

EFFECTIVENESS OF GROUNDWATER SERVICE PROVIDERS IN NORTHWEST BANGLADESH

M.B. Uddin¹, M.W. Rahman², K.S. Farid^{2*} and M. Mainuddin³

ABSTRACT

This study examines the effectiveness of groundwater service providers of Bogura and Chapainawabgonj districts in Northwest Bangladesh by employing qualitative approach. Required data were collected through focus group discussions, key informant interviews, in-depth interviews, case studies, and observation from purposively selected participants, and analyzed through qualitative content analysis. Findings reveal that though majority of the farmers are dependent on institutional groundwater service providers, namely Barind Multipurpose Development Authority, Bangladesh Agriculture Development Corporation, and Rural Development Academy for groundwater irrigation, the share of individual tube-well owners is increasing noticeably. Provider specific effectiveness was assessed based on managerial, operation, and economic efficiencies. It is found that water buyers mostly prefer individually owned tube-wells for irrigation instead of institutional providers. Good service delivery, good operational and managerial practices, comparatively low irrigation charges, and regular water supply are the important factors motivated water buyers to choose individual service providers over institutional providers.

Key words: Community, institutional service provider, effectiveness, groundwater irrigation

I. INTRODUCTION

Increased groundwater accessibility resulting from the expansion of deep and shallow tube-wells for irrigation purpose helped Bangladesh to attain near self-sufficiency in rice. However, groundwater irrigation remains crucial to sustain agrarian growth to meet Bangladesh's future food requirements (Qureshi *et al.*, 2014). Moreover, Bangladesh has been experiencing an increased frequency of drought in recent years. It is a recurrent phenomenon in some parts of the country, but the northwestern region is highly drought-prone because of the high variability in rainfall (Shahid and Behrawan, 2008). All the rivers and canals of this area dry up during dry season, and make the people completely dependent on groundwater, especially for irrigation (Deyet *et al.*, 2013). Therefore, effective management of groundwater is essential. Several approaches of groundwater management have been adopted in recent years that sensitize and involve the community to work on the issue. As a highly decentralized resource, groundwater business has been mainly developed through private initiatives and its management can only be effective through proactive community participation. An enabling environment by bringing together water buyers, irrigation businessmen, local leaders, and local administration is necessary for effective ground water management (Nchoung, 2013).

Groundwater irrigation has probably been the most significant development in Bangladesh agriculture since 1980s. In this process, Barind Multipurpose Development Authority (BMDA) has installed more than 10,000 deep tube-wells (DTWs) in Barind area of northwest region and quite a large number of shallow tube-wells (STWs) have been installed in this region by private initiatives (Ahmad *et al.*, 2008). Moreover, informal water markets for irrigation have been developed quickly with the rapid expansion of tube well irrigation over the last decades. With the expansion of water markets in the private sector, the pricing system has also been undergone changes to suit varying circumstances. Cost of irrigation, therefore, found different considering

¹Department of Rural Sociology, Bangladesh Agricultural University, Mymensingh

²Professor, Department of Rural Sociology, Bangladesh Agricultural University, Mymensingh

³CSIRO, Canberra, Australia.

*Corresponding author: K. S. Farid, Department of Rural Sociology, Bangladesh Agricultural University, Mymensingh
E-mail: ksfarid@bau.edu.bd

ownership of the tube well such as public or private, type of fuel such as diesel or electricity, and type of tube well such as STW or DTW. The cost of irrigation by privately owned tube wells is much higher than that of government tube-wells and cost is also higher in case of diesel than electricity driven pumps (Deyet *et al.*, 2013; Mondal, 2015). Despite substantial increase in irrigation cost, groundwater use for irrigation has become increasingly important. Due to high installation, operational, and management costs, the large-scale development of surface water resources in Bangladesh is fewer. Groundwater irrigation, therefore, remains crucial to sustain agrarian growth to meet Bangladesh's future food requirements (Sharma and Minhas, 2005; Qureshi *et al.*, 2014; Mukherji and Shah, 2005).

Various factors are responsible for effective management of groundwater and of groundwater service providers. By applying a qualitative content analysis approach, Nchoung (2013) found six factors such as community involvement, managerial power, groundwater problems, monitoring legislation, institutional arrangement and resource tools as substantial where three of them facilitated groundwater management but three others constrained the management. Kahnert and Levine (1993) showed that the performance and management of public tube wells in eastern India are less satisfactory than that of the private tube-wells; and though they are justified on equity grounds, small and marginal farmers rarely seem to have been the primary beneficiaries. Although there are clearly benefits from groundwater irrigation, the poor do not seem to have benefited substantially.

The earlier studies emphasized on groundwater management and very few emphasized on comparative effectiveness of various service providers that supply groundwater to the community members for their agricultural activities. To assess the comparative advantages and how community effectively participates in groundwater management with the different ownership of irrigation technologies in the agriculture is the main concern of this study. As an invisible common pool resource, groundwater management brings a set of complexities about who uses and who provides as well as who develops and manages the water as it is difficult to exclude users. Therefore, community participation brings a discipline in the process of management and brings users together to arrive at mutually agreed decisions on usage. Simultaneously, it builds in an ethos of self-regulation and sustainable use of groundwater to be followed by all (Chowdhury, 2012). The principle that community resources must be managed by the community concerned along with local government institutions guides participatory water management. In this backdrop this study thoroughly examines the various features of groundwater business of different service providers and eventually evaluates their comparative effectiveness. It also evaluates the effectiveness of service provision of various tube-well ownership categories in northwest Bangladesh. It can reasonably be claimed that this study is different from earlier studies and may contribute significantly to the existing literature as well social science discipline. The findings will provide valuable information to the researchers, development workers and policy makers for future work on community-based groundwater management.

II. METHODOLOGY

The qualitative technique was the prime research approach adopted for village level study. Accordingly, two villages namely *Ajhoir* of Nachole upazilla and *Alokchattrra* of Kahaloo upazilla were selected randomly from purposively selected districts of Chapainawabgonj and Bogura, respectively. The selected districts are located in the northwest Bangladesh where the ratio of groundwater to surface water use is much higher compared to other parts of the country (Shamsudduha *et al.*, 2011). Farmers of the selected villages use groundwater for irrigation that is supplied by BMDA, BADC, RDA and private owners. Hence, a specific command area of

BMDA, BADC, RDA and private tube well owners were selected randomly from the selected villages. After selection of the command areas, qualitative tools such as focus group discussion (FGD), in-depth interview (II), key informant interview (KII), case studies, and observation were performed in order to collect necessary data for the present research. A total of eight FGDs, eight KIIs, six in-depth interviews, and five case studies were conducted with the participants selected through purposive sampling. Table 1 shows the complete list of qualitative data collection method followed in the present study. FGDs were conducted among water users of different groundwater irrigation service providers, irrigation committee and resource persons in the locality for generating diverse views. Homogenous and mixed group discussions were performed. Similarly, KIIs and IIs were also performed with various stakeholders for gathering and validating the information.

Table 1: List of the qualitative methods applied in the present study

| Methods | BMDA/ BADC/RDA/ Individual installed tube-well users | Tube-well Operators/ Managers | Tube-well specific officials | BADC/ RDA irrigation committee | Individual Owners/ Users | Mixed group/ Resource person | Total |
|---------------|--|-------------------------------------|------------------------------------|--------------------------------------|--------------------------------|---------------------------------------|-------|
| FGD | 4 | - | - | 2 | - | 2 | 8 |
| KII | 1 | 3 | 1 | 1 | 1 | 1 | 8 |
| II | 1 | 2 | 1 | 1 | - | 1 | 6 |
| Case study | 2 | 1 | - | - | 2 | - | 5 |

During FGDs, KIIs, IIs, and case studies, all questions were open ended and the discussions were based on prepared FGD, KII, and II guides, and case study check list, respectively. The researchers facilitated discussion, where participants were allowed to feel free in sharing their views. Each FGD was an interactive discussion between the facilitator (here the researcher) and 8-10 pre-selected participants and lasted for 60-90 minutes. Each KII and II was one-to-one open discussion between the researcher and the participant and lasted for 45-60 minutes. An extensive observation was made to document the daily activities related to the groundwater services provided by the sellers as well as received by the water buyers. One of the researchers spent about two months in the field during irrigation season. Continuous field observation in fact helped the researcher to evaluate the performance of different groundwater service providers in the selected areas.

Findings were generated based on the qualitative content analysis, which focuses meaningful description and interpretation of topics and themes emerged during data collection from the study participants. For content analysis, records and field notes of the FGDs, KIIs, in-depth interviews, case studies, and observations were transcribed first and then transcripts were thoroughly examined. Topics, themes, and issues related to the study objectives were identified from the transcripts. Later on, thick description and logical interpretation of each topic, theme and issue were written, which were then systematically arranged, categorized and conceptualized based on the objectives of the study. Case studies have been developed to explore the effectiveness of specific groundwater service provider on the basis of an individual case as a case study explores and investigates an individual's real-life phenomenon through detailed contextual analysis (Hennink *et al.*, 2011). Ethical issues were addressed by ensuring the anonymity of participants and confidentiality of the information shared. The participants were fully aware of the objectives

of the study and the use of the data provided by them. The researcher provided a convenient environment for the participants during data collection so that they can willingly disclose their thoughts, experiences and ideas related to the study objectives. The study describes the process of local people's participation in groundwater service provision. Managerial, operational and economic efficiencies were thoroughly evaluated for different groundwater service providers and comparative features of different groundwater service providers (institutional and individual) are presented in descriptive tabular form on the basis of qualitative content analysis for examining the effectiveness of specific service provider.

III. RESULT AND DISCUSSION

Groundwater is a critical component of northwestern parts and its effective management is vital to present and future generations. Effective participation of relevant stakeholders is important for groundwater management. It depends generally upon commitment of stakeholders rather than coercion (Maheshwari *et al.*, 2014). This section provides the findings of the present study on the basis of the qualitative content analysis. The sub-sections included here are tube-well specific managerial practices, community participation process in groundwater management, effectiveness of groundwater service providers, and comparative effectiveness of different service providers. Finally, description of the case studies is provided.

Tube-well specific managerial practices

Good management practices depend on various managerial tools including administration, communication, finance and accounts, human resource, monitoring and operating system of tube-wells that were examined based on ownership and community participation (Carter *et al.*, 2005). It was observed that different service providers practice different types of managerial activities. The operators of BMDA (Barind Multipurpose Development Authority) tube-wells perform all managerial tasks and the operators are selected by the BMDA authority. Through field investigation, it was found that community or groundwater users mostly depend on the operators for irrigation and its related issues. In contrast, BADC (Bangladesh Agricultural Development Corporation) and RDA (Rural Development Academy) tube-well authority set up a tube-well specific irrigation committees and all kind of managerial activities are performed by these committees. Committee members communicate with farmers for groundwater irrigation. In case of individual owner, all kind of managerial activities are done by tube-well owners and they bear all sorts of operational expenses, negotiate with water buyers, manage machinery equipment, etc. As per response of an individual tube-well owner "*for groundwater irrigation, farmers mainly contact with the owners in case of individually owned tube-wells while for BMDA, RDA and BADC farmers contact with the operators or managers*". Managerial activities of different management authorities are presented in Table 2.

In the study region, different organizations have different levels of control and it varies in terms of tube-well specific operation. BMDA has appointed different kinds of managerial or operational personnel. It was seen that every tube-well is run with the help of an operator who was selected and directed by the BMDA authority. In most of the cases, tube-well operators or drivers control over the community who want to buy water for cultivation. Both BADC and RDA authorities practice same patterns of controlling system to manage their tube-wells and irrigation water users. Both authorities maintain an irrigation water committee for performing the irrigation related activities and also select a tube-well operator by the committee members. Irrigation committee possesses all kinds of controlling power for supplying water to the farmers. One participant

mentioned that “I have no rights to manage tube-well; all managerial works are done by tube-well operator and president of irrigation water committee” (BADC irrigation committee member). On the other hand, individual tube-well owner has total freedom to manage, operate and control of his installed tube-well to provide irrigation water. Owners provide services to the farmers when they need it.

Table 2: Managerial activities of different irrigation tube-wells

| Managerial Activities | BMDA tube-well | BADC tube-well | RDA tube-well | Individual tube-well |
|-----------------------|---|---|--|--|
| Administration Unit | BMDA staffs provide information and technology | BADC authority at centre and irrigation committee at field | RDA water management department controls this unit | Tube-well owners control this unit |
| Communication | Authority communicates with operators who communicate with the farmers | Irrigation committees formed by BADC authority communicates with farmers | Water users communicate with irrigation committees formed by RDA authority | Owners give information to community who communicate with owners |
| Finance & Accounts | Recharge by vendors from BMDA office, Farmers use prepaid card for irrigation water | Water pricing is based on use of electric unit, 18 unit is considered as one hour | Financial management is done by committee, RDA collects Tk.28/decimal | Individual owners collect money per hour basis |
| Human Resources | Appoints operators for community management | Water management board usually set up a committee of eighteen members | Irrigation committees manage the water users or communities | Owners maintain all activities |
| Monitoring system | Authority monitors tube-wells and operators, operators maintain the specific farmer | Appointed managers and operators and in some cases authority monitor field operations | Specific tube-well committee monitors the community for irrigation water | Only tube-well owner is responsible for monitoring |
| Managerial system | Managed by operators | Managed by appointed staffs and water committees | Managed by appointed staffs and water committees | Owners managed water users and tube-wells |
| Operating System | Operators repair the machinery with the involvement of community | Tube-well operators do this work | An operator selected from the committee is responsible for operation | Owner operates his own tube-well |
| Maintenance | Controlled by operators | Done by operators and irrigation committee | Done by operators and irrigation committee | Tube-well owners' responsibility |

Community participation process in groundwater management

Community participation is the process through which community members and organizations build continuous and stable relationships by applying a collective vision for the benefit of the community as a whole (Nchoung, 2013). Community participation encourages local leadership and nurtures and promotes their functions. The engagement of the local community is an ongoing and never-ending process to achieve and maintain resource sustainability. Participatory

groundwater management does not generally happen spontaneously (Maheshwari *et al.*, 2014). The present study documents that community participate at different levels in groundwater management by forming groups in the name of groundwater irrigation committee who provides space to the community to discuss and exchange ideas on how to manage the irrigation for crop farming. Farmers reported that they have involved with these groups voluntarily. At the initial phase of groundwater irrigation in the Barind tract, different irrigation service providers (i.e., BMDA, BADC and RDA) of northern Bangladesh installed tube-wells, and started motivating community to grow dry season crops through purchasing water from them. Gradually farmers' community became interested to engage in groundwater use with active involvement with the groundwater service provider institutions by forming groups to have the access to water. The committee of the water user group manages groundwater abstraction and utilization. Earlier community was solely dependent on them for irrigating their land and they had easy access to the institutions.

Interestingly, there was flexibility to be engaged in irrigation business. However, the situation has changed over the period. Groundwater service providers' business motive increased and they started earning more profit. It does not mean that farmers are not getting benefit rather water sellers are capturing the most benefits. There is allegation that they charge higher water price, impose extra fee for irrigation and impose some rules and regulations. Thus, community became a bit reluctant to form group for running irrigation business under BMDA, BADC and RDA though they still dominate the irrigation sector in the Barind tract. Gradually, individual tube-well ownership emerged and they started irrigation business by their own. The case study, which is described in Box 1, supports this scenario.

Box 1: The story of an individual tube-well owner

Mr. A is an individual tube-well owner. He was the water buyer of BMDA like other farmers before 2012. The main reason for his transfer from BMDA to individual ownership is the inefficient management and high price of water. According to him, *"at the initial stage, BMDA helped us greatly but the management of BMDA was not so good thus I decided to install tube-well of my own"*. Water price of his tube-well is comparatively lower with a flexible payment system than that of institutional providers. One can pay him irrigation charge after harvesting the crops which is not common for other water supplying authorities. In most of the cases, water buyers are happy to get involved with him: *"water buyers are willing to engage with me as they get timely irrigation"*. He wants to expand his water business in future: *"I want to install more tube-wells in future to provide irrigation water to the farmers when needed, especially to small and marginal farmers"*. Good relation between water buyers and sellers was found in case of individual owned tube-wells. There was no significant blame against them.

Examination of service provisions of different service providers

Community participation in groundwater management generates active interest of the community in its operation and maintenance and reduces financial and managerial burden of the institutions as users manage considerable part of the operations and pay for the services (Rashid and Yusuf, 1996). The service delivery methods of the different groundwater providers are discussed in this section on the basis of managerial, operational, and economic aspects of service provision.

Managerial aspects of service provisions of different service providers

Sustainable management of groundwater includes increasing and sustained investment in groundwater, appropriate policies and regulations, legal framework, institutions with sufficient

authority and accountability, and development and implementation of comprehensive and adaptable management plans (Islam *et al.*, 2014). The management picture is similar for tube-wells of BMDA, BADC and RDA and managed by managers or operators acting as de facto owners. Only individual installed tube-wells are managed by an individual. In-depth interviews confirmed that community is not happy by getting services from institutional authorities. Most of the participants blamed the institutional authorities for their managerial performance and command areas of BMDA, BADC, and RDA have been decreased because of managerial constraints. In fact, managers failed to offer better services when farmers required. Moreover, as mentioned earlier that BADC nominates irrigation committees in the field level in order to manage its irrigation business. However, neither they nor water users or community have control over different water selling institutions. Owners possess all kind of powers to provide irrigation water and selecting operators or managers for doing their business. He mentioned that *"I have no right to manage tube-wells; tube-well specific operators and president of irrigation water committee do all managerial works"*. Furthermore, tube-well operators also play vital role in distributing water and in decision making process as to where to provide water first. They have the power to select water buyers or users as well on the basis of their wish. In case of irrigating plot, first they supply water to the owners or managers' plots, then to their close relatives, then to the buyers who pay water charges regularly and timely and finally to others. Furthermore, operation and maintenance have some institutional complexity as it has to be done by maintaining administrative procedure. In contrast, for individual tube-well, owners maintain his/her machine as his own. Thus, individually owned tube-wells have less complexity in managing irrigation business, and owners could use the machines more productively than other organizations. The findings confirm that effective groundwater service provision is in most of the cases related with the level of managerial efficiency, that is, there is a positive relationship between effectiveness and managerial efficiency.

Operational aspects of service provisions of different service providers

Operation and maintenance of any organization needs to reflect the practical aspects of equipment, regulation, administrative procedure and incentives to ensure proper delivery of services (Rashid and Yusuf, 1996). Institutions are operated more or less in isolation, both in planning and implementation of schemes. Better operation and maintenance of tube-wells under an appropriate system acceptable to farmers is necessary for better operational efficiency. Irrigation water seller authority appoints operators for efficient water management. Operators have responsibility for tube-well specific management and repairing and maintenance. For irrigating land, farmers mostly depend on tube-well operators. However, they do not get proper support from the operators especially from BMDA tube-well operators. One FGD participant mentioned that *"BMDA tube-well operators act as autocrats. Operators do not perform their work timely and we are mostly suffered by them"*. BADC and RDA installed tube-wells portrayed similar situation as well. For BADC tube-well, one person has the responsibility for operational activity at field level. BADC authority does not exist in the field level operation. Sometimes they visited the field. One participant during in-depth interview mentioned that *"I do not get proper services from them when water is needed. Operator is not available in the field that leads to delay of irrigation."* Moreover, the FGD participants mentioned that *"We faced many challenges in buying water as operator seems to be autocratic, maintenance and repair cost of tube-well imposed on us."* In order to getting irrigation water, therefore, water buyers or farmers preferred individually owned tube-wells because of easy terms and conditions of operational activities. Individual tube-well owners operate their tube wells timely and they provide irrigation water

when farmers needed. In fact, timely and reliable supply of water motivates farmers to choose individual owned tube-wells.

Economic aspects of service provisions of different service providers

Economic efficiency depends on ultimate benefit of supply-side and demand-side groups or community that they are expected (Koundouri and Groom, 2000). BMDA irrigation water users or community bear cost on the basis of hour. From the farmers' point of view, they paid Tk.110 per hour for irrigating their crop field. On an average, it is estimated at Tk.7500 to Tk. 9000 per acre for every *Boro* season. It was observed that irrigation charge varies with the service providers. BADC and RDA installed tube-well authorities provide water for irrigation to the farmers on the basis of per decimal of agricultural land. RDA user shave to pay Tk.28 per decimal in *Rabi* season, that is, about Tk.2800 per acre. At the same time, BADC users pay Tk.37 per decimal, that is, Tk.3700 per acre. In this region, BADC and RDA authorities supply large volume of water because they use eight-inch irrigation pipe. Individual tube-well owners supply irrigation water on the basis of hour. Farmers pay Tk.90 per hour and at the same time they also gave 5kg rice per acre to the individual tube-well owners and they don't need to pay operation and maintenance cost. Community people are mostly economically sufferer as they have to bear all kind of repairing and maintenance costs in case of BMDA, BADC and RDA. Farmers are not happy with this arrangement, but in most of the cases there is no alternative as mentioned by FGD participants: *"We have no way to move from BMDA to other water suppliers. BMDA earns more benefit and water pricing is also high. We are not interested to pay for operation and maintenance cost and the operators illegally collect more money that is burden for us"*. One operator mentioned the similar thing that *"farmers are not happy for paying the operation and maintenance cost under this arrangement"*. Present situation indicates that most of the farmers want to be released from institutional authorities. Findings confirmed that individual owned tube-wells are more economically viable than that of institutional tube-wells.

Comparative effectiveness of different service providers

Different water sellers provide different kind of services in the study areas. Detailed mode of operation of each and every water seller is presented in the Table 3 in order to assess their effectiveness from a comparative point of view. These features include engagement process, water pricing, payment method, accessibility, control mechanism, community preference, beneficiary group, incentive provision and political interference. It is clear from Table 3 that users can pay water charge to the individual owners through direct payment. On the other hand, payment is made through digital card in case of BMDA and by paying electric bill in case of both BADC and RDA. Therefore, it can be said that payment system is easy in case individual ownership as the farmers of Bangladesh is convenient to pay cash directly. Community gets more preference in case of individual ownership than that of the BMDA, BADC and RDA. Moreover, in case of individually owned tube-wells there is no instance of political interference, which is somewhat present in case of BMDA and not that much present in case BADC and RDA.

Findings of this study show the changing landscape of irrigation business in the study areas. The individual owner is getting priority from both water buyer and sellers end. Regarding effectiveness, farmers mostly interested to purchase groundwater from individual tube-well owners. They felt comfort to negotiate with the individual owners. In fact, water buyers become frustrated for imposing extra cost of repairing and maintenance of irrigation equipment by the different water seller institutions. Hence, many institutional tube-wells' command areas have been shifted to individually owned tube-wells. Moreover, community believes that individual

ownership is more efficient and trustworthy than institutional ownership. According to a participant, *“I feel comfort to be engaged with individual owner because there is no pressure on me to bear any extra cost of irrigation”*. Another participant mentioned that *“I do not face any problem by engaging with individual tube-well owners. When an individual owner started his operation I decided to move from BMDA authority”*.

Table 3: Comparative features of different irrigation service providers

| Criteria | BMDA | BADC | RDA | Individual |
|------------------------|---|---|--|--|
| Engagement process | Authority influences community first, then community is motivated to engage | Formulation of committee and communication with farmers | Committee members and communicate with users | Farmers communicate with owners |
| Pricing | Tk.110 per hour | Tk.37 per decimal | Tk.28 per decimal | Tk.90 per hour |
| Payment | Digital card system | Electricity bill | Electricity bill | Direct payment |
| Accessibility | Relatively high with some preferences | Committee-led access to users | Committee-led access to users | High accessibility |
| Control mechanism | Owner as well as operator-led control | Owner-led control but committee-led decision | Owner-led control but committee-led decision | Owner-led decision and control |
| Community preferences | Less | Less | Less | High |
| Beneficiary | BMDA authority is usually benefited | BADC authority is mostly benefited | Both providers and users are benefited | Both providers and users are benefited |
| Incentives provision | No direct incentive for buyers and sellers | Direct incentive for sellers | Direct incentive for users | No incentive for buyers |
| Political interference | Presence of political interfere | Less political interfere | Less political interfere | No interference |

Assessment of service providers' effectiveness based on case studies

The effectiveness of various groundwater service providers is also assessed on the basis of four case studies conducted with three water buyers of various providers and one operator. The case of Box 2 approves the fact that buyers do not like BADC at present because of some unwanted cost they have to endure, because of which they wish an increase in individual owners' tube-wells with a subsequent decline in BADC ownership in case of irrigation business in their respective areas.

Box 2: BADC buyer who wants to shift to individual ownership

Mr. B purchases water from BADC installed tube-well and he is the member of irrigation water committee as well. At present he faces many problems in participating with BADC. BADC appoints operators/managers but BADC does not pay the salary, which is provided by the users and committee members. According to him, *“I have no interest to pay such amount of money (salary of the operators); it is an extra burden for me. In case of individually installed tube-well this practice is absent”*. Command area of BADC installed tube-wells are decreasing day by day due to lack of efficient managing system, operating system and comparatively high water price. He mentioned that most of farmers are interested to buy water from individual owner: *“If BADC ownership shifts to individual owners I think it will be better for me as well as for others”*.

Nevertheless, the case study of a BMDA operator presented in Box 3 says a different story. According to this case study, BMDA is still beneficial to some extent for the farmers in its operating area though public trust has decreased because of its poor managerial efficiency. The main reason of poor managerial efficiency of BMDA is that their operators have to do a lot of activities including selection of water buyers, distributing waters, collecting charges, etc. along with operation and maintenance of machine. Therefore, more operators should be appointed in order to reduce workload of a specific operator.

Box 3: A BMDA operator who is in favour of his institution

Mr. C is a BMDA tube-well operator. He mentioned that poor managerial efficiency of institutional providers decreases community's trust to buy water from them. Although he was recruited as operator but he has to do all kind of managerial activities at field level. Selection of water users, maintaining serial, irrigating crop land, collecting money from water buyers, whole bunch of work are done by him, which reduces his managerial efficiency. According to him, *"it is not easy to do all kind of managerial activities by an operator in the field"*. However, he still considers BMDA as beneficial for water users as he believes *"BMDA is better, it is a large organization"*. As an operator he has given more preference to BMDA tube wells.

Though the operators of BMDA still talk in favour of BMDA, their buyers do not want to buy water from them anymore because of not getting water timely when they require it. Moreover, despite supplying water through three-inch pipe instead of six-inch, they charge the similar price, which is not acceptable and expected by the buyers. This scenario is presented in Box 4.

Box 4: BMDA buyer who does not like his provider anymore

Mr. D is a water buyer of BMDA installed tube-well for the last nine years. But at present, it is very tough for him and others to buy water from BMDA as they have to wait longer period to irrigate their land and they do not get water timely. At the beginning, the authority used six-inch water pipe to provide irrigation water and now they use three-inch pipe (due to decline of water level). However, they kept water price per hour same as before. He urged that this is the extra burden for water buyers. Moreover, they charge the buyers if there is any damage of various machineries. According to him, *"I have to pay extra charges for irrigation if any tube-well machinery or pipe line is damaged"*. In fact, community has nothing to do in this existing system. In reality, operating efficiency depends on tube-well operators. For this reason, community gets interested to involve in selecting the operator.

Basically, the farmers in the study areas like the individual owners most for buying irrigation water. Box 5 has discussed the thoughts of an individual owner's water buyer. It can be conferred that because of its economic viability, individual ownership is more preferable to the farmers as it has more comparative economic advantages than that other service providers. Moreover, buyers do not need to pay any hidden charge in this case.

Box 5: An admirer of individual ownership

Mr. E irrigates his all crop land with the help of individual owners' tube-well for last five years. He gets more benefits in buying water from individual owners. However, at the initial time of tube-wells installation, farmers were benefited mostly from BMDA and other authorities. Recently, it has been changed. Farmers or water buyers mostly prefer economically viable institutions for doing business as well as receiving better services in field level operations. Hence they prefer individual owners over institutional arrangement as they are economically more benefited from individual owners than that of institutional water suppliers. He mentioned that *"we are not liable to pay any extra charge in case individual owned tube-wells. For this reason we prefer to buy water from them"*.

From the above case studies, it can clearly be said that individually owned tube-wells are getting popular in the study areas for the supply of irrigation water and therefore, the involvement of water buyers with them is increasing day by day. Though institutional service providers were beneficial for the farmers in early stage of groundwater supply, currently individual ownership has been proved to be more beneficial in terms of managerial, operational, and economic points of view.

IV. CONCLUSION

From actual understanding of effective management of groundwater among different service providers' effectiveness criteria, water users or community or farmers are mostly interested to buy water from individual tube-well owners. From management approach it is said to be perfect, if the demand-side elements balance with its supply-side inputs. This is matched with individually owned tube-wells. Farmers usually purchase water from water seller considering the price of water per acre. The actual cost of buying water from RDA is lower compared to other service providers. BMDA price is almost same irrespective of season. They are bit costly due to additional maintenance cost and maintenance and technical operation are slower than that of other institutions. Generally, BADC and RDA set price based on land area (decimal) but BMDA and individual owners sell water per hour basis in the study location. However, farmers still prefer individual tube-wells considering the managerial and operational efficiencies. In respect to community participation, tube-well specific irrigation committee is formed in case of institutional sellers and they have the sole control over irrigation business. However, tube-well operators play vital role in distributing water and in decision making process. In case of irrigating plot, first water goes to the owners or managers' plots, then to their close relatives, then to the regular and timely water charge payers and finally to others. This sequence becomes even more pronounced during a crisis, when water availability is reduced. Considering the socioeconomic circumstances of the poor, it is probable that they are always last to have their lands irrigated. On the other hand, individual tube-well owners have full freedom to manage, operate and control their installed tube-well to run irrigation business. Individual owners provide services to the farmers when they need it. For these reasons along with less complexity, groundwater users prefer individually installed tube-wells than BMDA, BADC, and RDA installed tube-wells. Considering the importance of groundwater irrigation in northwest Bangladesh, the water supplying institutions including BMDA, BADC and RDA should take care of selecting manager/operators who really work for the community as a whole. BMDA should be pro-active in repairing the machineries and the repairing cost should be borne by the authority. Finally, it can be concluded that the institutional service providers should maintain ethics during distribution of water. They should not prioritise powerful groups rather they should distribute water according to the rules and regulations. Therefore, community based groundwater management under institutional arrangement should be the top priority by the relevant stakeholders.

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