Institution of Ground Water Market for Management of Ground Water Resource: A Study from Assam in Northeast India

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Abstract:

Assam in the north eastern region of India has the endowments to ensure agricultural growth in the sense that the state has huge reserves of ground water in addition to the enormous surface water availability. Returns to both labor and capital in the state are considered high as potentials for exploiting the existing technology are yet largely untapped. As insufficient irrigation infrastructure is identified as a major constraint on exploiting such potentials, investment for expanding irrigation capacity is needed. At the same time, putting necessary institutions in place to ensure that the installed capacity is effectively utilized is also equally important. Compared to relatively larger government irrigation schemes, the privately owned and operated tube well based small scale projects in the state have relatively better utilization efficiency. However, utilisation of irrigation potential of these schemes is also affected by fragmented and small size of holdings in the state. Emergence of the institution of ground water markets, however, is expected to improve utilisation efficiency of irrigation as it can make optimal use of the scarce natural resource of ground water. To investigate into some of the questions related with enhancing utilization efficiency and better management of the common pool resource of ground water, a study of ground water markets in Assam was taken up. Using inputs from field investigations, the study examined the nature of ground water markets in the state, the issue of reliability of water supply and the conditions for viability of this market for ensuring better management of ground water resource in Assam. The study points out that apart from improving utilization efficiency of irrigation, reliability of water use has also increased considerably with emergence of ground water markets in the state.

Keywords

Irrigation, utilization, water market, efficiency, institutions

I. Introduction:

Development of groundwater resources has played a crucial role in augmenting agricultural production and sustainable development in India. The expansion of ground water irrigation has been considered to be the most decisive harbinger of the Green Revolution technology in the country (Chadha, 2002). Tube well technology was responsible not only for introducing new crops and re-shaping existing crop combinations, but also for pushing up cropping intensity. Water extracted from ground water source is considered to have a number of advantages in agriculture and non-agricultural uses over water from surface flow. The productivity per unit of water tapped is much higher in the case of groundwater compared to surface irrigation. Land productivity per hectare of net cropped area for ground water irrigated areas in Punjab and Tamil Nadu was found to be higher than canal irrigated areas by 1.5 to 2 times (Chadha, 2002). This can be explained by two factors: a) groundwater irrigation involves much less waste by way of conveyance and application losses and b) farmers have much greater flexibility to adjust timing and the quantum of water application to the crop needs (Vaidyanathan, 1999). Hence the government policy of supporting and encouraging private investment in groundwater development was considered justified. However, continuation of excessive reliance on ground water for irrigation has already resulted overexploitation of this common pool resource in many parts of the country. Subsidised irrigation water and free electricity to the farm sector have been held responsible for over-exploitation of groundwater resources leading to adverse environmental consequences such as soil degradation through water logging and salinity and fall in the water table (Government of India, 2001, 2002). In the changed scenario there are now calls for relocation of production of food grains like rice from large farmers in green revolution areas, where economic and environmental costs of these crops have become prohibitive (Singh and Kalra, 2002; Sidhu, 2002), to small and marginal farmers, and eastern and rain fed areas where returns to both labour and capital are high (Government of India, 2001, 2002).

Assam in the eastern part of India is primarily an agricultural economy in the sense that about 53% of its total work force is directly dependent on agriculture

(Government of Assam, 2011). In 2009-10, agriculture sector accounted for about 26.82% of the NSDP in the state (Government of Assam, 2010). The total geographical area of the state is estimated to be 78,438 sq. km. of which about one-third is being put under cultivation. In the year 2007-08 (the latest year for which figures on total area and classification of area are at present available), the net sown area in the state was 27, 52, 979 hectares and the total cropped area was 38,38,732 hectares. Thus the cropping intensity in the state worked out to be 140%. Winter paddy is the principal crop in the state and it is mostly rainfed. Irrigation coverage in the state is very limited. In 2002-03, the net irrigated area as percentage of net sown area in the state was estimated to be 6.23 against 40.01 for the country (CMIE, 2006). More importantly, this figure has been declining over the years. Interestingly, the state has huge potentials for exploitation of the HYV-fertilizer technology, for which, however, expansion of irrigation network is important.

Assam is known for its rich endowment of both surface and ground water resource. The Brahmaputra and the Barak and their tributaries are the two major sources of surface water in the state. The Brahmaputra is ranked fourth among the large rivers of the world in terms of discharge at the mouth at 19,830 cubic metre per second (Goswami, 1989). The water resource potential of the river basins in India is estimated to be around 186.96 million hectometer. Significantly, the two river basins of the state (i.e. The Brahmaputra and the Barak) account for as high as 32% of the country's total surface water potential. Besides the water flowing in the rivers, Assam is richly endowed with ground water reserves. According to an estimate of the Central Ground Water Board, the gross ground water reserve for the state as a whole stands at 24,719 million cubic metre. Even after leaving aside about 15% of this amount for domestic and industrial use, an amount of 21,011 million cubic metre is available for irrigation. But on an average only about 5% of this amount is being annually utilised. Thus use of ground water for agriculture and non-agricultural purposes is fairly limited in the state.

Development of irrigation infrastructure in the state is predominantly under government ownership and control. The State Irrigation Department is entrusted with the responsibility of expansion and maintenance of irrigation network. The schemes

developed by the Irrigation Department can be classified into major, medium and minor categories. Most of these schemes are relatively large, each catering to a group of farmers. From technical point of view these schemes can be further divided into surface flow, surface lift, ground water lift schemes, etc. The ground water lift schemes under government sector are mostly DTW based minor irrigation schemes. Although development of irrigation infrastructure in the state started immediately after independence, here was, however, no significant private investment in this sector till the later part of the 1990s. However, with the financial assistance of World Bank and NABARD under some specific schemes in the recent past, facilitation of private investment in irrigation sector was possible. Notable among these schemes are the RIDF of NABARD and ARIASP of World Bank. These schemes supported ground water irrigation projects which extract water from a relatively much lesser depth and are known as shallow tube well (STW) schemes. Under the above schemes, a total of 1, 15, 000 STWs were set up in different parts of the state till the end of financial year 2000-01. These projects are much smaller in size and have a potential of 2 hectares each. Thus the potential created under these STW based schemes was around 2, 30, 000 hectares. These schemes are under private ownership, usually owned by single farmer, but sometimes the water is shared with neighbouring farmers for market and non-market exchange.

With the setting up of ground water based STW schemes, the demand for ground water resources for agricultural activities in the state has started increasing. However, compared to many Indian states where excessive reliance on ground water irrigation has led to overexploitation of groundwater reserve[1], the demand and use of ground water in Assam is still very limited. But a matter of concern is the fact that even the small amount of irrigation potential created through shallow tube wells (STWs) has remained under-utilized (Dutta, 2011). The main factor restraining the fullest utilization of potential created under these STWs is the fragmented and small size of holdings. In spite of this factor, emergence of the institution of water markets in few locations of the state seems to have facilitated better utilization of irrigation potential created. In such areas farmers owning pump set and having excess capacity due to small size of their holding have been found to supply irrigation water to neighbouring farmers who on their own do not have the infrastructure for the

purpose. Markets increase economic efficiency by allocating resources to their most valuable uses. In other words, if certain conditions are met, markets provide the correct incentives and lead to efficient resource use. Thus, water markets can be one effective instrument for achieving a more efficient allocation of water. The present work is an attempt to examine how emergence of water markets has helped in better management of ground water in the state. This is examined primarily with reference to utilization efficiency of irrigation. Thus the hypothesis to be verified in the following analysis is that emergence of water market, by reducing uncertainties of water availability, results in better utilization efficiency of irrigation in the state.

The whole paper has been organized in four sections. Section II describes the data source and methodology adopted for carrying out the study. This is followed by the presentation of results of analysis of primary data in section III. The last section summarizes the conclusions emerging from the study.

II. Data Source and Methodology:

The study is based on the data collected in a field study carried out by the author in Nagaon district under Central Brahmaputra Valley Zone in the state in the year 2005-06. Selection of the district was done in consultation with the concerned officials from the Department of Agriculture, Government of Assam. It was also based on the fact that maximum number of ground water based irrigation schemes in the state has been installed in this district. Moreover, a good number of major and medium canal irrigation schemes within the command area of which emergence of ground water market is noticed are situated in this district. The sample of farms was selected using a multi-stage sampling process. In the first stage, four representative Agricultural Blocks were selected from the district. Then from each of the selected Blocks two villages were selected. Finally, from each of the selected villages about 20% of farm households were selected at random for collection of data. Besides collecting data from officials of the State Agriculture Department associated with the projects, responses of randomly selected 126 farmers using irrigation from privately owned shallow tube wells were gathered.

Besides using simple statistical tools like averages, ratios and percentages for summarisation and comparison, relatively rigorous method of regression analysis has also been carried out for verification of some of the findings. In particular, the effects of emergence of water markets on the rates of utilization of shallow tube well schemes are examined by a regression analysis specified and presented in section III.4.

III. Results and Discussion

The relevant results of analysis of data are discussed under the following sub-heads.

III.1 Structure of Water Markets:

Water market is basically a localized, village level institutional set up through which owners of modern water extraction mechanisms (WEM) supply water to other members of the community at a price (Shah, 1993). Water markets can be both formal and informal. A formal water market is associated with a legal system while importance of informal contract enforcement is emphasized in case of informal water market (Easter et al, 1999). As opposed to the informal water markets in countries like India, formal water markets are found to be prevalent in advanced countries like the United States of America, where water rights are clearly defined and rest with the state (Marino and Kemper, 1999). A number of studies have reported that informal kind of ground water markets work fairly well as long as recharge to streams is adequate and the market has sufficient number of sellers (Palanisami and Easter, 1991, Shah, 1993, Saleth, 1998). Availability of water resources is one important factor in determining the pace of growth of water market. Normally in locations where supply of water is high, the pace of development of water market is rapid. But in Eastern Indian states of Orissa, Bihar and West Bengal, in spite of abundance of easily accessible groundwater reserve, groundwater markets are highly underdeveloped. Assam in the eastern part of India with high rainfall and rich endowment of ground water reserves also falls in this category.

The preliminary examination of the farm households selected for the study revealed that of the total 121 farm households taking part in water transactions, as large as 79.3% were small and marginal farmers (less than 2 ha) and a small 20.7% were in the 'others' category. The average size of holding was 0.61 ha for marginal farms, 1.44 ha for small and 2.99 ha for large farms with an overall average holding size of 1.42 hectares. Thus small and marginal farms are found to dominate the agrarian structure of the sample farms. The structure of market is found to be informal, based on informal contract enforcement.

The structure of water market prevailing in the district in terms of different categories of water users is presented in table 1. It shows that buyers and self users + sellers are the dominant categories of participant in the water market. While majority of the small and marginal farmers (51.02% of marginal farmers and 38.03% of small farmers) are found to be buyers, most of the large farmers (64%) belong to self users and self-users + sellers category. It explicitly illustrates that the number of water buyers decreased as the size of farm increased, while the number of sellers increased with the size of the farm.

Table 1

Number of Farm Holdings across Various Forms of Water Markets

Farm Category	Categories of water user					Total
	Self users	Self users + sellers	Self users + sellers + buyers	Self users + buyers	Buyers	
Marginal	8 (16.33)	14 (28.57)	0 (0)	2 (4.08)	25 (51.02)	49 (100)
Small	10 (21.27)	12 (25.53)	4 (8.51)	3 (6.38)	18 (38.3)	47 (100)
Others	7 (28)	9 (36)	5 (20)	1 (4)	3 (12)	25 (100)
Total	25 (20.7)	35 (28.92)	9 (7.43)	6 (4.95)	46 (38.01)	121(100)

The figures in parentheses represent percentage of total in each row

III.2 Nature of Transactions in the Water Market:

As already mentioned, the water markets in the study area are informal, based on informal contract agreements. Water charge realized is based on area approach where the amount of water charged is based on the amount of land irrigated. The mode of transactions in the market is found to be both cash and kind depending on situations. The pattern of water charge realized in the district is presented in table 2.

Table 2

Nature of transactions across Categories of Users

Mode of Transaction	Percentage of farmers buying water	Percentage of farmers experiencing price discrimination
(1)	*(2)*	*(3)*
Cash	27.87	4.96
Kind	6.56	
Both	65.57	

The table shows that most prevalent mode of transactions among the water buyers is a combination of both cash and kind. While about 65.57% of the sample farmers purchasing water paid in both cash and kind, only 6.56% of farmers paid water charge in kind. The rate for kind transactions was found to be 5.98 quintal per hectare. Cash transaction includes a charge in cash in addition to the cost of fuel for running the machine. In a few occasions (less than 5%), some form of price discrimination was noticed where the buyers have to pay a part of the total charge of the amount usually charged. This is practiced mostly when the parties involved are related to each other. In one case, price discrimination was noticed where both the parties had to enter into an agreement to irrigate each other's field due to fragmentation of holdings. In this case the user had to pay only the running cost (in the form of fuel cost) for irrigating the land.

III.3 The Rates of Utilization of Created Potential of the Systems:

To examine the efficiency in utilization of the shallow tube wells (STW), utilization rates have been calculated. The figure of annual irrigable area for many of the private shallow tube well (STW) based projects could not be ascertained due to insufficient

information. Therefore, the utilization rate had to be computed using data on net area irrigated and net irrigable area. The net irrigable area of any STW project has been assumed to be 2 hectares per STW as per the standard followed by the Directorate of Agriculture of Government of Assam. The utilization rate for the sample projects has accordingly been defined as the ratio of net area irrigated to net irrigable area expressed in percentage. The utilization rates of the STWs in different locations are shown in table 3.

The table shows a relatively higher overall utilization rate for all the STW based schemes in different locations in the district. The overall utilization rate of 64.00% for the district is higher than the figure estimated for the district for data collected in 2000-01.[2] Even this utilization rate of shallow tube wells can do with considerable improvement. However, there are considerable variations in utilization rates across locations of the schemes. While the highest utilization rate is observed in Chakalaghat Block, Hojai has experienced the lowest utilization rate.

Table 3

Utilization Rates of Irrigation Projects in Different Locations

Location	Utilization Rate (in %)
(1)	*(2)*
Sowaloni	60.09
Lailuri	74.54
(Ambagan	**67.32)**
Katimari Grant	89.88
Kawoimari	107.1
(Chakalaghat	**93.71)**
Milikbasti	53.29
Dariabasti	41.12
(Hojai	**46.98)**
Bhomoraguri	71.44
Saruhisa	67.52
(Batadrava	**69.88)**
Overall	**64.00**

For maximum utilization of created potential of STW based irrigation schemes, farmers possessing STWs should have a minimum area of compact plot. In the present case, since the capacity of the STW scheme is estimated to be 2 hectares, the ideal amount of minimum compact plot should be 2 hectares or more. However, on scrutiny of the largest compact plot held by the farmers, it was found that most of the farmers possessing STWs do not have the compact minimum area of land required for maximum utilization of the potential created. As such, fullest utilization of the created potential of STWs has not been possible. As high as 119 of the total 126 sample farmers (i.e. 94.4%) were found to have compact plot of land less than 2 hectares. With such fragmented holdings, utilization of full capacity of shallow tube wells is not possible. When the capacity is not utilizable within the holding, water can be shared with neighboring holdings. Since a water market has not developed in most parts of the state, such sharing of capacity of tube well based projects is yet to be a wide spread phenomenon. In Nagaon district, however, emergence of water market has taken place in many areas with the spurt of growth of shallow tube well based irrigation schemes in the recent years. In some locations here, farmers owning pump set and having excess capacity due to small size of their holding have been found to supply irrigation water to neighbouring farmers who on their own do not have the infrastructure for the purpose. Once such markets take root, farmers with excess irrigation capacity are able to utilize it and farmers for whom setting up of pump sets is not viable, can procure the necessary irrigation facility from the market. Development of water market, thus, can one hand contribute towards better utilization of installed irrigation capacity and on the other hand, can economize the total capital investment in private irrigation system.

III.4 Utilization Efficiency of Irrigation Schemes and Water Market:

Since spread of water market can increase utilization efficiency of the irrigation schemes, it was decided to examine the extent of water transaction amongst the sample farmers. Extent of participation in water transaction by the owners of STWs was considered to be the variable representing diffusion of water transactions. The estimated results are presented in table 4.

The table shows that the overall participation rate of owners of STWs in water transaction in the district (66.7%) is relatively better. This clearly shows diffusion of water market in the district. However, there are extreme variations in the participation rate across locations. For example, while all the well owners in Kawoimari village participated in water transactions, only about 23.1 per cent of farmers in Darabasti and 53.8 per cent in Milikbasti under Hojai Block took part in water transactions. On further enquiry, however, it was found that in these two villages (Dariabasti and Milikbasti), the opportunity for emergence of water market was lacking. For effective functioning of water market, certain conditions should exist. First, the buyer has to perceive irrigation through purchase of ground water as the most agreeable alternative in comparison to other sources of irrigation. Second, the seller of water should have pumping capacity in excess of his own requirements. Third, willing buyers are available within the command area of the supplier's irrigation equipment in case the pump set is fixed. And fourth, buyers are able physically to gain access to the water (Pant, 1992). However, in the above mentioned two villages in Hojai Block, the concentration of STWs is very high and because of this, prospective buyers are hardly available for purchasing water here. Thus, there is a negative correlation between the numbers of STWs possessed by the farmers and participation rate of farmers in water market.

Table 4

Rates of Participation in Water Market by the STW Owners

Location	Participation Rate (in %)
(1)	*(2)*
Sowaloni	77.8
Lailuri	90.9
(Ambagan	**85.0)**
Katimari Grant	85.7
Kawoimari	100.0
(Chakalaghat	**88.9)**
Milikbasti	53.80
Dariabasti	23.1
(Hojai	38.5**)**

Bhomoraguri	83.3
Saruhisa	62.5
(Batadrava	**75.0)**
Overall	**66.7**

To examine whether growth of water market has contributed positively to utilization efficiency of irrigation schemes in the district, 'utilization rate of owned shallow tube well schemes' has been regressed to 'the participation rate in water market' (denoted in short as PWM). The results are presented in table 5.

Table 5

Results of Regression Analysis of Utilization Rates of Shallow Tube well Schemes

Variables	Coefficients/Values	Standard Error
(1)	*(2)*	*(3)*
Constant	46.640***	5.601
PWM	30.742***	6.860
R^2	0.216	
F (1,74)	20.081***	

*** Implies significance at 0.01 level

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Though the value of R^2 is not high, the F- statistic for overall regression and the coefficient of the variable the participation rate in water market (PWM) are statistically highly significant. The positive sign of the coefficient of PWM means that higher the rate of participation in water market better is the utilization rate. In other words lack of development of water market hampers fuller utilization of privately owned shallow tube well schemes. Thus, it can be concluded that the relatively better utilization efficiency of STW based irrigation schemes in the district is made possible by emergence of ground water market.

IV. CONCLUSIONS

Thus the findings emerging from the above discussions can be summed up in the following points.

- A large number of farm households were found to be engaged in water transaction activities in the district either partly or fully. While the buyers have an inverse relationship with the farm size, sellers have direct relationship with farm size. The structure of water market is found to be informal based on informal contract enforcements.
- Transactions in the water market are based on area approach. Both cash and kind are charged by the sellers for supply of water to the field. In some instances, price discrimination in water charge is also noticed.
- The utilization rates of the STW based schemes are relatively higher, but this also can do with considerable improvements. The main factor hindering full utilization of irrigation capacity of STW based private projects is fragmentation of holdings. Because of fragmentation of holdings farmers having STW based irrigation systems often do not hold large enough compact plot to fully utilize the capacity of their irrigation devices.
- Emergence of ground water market has facilitated better utilization of irrigation potential in spite of predominance of small and fragmented holding. The owners of STWs have been found to use the market to utilize their excess irrigation capacity by supplying water to neighbouring farmers.
- Spread of water market is constrained to some extent by concentration of more STWs in some parts of the study area. While this results in better accessibility to irrigation water, a part of created potential remains underutilized in the face of fragmented land holdings. In the absence of proper implementing agencies for set norms for installing shallow tube well schemes, higher concentration of these pump sets in a locality may result in lowering down the ground water table. In case of Assam, however, this possibility may not be imminent.

On the basis of these findings following suggestions can be made for better utilization efficiency of shallow tube well based irrigation system in the state.

- The emergence of ground water market should be facilitated as its development can ensure better utilization of irrigation capacity of shallow tube well based projects in spite of the problems arising because of small and fragmented holdings. However, as this market develops, certain regulations may become necessary to ensure that the market delivers the goods. Market facilitates optimum allocation of resources if it remains competitive. Thus, steps will have to be taken to prevent the growth of monopolistic tendencies. Moreover, as of now, ground water is an open access common property resource. Therefore, there is a danger of market-induced over exploitation of this resource leading to the proverbial 'tragedy of commons' (Hardin, 1968). Ground water based irrigation in such a situation may not be sustainable in the long run. In the context of a study in Bangladesh, Fujita and Hossain (1995) have already apprehended the possibility of over exploitation and depletion of the common property resource of ground water because of growth of "private gains based market". The regulations to avoid these problems may be in the form of specification of the size of the pump or in the number of pumps one can possess. (For example, one may not be allowed to install a very large capacity pump or a person already possessing a pump should not be allowed to have the second on subsidy).

- Some regulations of this nature on paper have already come into existence. As per the guidelines of Agriculture Department, Government of Assam, an STW should not be installed within 200 metres of another STW. However, enforcement of this regulation was not found in practice. As such enforcement machinery should be made stronger so that overexploitation of ground water may not lead to lowering down of water table in future. Failure to implement these regulations may render STW based irrigation schemes in the state unsustainable in the long run.

NOTES:

1. The number of blocks overexploited and dark has gone up to 445 in 1997-98 from 253 in 1984-85.
2. The utilization rate of STW based projects in Nagaon district was 40.40 as per estimate made by the author in another study. (Dutta and Bezbaruah, 2006)
3. The average size of holding of marginal and small farmers will be less than 1 ha and 1-2 ha respectively.

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