, which is a scarce input in the basin. Substantial amount of subsidy is also being given to encourage the farmers to adopt this method; some of the farmers said they would substitute irrigation between different crops that they cultivate; and some other farmers said they would reduce the number of irrigations as such, provided their efforts are being rewarded properly.

The results from the main survey reveal that almost all the potential buyers of water are located in the LBP canal and the entire potential sellers are located in the other Old System[8] (except only one buyer from Arakkankottai canal). Altogether, we have identified 125 farmers as potential buyers and 129 as potential sellers. The remaining 54 farmers (i.e 17.5 percent) in our sample were not willing to participate in water trading. To elicit the WTP/WTA values, we have used 'repeated experimental method of value elicitation' in the field. This method involves asking the WTP/WTA question to the same farmer in every subsequent rounds, wherein the the WTP/WTA values elicited during the previous round is communicated to the farmer in each subsequent rounds. For example, as explained in the Methodology section earlier, the maximum WTP value of the potential buyers and minimum WTA values of the potential sellers are elicited separately during the first round. Subsequently, the maximum WTP value of a water buyer (who stated a lowest WTP value among all buyers) elicited during the first round was communicated to a seller (who stated the 'highest' WTA value among all sellers in the first round) who was asked if he was willing to 'revise' his WTA value accordingly. Similarly, a buyer (who stated the lowest WTP value among all buyers) was provided with the WTA value of the seller (who stated the highest WTA value among all sellers) and asked if he was willing to revise his WTP value accordingly. This kind of repeated experiment is expected to eliminate any information asymmetry among the buyers and sellers that may potentially affect the water trade in the absence of such information flow. The major objective of this experiment is to create a 'real market' situation for the water buyers and sellers so that the trade in water could reach an 'equilibrium' point.

In our experiment, we found that out of all the 148 sample farmers in LBP canal, 124 farmers (i.e. 83.78 percent) were willing to pay for additional water equivalent to 'ten irrigations'. We had one farmer from Arakkankottail canal in the Old System as a potential buyer. Similarly, out of the 162 sample farmers in the Old System we have identified 129 'willing sellers' (around 79.6 percent) spread across all the three canals in this System. The

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[8] It should be noted that at present there are ongoing conflicts over water between the LBP farmers and the farmers in the Old Canal System and therefore, one may wonder how the farmers in the Old Canal System will be even willing to accept that there is an 'excess' water in their fields, let alone agree for transferring water to the LBP farmers. The point to be noted here is that the ongoing conflict is mainly to retain the 'riparian rights' possessed by the farmers in the Old System and therefore, the potential sellers are willing to 'sell' the excess water to any potential buyer located anywhere in the Basin ***provided that they are adequately compensated for transferring the water***.

mean WTP value stated by the potential buyers for obtaining ‘10 additional irrigations’ during the first round of our experiment stands at Rs.274.44. However, the mean WTA compensation, elicited in the first round for selling excess water equivalent to same number of irrigations is estimated to be Rs. 318.44. The results on WTP and WTA values derived from the first round indicate that even though there are water buyers and sellers who are willing to exchange excess water, the exchange will *not* take place smoothly because of the fact that the mean value of ‘selling price’ (i.e. WTA) is greater than that of ‘buying price’ (i.e. WTP). The reason for this WTP/WTA disparity affecting the market exchange is that since the buyers (sellers) had no idea about the selling (buying) price of the water sellers (buyers) during the initial round they had to value the water based only their ‘own’ preference. However, one’s value of water in a market environment not only depends on one’s own individual preference but also on how much value that others place on the same amount of water. This means that a buyer’s WTP for water is not dependent entirely on his own valuation but also on the WTA value of the seller. Recognising this ‘interdependent’ nature of the valuation process, we conducted the second round of value elicitation with a view to see how disclosing the value of water elicited in the first round affects the value of the respondent in the second round. In the second round, we have communicated the maximum WTP value of that farmer whose stated WTP value was lowest among all buyers (i.e. Rs. 75.00) to all the sellers. Similarly, we have informed the buyers about the minimum WTA value of that farmer whose stated WTA value was highest among all sellers (i.e. Rs. 960.00). All these farmers were asked if they were willing to revise their initial value given by them in the first round, and were subsequently asked to revise the values in case they were willing to do so. In the case of buyers, 110 farmers out of 125 (88.00 percent) farmers were willing to revise their WTP values and did so accordingly. In the case of sellers, 42 farmers out of 129 (32.60 percent) were willing to revise their stated WTA values and revised subsequently. After the second round, we found that the mean WTP value increased to Rs. 318.44 and that of the WTA value declined to Rs. 302.00 approximately.

Table-7: Change in the WTP values Across Three Rounds

Elicitation Round	Number of Farmers	Mean Value	Median Value	Minimum Value	Maximum Value	Std. Deviation
WTP1	125	272.44	250.00	75.00	560.00	156.80
WTAC1	129	318.44	260.00	100.00	960.00	195.31
WTP2	125	308.12	250.00	100.00	600.00	169.53
WTAC2	129	301.97	250.00	75.00	960.00	190.51
WTP3	125	312.64	250.00	100.00	600.00	170.14
WTAC3	129	300.03	250.00	75.00	960.00	190.25

Source: Computed from the primary data.

In the third and final round, we have repeated the same procedure followed in the second round. In this round, only 24 buyers (i.e. 19.20 percent) did revise their WTP value again; in the case of sellers, only 10 sellers (i.e. 7. 8 percent) revised their WTA values. In all the rounds, the buyers revised their values 'upwards' while the sellers revising their values 'downwards'. Another round of elicitation was not possible because almost all farmers in both the categories refused to revise their values any more. So, we stopped the elicitation process with three rounds. In the final round, the mean WTP value slightly increased to Rs. 312.64 and the mean WTA value declined to Rs. 300.03. The repeated rounds of value elicitation suggest that in a 'market set-up' where full information about the buying and selling prices made available to the farmers, the WTP and WTA accept values converge to an equilibrium point, making the trade in the water to be optimal. Out of all the buyers, 64 percent of them are willing to pay the equilibrium price of Rs. 300 and 63 percent of sellers are willing to accept this amount as compensation. *This means that water trade will take place at least among 63 percent of the farmers whose are willing to participate in water trade*.

The analysis of WTP and WTA values for a possible water trade suggests that an alternative institutional arrangement with more 'incentive-based' mechanism inbuilt in it would generate more benefits to the farmers in the Bhavani basin, through more efficient allocation of water. Since the tradable water rights provide such kind of incentives, making effort to introduce it in the Bahavani basin would generate substantial benefits to the farmers.

7. Conclusions

In the present study, we tried to explore the possibility of introducing a new institutional approach namely, tradable water rights, for allocating water efficiently among the farmers both within as well as across the canal systems in the Bhavani river basin, Tamil Nadu, India. Around 82 percent of the sample farmers were willing to participate in the proposed tradable water rights system. To estimate the 'benefits' that could be obtained from the water allocation under the tradable regime, we have elicited WTP values from the potential buyers and WTA values from the potential sellers for exchanging tradable water. Through the repeated experiments, we have arrived at equilibrium level of WTP and WTA values under which trade in excess water could take place. The elicited WTP and WTA values suggest that there is a greater potential for allocating water through tradable permits mechanism, which would result in increased net benefits to the farmers. Under the existing institutional arrangement, the water allocation pattern is found to result in inefficient use of water; therefore, diverting water from the willing sellers to willing buyers would generate larger net benefits in the Bhavani basin. Therefore, our study results suggest that the tradable water rights mechanism, if introduced in the Bhavani river basin, can act as an efficient, alternative institution by way of increasing the 'value' per drop of water.

Implementing tradable water rights requires supplementary institutions and institutional arrangements. Within the agriculture sector, the tradable water rights can be initially traded among the WUAs (Rosegrant and Binswanger, 1990), rather than across individual farmers. It should be noted that there are 44 WUAs in the LBP canal and these associations were created deliberately for managing the water scarcity problem within the canal system. Each WUA controls 4 or 5 'sectors' and each sector covers 1000 acres. We found that these WUAs are functioning effectively for the several years in the past. The functioning of these WUAs is being coordinated by an umbrella organization created by the members of all the 44 WUAs. This organization is governed by a President and a Secretary, who are selected democratically by the members of the WUAs. The cost of running these WUAs and the umbrella organization is met with from the financial contribution both from the government as well as from the members of the WUAs. For example, the one time functional grant of Rs.450.00 per hectare (Central government's share of Rs.225.00 and the State government's share Rs.225.00) is being released to the WUAs on receipt of farmers' contribution of Rs.50.00 per hectare. The functional grant and farmers' contribution were deposited by the PWD in the National Banks. The interest accruing from the above deposit is being utilized for the day to day functioning of the WUAs as per the resolution passed by the WUAs. In recent years, the PWD also releases grant the WUAs as a maintenance grant at the rate of Rs.100 .00 per hectare per year. This also supplements the fund position to certain extent. With these institutional and financial arrangements, the WUAs in the LBP are found to function efficiently. On top of everything, the transaction cost of running these organizations is also very low. Therefore, the WUAs promise a greater potential for making the tradable permits more efficient. However, these kinds of well-established, formal WUAs are not found in the Old System of the Bhavani basin. There are few informal associations functioning in the Old Systems but they are fragmented in terms of their objectives, functioning, etc. Therefore, establishing formal WUAs in the Old System and integrating all these WUAs under a River Basin Authority will make the tradable water rights regime more practicable. Installing these institutions and making them to function involves transactions costs which need to be measured; this can be an area for further research.

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