EFFECTIVENESS OF COMMUNITY PARTICIPATION IN GROUNDWATER MANAGEMENT IN NORTHERN BANGLADESH

MS THESIS

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MYMENSINGH-2202

JUNE 2018

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BY

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Roll No.: 16RSJD-01M

Registration No: 45728

Session: July-December/2016

MASTER OF SCIENCE (MS)

IN

RURAL SOCIOLOGY

Department of Rural Sociology

Bangladesh Agricultural University

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June 2018

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ABSTRACT

Present study was undertaken to find out the tube-well specific groundwater management, effectiveness of community participation and identify various problems and constraints faced by groundwater users and the owners. Bogura (Kahaloo upazila) and Chapainawabgonj (Nachole upazila) district from northwestern Bangladesh were selected purposively as the selected districts mostly depend on groundwater for agriculture and household activities. Two villages namely Allakchattra under Kahaloo upazila and Ajhoir under Nachole upazila were selected randomly for empirical investigation. The study employed qualitative techniques, hence relevant information and data were collected through Focus Group Discussion (FGDs), Key Informant Interview (KIIs), in-depth interview and case studies. Findings revealed that majority of the farmers were dependent on various institutional groundwater service providers (BMDA, BADC, and RDA) and small portion were involved in individually owned tube-well owners for irrigation. It was revealed that community or water buyers pay irrigation charge in cash and/or by sharing their crops. In case of BADC and RDA installed tube-wells, irrigation committee was formed and the committee took the responsibility for selecting water buyers and collecting irrigation/water charge and overall management process. Except individually owned tube-wells, all other institutional tube-well operators played dominant role in the irrigation business. On the aspect of tube-well specific effectiveness, based on assessment of several criteria, water buyers mostly preferred the individually installed tube-wells for irrigation. Good service delivery, good operational and managerial practices, comparatively low irrigation charges and regular water supply were identified as influencing factors that motivated water buyer to choose individually installed tube-wells. Hence, the command area of individually owned tube-wells gradually increased than that of institutional tube-wells. Several problems and constraints on groundwater management were identified from water suppliers and buyers' point of views. Water pricing and its collection, repairing and maintenance hassle, formation of water user committee, inadequate supply of electricity, less cooperation from water buyers and political interfere were identified as main challenges for water sellers. While unavailability of water, high irrigation charge, imposed maintenance and repair cost, operational mismanagement, lack of proper monitoring and political interfere were found as obstacles for water buyers. Study suggests that both water buyers (community) and sellers should work closely to improve the groundwater management practices and ensure sustainable use of groundwater.

ACKNOWLEDGEMENTS

At the beginning, the author bows to the grace and mercy of the Almighty Allah, who has enabled him to complete the research work and to prepare the thesis.

The author acknowledges his gratitude and indebtedness to his supervisor Dr. M. Wakilur Rahman, Professor, Department of Rural Sociology, Bangladesh Agricultural University, Mymensingh-2202, for his encouragement and support.

The author expresses his heartful gratitude, sincere appreciation to his respected co-supervisor Kazi Shek Farid, Associate Professor & Head, Department of Rural Sociology, Bangladesh Agricultural University, Mymensingh-2202, for his scholastic guidance, constructive suggestions, helpful criticisms and continuous inspiration towards the completion of this thesis.

The author express profound gratitude to all respected teachers namely Professor Rafiqun Nessa Ali, Dr. Md. Shajahan Kabir, Dr. Mohammad Musfequs Salehin, Associate Professor, Sadika Sharmin, Lavlu Mazumdar, Assistant Professor, Flora Begum, Assistant Professor, Md. Assaduzzaman, Assistant Professor, Nisith Zahan Tanny, Department of Rural Sociology, Bangladesh Agricultural University, Mymensingh-2202, for their intellectual guidance and suggestions.

Author would like to show his gratitude to Dr. Md. Salauddin Palash, Professor, Department of Agribusiness and Marketing and Dr. Hasneen Jahan, Professor, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh-2202, for their instructions, and advices.

Author is very thankful to Rini Ara Begum, SAAO, Nachole, ChapaiNawabganj and Md. Jalil Mia, SAAO, Kahaloo, Bogura for their co-operation during data collection.

The author expresses his profound gratitude to CSIRO (Commonwealth Scientific and Industrial Research Organization) and South Asia Sustainable Development Investment Portfolio for funding which was supported by the Australian aid program.

The author is grateful to the respondents for talking a lot trouble in supplying necessary information without which it would not be possible to write up this thesis.

The author expresses his deepest gratitude to his elder brother Assaduzzaman Papon and Shambu Singha for moral support and help throughout the research.

The author deeply owes his whole hearted thanks to all the relatives, friends, well-wishers, especially Md. Shofikuzzaman Shoaib, Hamidur Rahman Milton, Kazi Tousif Ahmed, Biplob Mollick, Asif Mahmud Bandhan, Additty Chakrabarthy, Sandra De Segma and Tamanna Ferdoush for their inspiration and help during the period of the study

Special thanks are due to all the officials and employees of the Department of Rural Sociology for their help and cooperation.

Finally, the author express his boundless gratitude to his beloved parents Md. Mafiz Uddin and Saleha Khatun for their blessings, inspirations, moral support and sacrifice in the entire period of academic life.

The Author

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ABBREVIATIONS AND ACRONYMS

BADC	Bangladesh Agriculture Development Corporation
BBS	Bangladesh Bureau of Statistics
BIADP	Briand's Integrated Area Development Project
BMDA	Briand Multipurpose Development Authority
CBNRM	Community-based Natural Resources Management
CPR	Common Pool Resources
CSISAMI	Cereal System initiative for South Asia-Mechanization and Irrigation
CWMS	Community Water Management Systems
DTW	Deep Tube-Well
DWAFRS	Department of Water Affairs and Forestry Republic of South Africa
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GEF	Global Environment Facility
GO	Government Organization
GWP	Global Water Partnership
IWM	Integrated Water Management
IRRI	International Rice Research Institute
KII	Key Informant Interview
LGED	Local Government Engineering Department
MoA	Ministry of Agriculture
NGO	Non-Government Organization
RDA	Rural Development Academy

ABBREVIATIONS AND ACRONYMS

SAAO	Sub-Assistant Agriculture Officer
STW	Shallow Tube-Well
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNESCO	United Nations Educational and Scientific and Cultural Organization
USA	United State of America

Chapter 1

INTRODUCTION

1.1 Background of the Study

Over the past two generations and especially since the pioneering 1972 UN Conference on Human Environment and then the 1977 Mar Del Plata UN Conference on Water, public attention has been drawn to the significance of water as the key to human sustenance (Varady *et al.,* 2012). Historically water was perceived as an ingredient for agriculture, transportation, industry, and human development. But when water was studied explicitly, it was typically by hydrologists, civil engineers, and chemists who sought to know its properties, characteristics, and potential for irrigation and power. Scholars devoted considerable attention to the ability of farmers, fishermen, pastoralists and other types of resource users to organize, manage, adopt, monitor and enforce institutional arrangements that govern their use of common pool resources (CPRs) in a sustainable manner (Ostrom *et al.*, 2002). Groundwater is an important resource for livelihoods and the food security of billions of people, and especially in booming Asia's agricultural economies. Globally, groundwater provides approximately 50% of current potable water supplies, 40% of the industrial water demand, and 20% of the water used for irrigation (UNESCO, 2003; Molden, 2007). In Asia and the Pacific, on an average, about 32% of the population uses groundwater as a drinking water source (Morris *et al.,* 2003). However, there are regions where dependence on groundwater for drinking purposes is much larger.

Water is an essential natural resource that shapes regional landscapes and vital for ecosystem functioning and human well-being (Emerton and Bos, 2004). The structure and functioning of aquatic and terrestrial ecosystems critically depend on the availability of sufficient amounts of water and its temporal distribution (Falkernmark and Röckstrom, 2004). Groundwater is a reliable freshwater resource. Its location underground prevents it from evaporative forces. Thus it serves as storage of most of the worlds' liquid fresh water. Being enclosed in the ground it is not also easily

contaminated. Since groundwater can be used wherever it exists without costly treatments, there is over dependence on the resource. Though in the past it was mainly used by rural dwellers for domestic water supply, presently, due to effects of climate change on surface water resources, pressures of population growth leading to expansion of towns and cities, groundwater is also supplied for uses in agriculture and industrial purposes. Groundwater as part of precipitation which has percolated through the soil and is found in the pore spaces of saturated layers of sand, gravels, clay or crystalline rocks beneath the earth surface (Cech, 2003). The impact of climate change on water resources, the problem of overexploitation of groundwater, industrial development and increased population that depend on groundwater are evidences that advocate for the need of sustainable groundwater management (Ako *et al.,* 2009).

Several approaches of groundwater management have been adopted in recent years that sensitize and involve the community to work on the issue. There is an urgent need for a concerted effort to integrate science and community participation for groundwater management. Groundwater is a 'highly decentralized resource' and one that has been mainly developed through private initiative, its management and protection can only be effective through proactive social participation. An 'enabling environment' for local community participation (at groundwater body or micro-watershed level) will often need to be facilitated and sustained, which will involve bringing together subsistence farmers, commercial irrigators, rural leaders, local administration and state government departments. In this context the promotion of community groundwater user, institutional arrangement is essential for sustainable management.

Groundwater irrigation has probably been the most dramatic development in Bangladesh agriculture since 1980s. In this process, Barind Multipurpose Development Authority (BMDA) has installed more than 10,000 DTWs in Barind area of northwest region. In addition, quite a large number of STWs have been installed in this region by private initiatives (Ahmad *et al.,* 2008). Due to gradual lowering of groundwater table, irrigation cost has been increasing because of more cost on fuel

and labor leading to increase of production cost. Cost of irrigation also found different considering ownership of the tube well (i.e. public and private), type of fuel (diesel or electricity), type of tube well (STW or DTW). The cost of irrigation by privately owned tube wells was much higher than that of government tube-wells and cost was also higher in case of diesel than electricity driven pumps (Dey, 2013). Agriculture is the major user of water in Bangladesh, with rice cultivation as the single most important economic activity. Rice is the staple food in the country, and is grown on 75% of the total cultivated land, constituting 90% of the total food grain production (BADC, 2013). However, groundwater irrigation also has serious consequences as energy costs are increasing, water levels are declining in the intensive irrigated areas of northern Bangladesh, and groundwater quality is deteriorating. Due to high installation, operational, and management costs, the large-scale development of surface water resources in Bangladesh is fewer. Groundwater irrigation therefore remain crucial to sustain agrarian growth to meet Bangladesh's future food requirements (Qureshi, 2009). The principle that community resources must be managed by the community concerned along with local government institutions guides participatory water management. Appropriate public and private organizations provide information and training to the local community organizations for efficient management of water resources (Chowdhury, 2012)

1.2 Community Participation and Groundwater

Successful water management practice for irrigation will depend on equitable participation of all groups of farmers as water user groups in management and cost recovery. In Bangladesh, there has been a rising dependence on groundwater due to lack of surface water resources. A recent study shows that groundwater level in some areas falls between 5-10 m in dry season and most of the tube-wells fail to lift sufficient water (Dey and Ali, 2010). By the year 2016, about 700 million people in 43 different countries suffering for water scarcity and 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world's population could be living under water stressed conditions by 2025 (UNDESA, 2016).

Despites such challenges, groundwater use for irrigation has become increasingly important although cost of irrigation increased substantially. Cost effectiveness of using irrigation water for different crops in different regions needs to be examined so that the appropriate crops in terms of profitability may be grown in different locations. International Rice Research Institute (IRRI) reported that, irrigation efficiency in Bangladesh is the lowest in the region, where the cost of irrigation is $117.60 per hectare compared to $25.58 in India, $17.94 in Thailand and $17.98 in Vietnam (The Daily Star, 2008). In Bangladesh, informal water markets for irrigation have developed quickly with the rapid expansion of tube-well irrigation over the last decade. In case of shallow and deep tube-wells, the owners of the irrigation equipment enter into deals for irrigation services with neighboring farmers in addition to using the equipment for irrigating their own land. With the expansion of water markets in the private sector, the pricing system has also undergone changes to suit varying circumstances.

To assess the comparative advantage and how community effectively participate in groundwater management with the different ownership of irrigation technologies in the agriculture is the main concern. Since groundwater is an invisible common pool resource, it brings with a set of complexities about who uses and who provides. When a potential user overuses groundwater for personal consumption, it leads to a situation where it decreases the availability of water for a community. Similarly dilemmas arise about who develops and manages the water and who uses it because with a common pool resource it becomes difficult to exclude users. Participation brings a discipline into this process of management. It brings users together to arrive at mutually agreed decisions on usage and recharge. Simultaneously, it builds in an ethos of self-regulation and sustainable use of groundwater to be followed by all (Chowdhury, 2012).

1.3 Rationale of the Study

Groundwater and its management is a global issue. Bangladesh has achieved a remarkable progress in the water supply during the last few decades because of the availability of groundwater. It has reported that over 97% of total population have

access to tube-wells/hand pumps, taps or ring wells (Crow and Sultana, 2002). Availability of groundwater for irrigation has contributed to manifold increases in crop productivity of Bangladesh, particularly in northwest region. However, the overwhelming population, food insecurity, poor water management and below average rainfall are putting unprecedented pressure on groundwater (Dey, 2013). Groundwater is under increasing threat from over-development, over-extraction and pollution, due to increasing population pressure, increasing living standards, industrialization, and a lack of proper management to match the demands and use patterns with the natural resource base (Sharma *et al.,* 2005*)*

Most of the authors have focused on groundwater management, importance, constraints and community participation in different area. Foster *et al*., (2002), interpreted that participatory groundwater management does not generally happen spontaneously. Sondipon (2017), stated that in absence of major surface water diversion, added pressure on groundwater will lead to further depletion of the sources. Rivers being recharged from groundwater causing a major natural loss of groundwater through Mahananda and the Ganges River. Islam *et al*., (2014), found that in Barind area, the problems that are being faced related to water availability, use, control and management are not new. In this regard, conjunctive use of surface and groundwater, development of a monitoring system and finally regional cooperation is essential. Varady *et al*., (2012) showed that the global groundwater governance community have only recently started to address these issues of global groundwater governance. Mukherji and Shah (2005) urged that develop and enable community-management of groundwater resources which includes training and organization of the Community and formal establishment of the different roles and responsibilities and accountabilities of the various groups in policies and regulations. Sharma *et al*., (2005), express that, informing groundwater users and involving them actively is a key to obtaining sustainable and acceptable solutions to groundwater management challenges. Mondal (2015), identified number of constraints and barriers in the sustenance and uptake of the treatment-based drinking water technologies. Ownership, unit cost, local availability and ease of operation and maintenance are among the principal factors affecting their sustained use.

In the line of previous study findings, present study is intended to investigate the effectiveness of community participation and groundwater management on the basis of different tube-well ownership category in northern Bangladesh. The earlier studies emphasized on groundwater management and few on community involvement however this study focuses on groundwater management and community participation in connection to identifying the effectiveness of different service providers. It is reasonably claim that this study is different from earlier studies and may contribute significantly to the existing literature as well social science discipline. Moreover, this study will be immensely useful for the researchers, development workers and policy makers for future work on community-based groundwater management.

1.4 Research Questions and Research Objectives

Based on above discussion on community participation and groundwater management, present study is undertaken to seek the answer of following specific research questions.

1. How does community participate in different formal and informal irrigation authorities for groundwater management in northern part of Bangladesh?
2. What are the factors that are responsible for effectiveness of groundwater management?
3. What are the main problems and constrains of groundwater management?

General objective of the study is to determine the effectiveness of community participation in groundwater management in the Ajhoir and Alokchattra village of Chapainawabgonj and Bogura district respectively. Accordingly, the study has undertaken to assess the following specific objectives:

1. To assess the existing community engagement process of groundwater management;
2. To examine the effectiveness of groundwater management practices;
3. To identify the problems and constrains of groundwater management;

1.5 Research Assembly

The whole study has been assembled within 7 chapters. Chapter one contains preliminary information and an overall idea about the study including research questions and research objectives. Chapter two comprises literature review on effectiveness of community participation and groundwater management. Third chapter explains methods of the research with specific analytical techniques. Fourth chapter assesses the existing community engagement process of groundwater management. Chapter five measures the effectiveness of groundwater management. Six chapter is about the problems and constrains of groundwater management in study area. At the end, chapter seven presents the summery and some recommendations for future use.

1.6 Conclusion

This chapter has presented a brief discussion of the background of the study and effectiveness of community participation in groundwater management in northern Bangladesh. Attempts are made here to justify why the study has taken place. It also lays down the objectives of the study and the logical sequence in which it is organized in the later chapters. Since any kind of analysis requires a thorough review of its available literature, the next chapter is devoted to reviewing the available literature related to community participation and groundwater in Bangladesh.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Review of literature refers to the works already done in the general area provides an exposure, necessary to determine the priority of what ought to be studied. Review of literature in any research is essential because it provides a scope for reviewing the stock of knowledge and information relevant to the proposed research. Literature and research of the major past works in connection with the present study were searched in the relevant libraries and research institutes, because this knowledge and information provide guideline in designing the future research problem and validation of the new findings. In this chapter, some selected studies related to the effectiveness of community participation in groundwater management are reviewed with emphasized on Northern Bangladesh. The exercise will contribute to a thorough understanding of the subject.

2.2 Community Participation and Groundwater management

Foster *et al.* (2002) examined that in most developing nation's public information offices deal with narrowly-focused communication programs, implemented through the national media without systematic assessment of impact. This approach is not well-suited to the technical complexity of groundwater resource management nor to the social aspects of stakeholder participation. A more appropriate approach to communication would need to be compatible with existing networks within which local groundwater agencies work. The stakeholder focus should be on building capacity to access, use and generate information – thus in groups with different capacities traditional community outlets, the mass-media and modern information channels all need to be considered.

Ong'or (2005) revealed that the community participation approaches that are being developed by communities to enable them to be included in the management of water resources and to reach a higher level of integration in watershed resources

management in the Lake Victoria Basin of Kenya. Watershed management in the Lake Victoria Basin primarily involves protection of water resources, conservation of the resources, and development of water resources. The integrated approach involves sustainable management of these resources for livelihood activities such as farming, harvesting, irrigation, pottery and brick making and general development while conserving the resources. The author was involved in community social movements, which have been established in some river basins as forums, consultative arenas, water user associations and community water lobby groups.

An IWM study (2006) found that the abstraction of groundwater for irrigation requirement was higher than the recharge, causing constrains for *boro* paddy cultivation, but the northern part has suitability for further groundwater development to meet the requirement for *boro* paddy cultivation. Studies also have noted that careful management can avoid problems in over exploitation of resources and environmental degradation of this area. Besides, distributing the water in right time in right amount or flow adjustment is the prime issue of concern for minimizing the impact of global environment change.

Schlager (2007) explored the promising types of linkages between communities of groundwater users and higher-level government authority. Local level governance is a key component of sustainably managing groundwater basins. How higher level governments can encourage and support local management efforts is an important topic. The shape and form of productive and complementary relations among resources users and different organizations and governments is not well understood and requires substantial investigation. This study put effort to explaining the conditions that contribute to the emergences and persistence to the farmer managed irrigation system.

Wahid *et al.* (2007) showed that the economically attractive high-yielding variety (HYV) *Boro* (dry season) rice cultivation during the groundwater irrigation season might not sustain in large parts of the project area (Teesta Barrage Project in Bangladesh), if the current trends in abstraction are continued. However, due to spatial variation in abstraction, nine out of 21 *thanas* (sub-districts) in the project area

may still be able to expand groundwater-irrigated cropland and a groundwater use potential of 40 mm/year may be created if deep-set shallow tube wells are used by the farmers to abstract groundwater.

Nchoung (2013) carried out a study to enhance groundwater management in Sandveld, a qualitative content analysis approach was used to evaluate six factors considered to be highly needed in groundwater management. This background was used to find out how institutional arrangement in South Africa facilitates or constraints groundwater management in Sandveld, a highly groundwater dependent area in the West Coast of the Western Cape. The results showed that all six factors community involvement, managerial power, groundwater problems, monitoring legislation, institutional arrangement and resources tools found but three of them facilitated groundwater management while three others constrained the management. Report identified the community involvement as ranked one.

Dewan *et al*. (2014) stated that in Bangladesh, Community-based Natural Resources Management (CBNRM) concept was applied to water, a culturally common natural resource key to coastal livelihoods. It is subjected to competing uses, while its management and maintenance help to protect against flooding and disasters. This paper reviewed the extent of success of such participatory water management. It does so by first discussing the changing discourses of participation in Bangladesh's water policy from social mobilization to decentralized CBNRM. Bangladesh is used as a case study to draw attention to how the creation of separate water management organizations has been unable to promote inclusive participation. It argues that the current form of decentralization through a CBNRM framework has not resulted in its stated aims of equitable, efficient, and sustainable management of natural resources; rather it has duplicated existing local government institutions.

Islam *et al.* (2014) reviewed the state of art on integrated water resources management (IWRM) approaches for sustainable irrigation at the basin scale under semi-arid and arid climatic conditions, with main emphasis in Barind area where Surface water irrigation has not been developed satisfactorily due to its limited availability and undulated topography. As IWRM is an interdisciplinary approach and used for

different objectives, the main emphasis is given to IWRM approaches for sustainable irrigation and their environmental aspects. Groundwater is the main source of irrigation as well as for domestic and industrial purposes in Barind area. In recent years, lowering of groundwater table is observed in some areas of the region. Lowering of groundwater table during dry months creates problems in the operation of STWs and hand tube-wells. In some places of Tanore Upazila, declining trend of groundwater level also observed. In the next 25 years, food demand of the country is expected to increase by 29% which will require increased cropping intensity. In absence of major surface water diversion, added pressure on groundwater will lead to further depletion of the sources. Rivers being recharged from groundwater causing a major natural loss of groundwater through Mahananda and the Ganges River. Reduction of surface water flows and lowering of groundwater table combined with climate change will aggravate the existing water scarcity problem. All these have compounded the sustainable management of water in this area. To overcome this complexity, an integrated water resources management (IWRM) is necessary. Upazila wise potential resource as well as usable resource, present and future demand for expanded irrigation coverage, number of DTW, surface water availability, impact of conserving surface water on kharies have been assessed for the study area which is very important for IWRM.

Maheshwari *et al.* (2014) conducted study in the Meghraj watershed in Aravalli district, Gujarat, and the Dharta watershed in Udaipur district, Rajasthan, India. The study involved the collection of hydrologic, agronomic and socio-economic data and engagement of local village and school communities through their role in groundwater monitoring, field trials, photovoice activities and education campaigns. The study revealed that availability of relevant and reliable data related to the various aspects of groundwater and developing trust and support between local communities, NGOs and government agencies are the key to moving towards a dialogue to decide on what to do to achieve sustainable use of groundwater.

Mathenge *et al.* (2014) draw attention to assess the performance of key institutions involved in the management of water resources and supply of water services in Ngaciuma-Kinyaritha Catchment of the Tana Basin of Mount Kenya Region. Findings

revealed that Community Water Management Systems (CWMSs) played and keep playing a key role in developing the existing water resources, thus increasing farming water profitability in the catchment. These CWMSs achieved 30% of the targets of the water sector reforms in ensuring domestic water security in Ngaciuma-Kinyaritha.

Afsana (2017) used a community empowerment framework of six elements, capacity building, human rights, organizational sustainability, institutional accountability, contribution and enabling environment (CHOICE), can be used as an underlying foundation to plan maternal health programs. Strategies for community empowerment, which include building up skilled human resources for health and community resources, are meant to free the community from powerlessness, lack of choice and poverty. The community is a source of valuable resources, in particular, people with expertise and skills who can act as agents for change. The community health workers introduced by BRAC create demand, provide community services and are themselves members of the community whose capacity is being built to influence pathways to community empowerment. Other means to engage the community for social change include the establishment of structured community support networks and use of interactive communication methods that engage a broad and diverse base of people in maternity care interventions.

2.3 Groundwater Situation in Bangladesh

Acheson *et al.* (1990) study concluded that private, state, and communal property are all potentially viable resource management options. This paper demonstrated how successes and challenges occur in all forms of government approaches as well. The examples within this paper demonstrate the exact same conclusion. The fact that this paper specifically examined the CPR of groundwater intensifies these complexities.

Ahmed *et al.* (1994) revealed that in Bangladesh, ground water levels are highest from August through October and lowest in April and May. A sharp rise in water level generally begins in May and continues until July. The range of fluctuation is from three to six meters in most areas. After July, the rate of rise decreases and in many areas ground water levels remain almost stationary from August to October,

indicating rejection of recharge because the aquifer is filled to capacity. The rejected recharge varies from place to place and depends upon several factors, including permeability of surface materials, rainfall amount and intensity, and the time factor. Highest potential recharge occurs in Dinajpur, Mymensingh, Sylhet, Noakhali, and Chittagong, and the lowest potential recharge occurs in Western Bangladesh in Rajshahi, Kushtia, and Pabna.

Aziz *et al.* (2012) reported that main source of recharging of groundwater aquifer in this area is rainfall, but rainfall is also dropping here. Average rates of maximum depth (dry season) and minimum depth (wet season) groundwater depilation are 0.23meter/year and 0.38meter/year respectively in Rajshahi district, some upazilas these rates are much higher than that of average. Groundwater recharge condition is very poor in Tanore, Godagari, Mohanpur and Baghmara upazilas and vulnerable for Boro rice i.e. irrigated rice.

Rahman and Mahbub (2012) emphasized that successive depletion of groundwater level with expansion of groundwater irrigation in Barind Tract has been discussed from mid 1960s to 2010 in the context of Tanore Upazila, which is located in severely drought prone area of northwest Bangladesh. This study presented the change of groundwater level with the spreading of groundwater irrigation in Barind Tract. They find that water level is continuously lowering at the rate of 1.37 ft/y in wet season and 0.72 ft/y in dry season.

Day *et al.* (2013) revealed a declining trend of groundwater table over the last 30 years (1981-2011), which implies groundwater use is not sustainable in the study area. The severely depleted district has been identified as Rajshahi followed by Pabna, Bogra, Dinajpur and Rangpur. The magnitude of the decline in groundwater table has been found between -2.3 to -11.5m during the study period. This mainly attributes to over exploitation of groundwater than recharging aquifer.

Villareal *et al.* (2016) reported that surface water constitutes 3% of the world's freshwaters and is visible, measurable and manageable; groundwater constitutes 97% of freshwater and is out of sight, generally not well measured, and therefore more difficult to understand, manage and protect in terms of quantity and quality.

Groundwater and surface water are intricately linked, with groundwater providing base flow to surface water systems (feeding water to rivers and wetlands), and acting as a buffer to supply water during dry periods and droughts. They also concluded, current and emerging challenges to maintaining the quantity and quality of groundwater resources include climate change and variability, pressures from a growing population, increasing urbanization, and large agricultural demands.

2.4 Groundwater Irrigation and Farm Income

Kahnert and Levine (1993) showed that the performance and management of public tube wells in eastern India have been less than satisfactory when compared to private wells; and though they are justified on equity grounds, small and marginal farmers rarely seem to have been the primary beneficiaries. They also pointing that the well owners may provide water free to marginal farmers to encourage them to work in their fields. Credit and subsidies and their role in promoting investments in groundwater by the poor remains unclear. More specifically for groundwater−based irrigation, discussants voiced uncertainty about the relative importance of improvement in farm income, increase and improvement in agricultural labor opportunities, and opportunities for income benefits from ancillary activities such as the sale, maintenance, and repair of pumping equipment, post−harvest processing and marketing, and so on. Although there are clearly benefits from groundwater irrigation, the poor do not seem to have benefited substantially. Available evidence suggests that the absolute level of well−being of the poor has increased, but that their relative status has declined with the advent of irrigation.

Food and Agriculture Organization (2003) highlighted three key points about groundwater management. First, access to groundwater will continue to allow intensification of agricultural production in response changing patterns of demand. Second, the scope for managing agricultural demand for groundwater is limited, particularly where rural communities are trying to escape from poverty. Third, the overexploitation of aquifers by agriculture is forcing users into economic and social transitions. It gives a brief diagnosis of the nature of current groundwater use and management practices and sets a path for a more practical approach. The limits of

conventional water management are discussed and the prospects for expanding the repertoire of management tools for groundwater are examined. It is argued that the rigidity of water resource management in many irrigation systems is not attuned to the inherent variability of the natural systems upon which they depend.

Qureshi *et al.* (2009) point out that increased groundwater accessibility resulting from the expansion of deep and shallow tube wells helped Bangladesh attain near self-sufficiency in rice, with national output increasing over 15 million tons in the last two decades. Available evidence suggests that the policy focus so far has been largely on "resource development", and not on "resource management". This has resulted in serious problems, most notably excessive drawdown in intensively irrigated areas, and the deterioration of groundwater quality.

Lenouvel and Montginoul (2010) conducted fine-tuned field work with farmers in order to understand the key factors of substitution between underground and surface water at the farm level. This study is to compare the "relative" and the "absolute" impact on farmers' income of several economic instruments which may be implemented to mitigate farmers' groundwater withdrawals in a multi-resource system. They suggest that in a conjunctive use system the elasticity of farmers' short-term groundwater demand is artificially enhanced by the substitution occurring between water resources. They also revealed that taxes and quotas seem ineffective to manage water from the farmers' viewpoint. There is a need for other economic instruments or even management approaches. Conjunctive use systems create a great management opportunity for groundwater

Zahid *et al.* (2011) reported on groundwater resources development in Bangladesh and also found out the contribution to irrigation for food security and constraints to sustainability. This study revealed that the groundwater resource is one of the key factors in making the country self-sufficient in food production. Groundwater-irrigated agriculture plays an important role in poverty alleviation and has greatly increased food production. Authors also mentioned that until now, availability of groundwater has not been a constraint to agricultural development. But this resource is increasingly facing various problems including quality hazards in many areas

where the exposure to pollution from agriculture, urbanized areas and industrial sites as well as arsenic contamination in shallower groundwater aquifers makes the water unfit for human consumption and in some cases even for irrigation purposes. High rates of pumping for irrigation and other uses from the shallow aquifers in coastal areas may result in widespread saltwater intrusion, downward leakage of arsenic concentrations and the general degradation of water resources. Besides, use of agrochemicals may cause contamination of shallow groundwater and sediments. Continuous decline of groundwater tables due to over-withdrawal has also been reported from some areas. Thus, the overall situation calls for urgent groundwater management for sustainable development. Groundwater management must adopt an integrated approach taking into account a wide range of ecological, socio-economic and scientific factors and needs.

Dillon *et al.* (2014) revealed that, in many settings local action by motivated communities has run ahead of state and national policies and been highly effective in managing groundwater storage, increasing farm incomes and protecting the environment. Clearly, where there are also supportive government policies, local reform is easier to implement. This paper concludes with a unifying synthesis of pathways through policy reform, based on integrated water resources assessment, and including evaluation of groundwater stress, community capabilities for collective action and the availability of other water resources.

2.5 Effective Groundwater Governance for Agriculture

Faruqee & Choudhry (1995) revealed that the management of water resources has become a critical need for Bangladesh due to growing demand and increasing conflict between alternative uses. Water is a unitary resource which means that controlling it in one location can have adverse impact on others. They also mentioned water resource management generally implies management of both the supply and demand for water. Because it is a scarce commodity, its use should be determined by opportunity cost pricing. Water is both a public and a private good and the system that allocates it should take into account the needs of all the users, particularly the

underprivileged class. Because it is a common resource, its development and management should involve all beneficiaries.

Department of Water Affairs and Forestry Republic of South Africa (2000) stated that integrated management of groundwater and surface water is required in order to provide for adequate protection of the resource. They showed that the major reason for poor management of groundwater resources, however, has been a lack of a structured approach to management and a lack of knowledge and information about groundwater. Equity in provision of water for basic needs, and sustainability, are thus now the most important principles of water resource management.

Chowdhury (2012) highlighted some issues of existing irrigation institutions and their impact on cost and price of irrigation water in Bangladesh agriculture. The study mainly deals with how public institutions and water markets have evolved over time in response to changes in irrigation technology and how they affect the cost and price of irrigation water. Farmers in Bangladesh do not pay for use of per unit of irrigation water. When surface water was abundant farmers solely depended on rivers, canals and ponds to irrigate their fields with traditional local methods where the maintenance cost of the apparatus and labor charges were the costs of irrigation. For the government run canal irrigation methods the farmers usually pay a fixed amount per unit of irrigated land per crop during the season and in case of participatory water management water user groups pay for maintenance of field channels plus management cost in some cases. The main challenge of public sector irrigation institutions is to design proper incentives for all stakeholders to participate in the participatory water management network. Successful water management practice for irrigation will depend on equitable participation of all groups of farmers as water user groups in management and cost recovery.

Iskandar *et al.* (2012) mentioned that the FAO/ GEF project "Groundwater Governance: A Global Framework for Country Action" is a comprehensive attempt to understand and articulate this notion in its entirety—as applied to the particular subject of groundwater. Non-technical, "soft" approaches to managing water have accepted the centrality of understanding modes of governance. The present water

crisis—in so far as the growing lack of access to potable water and water for agricultural and industrial use can be described in such alarming terms—is "mainly a crisis of governance," the Global Water Partnership proclaimed at the turn of the current century.

Shah (2014) found that groundwater has always proved difficult to manage. Management 'best practices' largely evolved in the industrialized countries, such as Australia, Italy, Spain, Mexico, and the USA, which have the scientific resources and institutional capacity. A review of the various 'groundwater governance models' suggests that while each has merit, none can claim to have achieved the sustainable use of groundwater. Moreover, there is little evidence to suggest that models that work in the USA or Australia will work in low-income countries, such as Bangladesh, Myanmar, and Pakistan. This study revealed that the socio-ecological and political environment is critical in determining the elements of an appropriate groundwater governance regime. It is clear that there is no 'one best way' to organize and govern a country's groundwater irrigation economy simply because of the many different socio-economic and political circumstances that exist. Groundwater governance is thus less about groundwater and aquifers and more about social systems, stage of economic evolution, and the society's political organization. The governance of groundwater irrigation in South Asia is particularly complex because it involves serving many millions of smallholder, private sector farmers.

2.6 Conclusion

To understand the effective groundwater management in agriculture irrigation almost all the empirical works conducted in Bangladesh and all over the world have been thoroughly reviewed. The review suggested that the overall situation calls for urgent groundwater management for sustainable development. Groundwater management must adopt an integrated approach taking into account a wide range of ecological, socio-economic and scientific factors and needs. Many authors draw attention about community participation for groundwater management and also suggested for policy recommendation in several regions. Chowdhury (2012) reported that successful water management practice for irrigation will depend on equitable participation of all

groups of farmers as water user groups in management and cost recovery. Dillon *et al*., (2014) unifying synthesis of pathways through policy reform, based on integrated water resources assessment, and including evaluation of groundwater stress, community capabilities for collective action and the availability of other water resources. However, they have not been addressed largely about the different organizations' effectiveness to provide irrigated water in all level of farmers in many areas. Therefore, present study intended to how community managed groundwater effectively with the participation of different water supply authority.

Chapter 3

METHODOLOGY

3.1 Introduction

The reliability of a research depends on the proper methodology. So, methodology is very important for any research and has to be chosen carefully to fulfill the purpose of the study. Methodology should be such that it would enable the researcher to collect valid and reliable information and to analyze those data to arrive at correct decision. From this point of view, researcher took an endeavor to adopt realistic methods. Several methods are used for collecting data in the field of social sciences. Among them, qualitative tools are adopted in this study to achieve the objectives of this study. Focus Group Discussion (FGD), Key Informant Interview (KII), in-depth interview, case study and field observation approaches were pursued in determining the effectiveness of community participation in groundwater management in the study area. Primary data were collected by applying those qualitative tools. For the secondary sources of data different books, journals, newspapers and also different official documents of government, non-government and international organization were used.

3.2 Selection of the Study Area

Selection of the study area is an important step and largely depends upon the objectives set for the study. Due to limitation of time and resources, the inclusion of the whole northern part of Bangladesh for investigation was not possible. In this study, the Ajhoir village of Nachole upazilla under Chapainawabgonj district and the Alokchattra village of Kahaloo upazilla under Bogura district were selected purposively. The selected villages are located in the northern Bangladesh where the ratio of groundwater to surface water use is much higher compared to other part of the country. In addition, the selected villages have different groundwater irrigation water supply institutions including BMDA, BADC and RDA. Shamsudduha *et al.* (2011) found that groundwater recharge is higher in the north-west than the south and north-east, a function of increased groundwater extraction in the former zones.

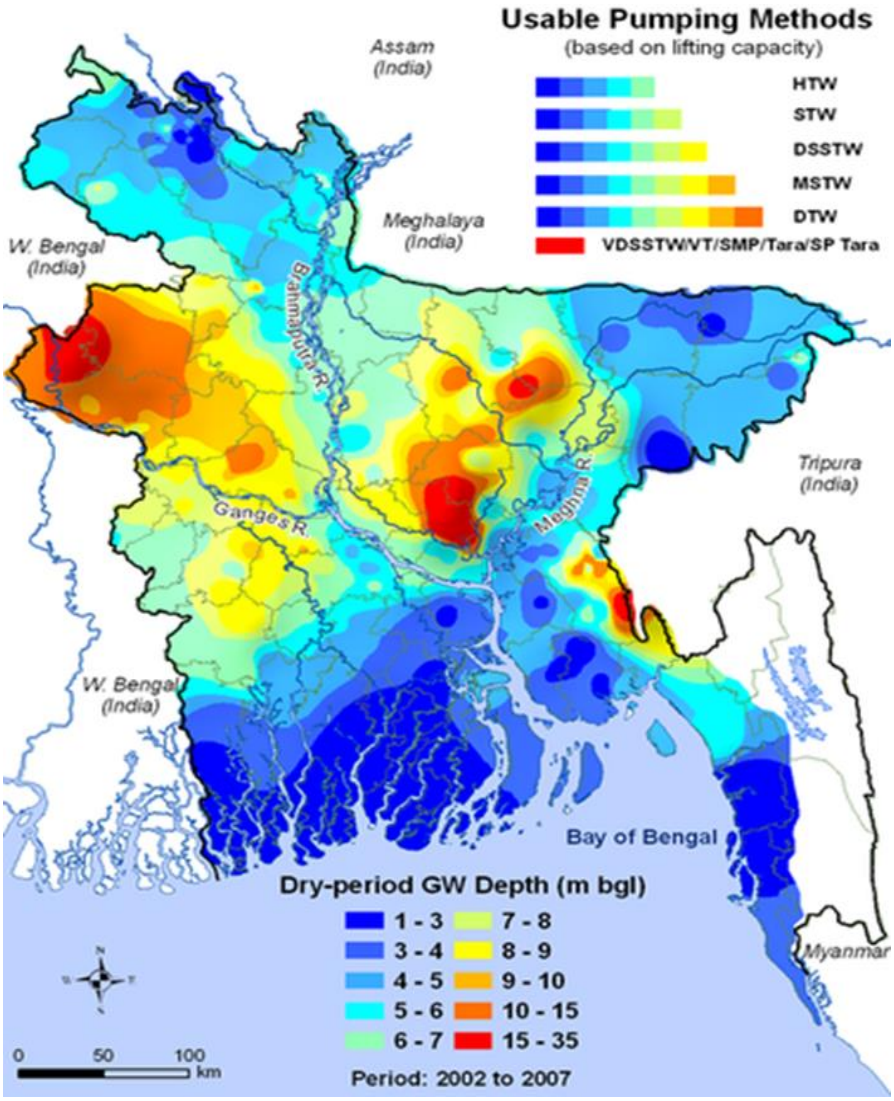
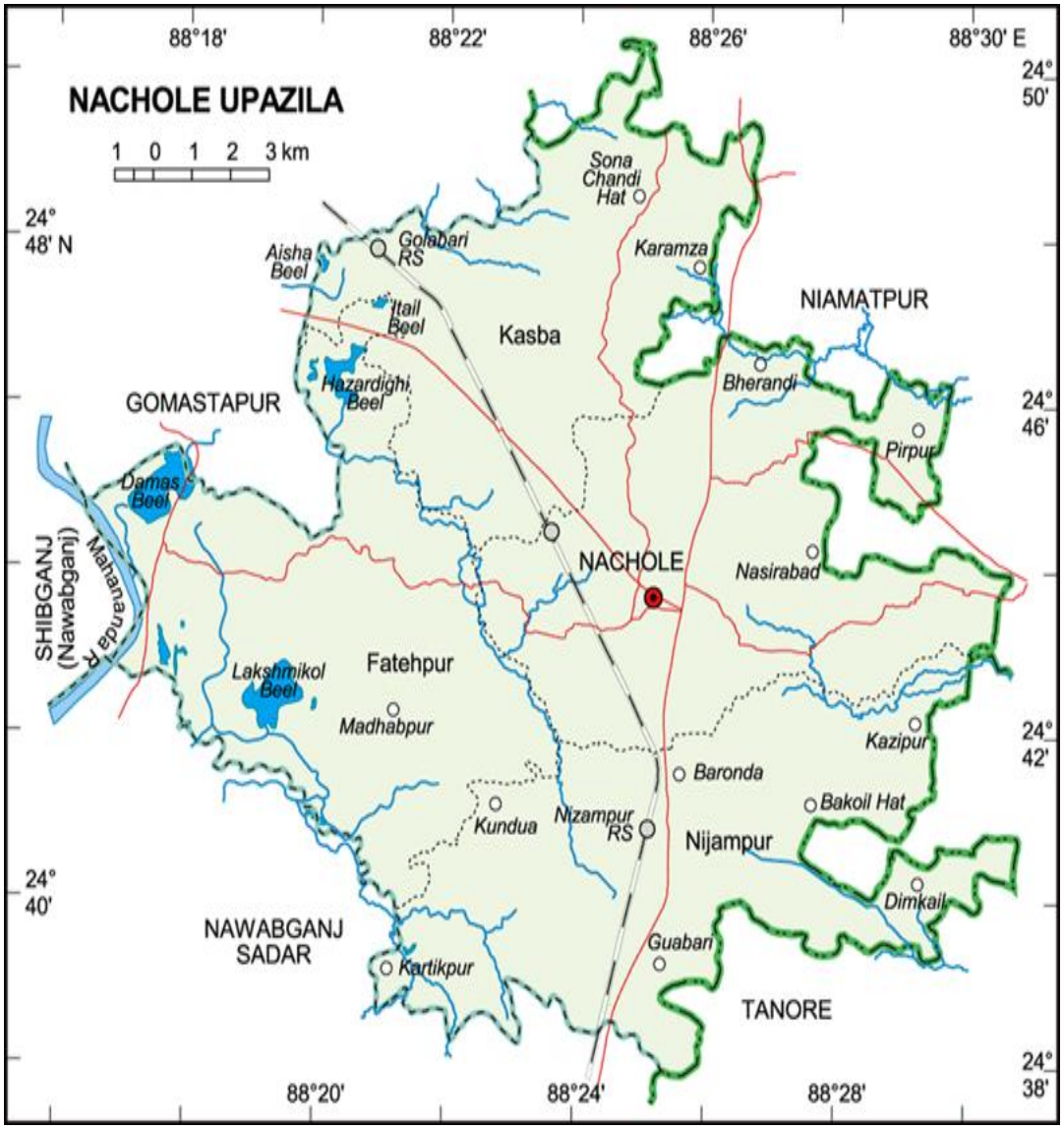


Figure 3.1: Groundwater level in Bangladesh

Source: Cereal System initiative for South Asia-Mechanization and Irrigation (CSISA-MI)

The area was selected based on the following aspects:

- Preferred area was suitable to fulfill the research objectives;
- Both area located under Northwestern regions;
- Most of all people of these areas depend on groundwater for irrigation as well as for household uses;
- This type of study was not conducted before in this area;



Source: LGED, Bangladesh

Figure 3.2: Map showing Nachole Upazilla

Source: LGED, Bangladesh

Figure 3.3: Map showing Kahaloo upazilla

3.3 Methods and Sources of Data

The qualitative technique is the prime research approach adopted in this study. In fact settled objectives of the study leads to apply qualitative tools. Qualitative tools such as Focus Group Discussion (FGD), in-depth interview, case study and KIIs were performed. In addition, field observation method was also applied in this study. A total of eight FGDs were conducted in the Ajhoir and Alokchattra villages in which four FGDs were conducted with BMDA, BADC, RDA and individually installed tube-well water users/participants as well as particular groundwater irrigation committee

members. Another two FGDs were conducted with the mixed participants who are generally engaged in different water supply authority for irrigation. Key Informant Interviews (KII) were conducted with experts in the field including operator, BMDA and BADC personnel. 5 case studies and 6 in-depth interviews were conducted with the different personnel who are mostly involved in groundwater irrigation. The research has tried to document the effective supply and demand sides related to groundwater management for the community. Distribution of qualitative techniques applied in this study is shown in Table 3.1

Table 3.1 Sample Distribution

Tools	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
Case study	2	1	-	-	2	-	5
In depth interview	1	2	1	1	-	1	6

Source: Field survey, 2018

3.4 Collection of Data

Collection of accurate and reliable data and other necessary information from the field is not an easy task. It must be done properly since the success of the study depends on reliability of the data. Data collection is the systemic approach for gathering information from variety of sources to get a complete and accurate picture of the study area. Various tools which were used for collection data in this study purposes.

3.4.1 Focus Group Discussion

Focus groups are a form of strategy in qualitative research in which attitudes, opinions or perceptions towards an issue, product, service or program are explored through a free and open discussion between members of a group and researcher (Kumar, 2011).

Total eight FGDs were conducted by the researcher among target group. In the time of FGDs, all questions were open ended and the discussion were based on prepared checklist. The researcher got freedom to convert the questioning approach according to the situation of FGD in connection to the research objectives. The discussion was facilitated by the researcher where participants were allowed to feel free in sharing but the conversations which misleads the discussion were always tried to avoid. Each conversation lasted for 60-90 minutes with 8-10 participants. The researcher has tried to make a convenient environment for the participant during FGD so that they can willingly disclose their thoughts, experiences and ideas related to the study objectives.

3.4.2 Observation

Observation was an integral part of the data collection method. The data was collected from March to April, 2018. During this period, farmers of the villages were busy in different kind of agricultural activities. Every tube wells were fully active for irrigation and operators, managers who are responsible for taking care of specific tube well are also busy. In *Rabi* season farmers are fully dependent on groundwater irrigation and thus they are highly engaged in different irrigation water suppliers. During irrigation period real scenarios as well as irrigation performance of different tube wells were observed through direct field observation.

3.4.3 Key Informants Interview

The key informant interviews involve interviewing a selected group of individuals who are likely to provide needed information, ideas and insights on a particular subject (Kumar, 1989). Key Informant Interviews are qualitative in-depth interviews with people who know what is going on the community. A wide range of people of the community including tube well operators, tube well owners, users' committee members and the officials were the main target of KIIs who had firsthand knowledge and information about the community. Eight Key Informant Interview were undertaken which will give the information about community participation and groundwater management.

3.4.4 Case Study

The case study method enables a researcher to closely examine the data within a specific context (Zainal, 2007). The method is widely recognized in social science studies especially in-depth explanation of a behavior are sought after. Case study explore and investigate an individual real-life phenomenon though detailed contextual analysis. That's why five case studies were conducted in this study to effective participation and groundwater management.

3.4.5 In-depth Interview

In depth interview is another important qualitative tool which helps to explore depth analysis on particular respondents. In this research such technique is mostly applied on the users, operators, managers, committee members and different resource person to gather realistic data related to groundwater irrigation. Several interviews were conducted among different community experts for better understanding of the supply side and demand side behavior of water management.

3.5 Period of Data Collection

The primary data of the present study were collected from March to April 2018, through numerous visits to the study areas. Data were collected via group discussion, participation and in-depth interview using checklist and guidelines with the BMDA, BADC, RDA and individual water supplier as well as water users of the selected villages. FGD guide was prepared to gather all the essential data. Participants of the case study and KII were selected through purposive sampling technique. FGD were conducted by the researcher along with the help of SAAO (Sub-Assistant Agriculture Officer) and other local members. On the other hand, KIIs were conducted by the researcher himself to document the overall effective community participation and groundwater management in the study area. The case study was also carried out by the researcher to explore managerial, operational and financial efficiency on different tube well ownership as well as irrigation water users' preferences.

3.6 Sources of Secondary Data

In connection to the research objectives, relevant secondary data were collected from journals, previous theses, and official documents of government, non-government organizations, websites and lastly different issues of the daily newspaper have been consulted.

3.7 Data Analysis

The present study makes an effort to explore simple analytical approach with the help of acquired knowledge through review of the relevant literature on community participation and groundwater management. The study describes the process of community participation in groundwater management. Data and information collected through FGDs and KIIS were synthesized and identified some key factors that influence community engagement or participation in groundwater management. For examining the effectiveness of groundwater management, financial, managerial, technical and operational activities were thoroughly evaluated for different groundwater service providers. The comparative features of different groundwater service providers (institutional and individual) were presented in a tabular form but description was given based on qualitative method.

3.8 Limitations of Data Collection

Data collection in rural areas presents unique problems for the researcher make an impact on the research process and hampers the outcome of the study (Pierce and Scherra, 2004). The present study has also been confronted with some challenges but mitigated tactfully. The challenges are given below:

- The first and most important problem faced in data collection was to convince the participants for interviews discussions and to adjust time as they were really very busy during data collection period;
- Sometime omission or contradiction or missing data found after returning from the field. To overcome this problem and bridging the gap repeated visits were made to collect data in the research area;

- Most of the respondent have no idea about research work, for this reason, it seemed difficult to explain the purpose of the study to convince them;
- Due to lack of proper knowledge, the respondents were indifferent to the objectives of the study and answers questions in careless manner. So, sometimes it was difficult to get correct information. However, several visits were made to overcome the challenges.

In spite of all the difficulties pointed here, the researcher could able to collect quality data from the field.

3.9 Conclusion

A structured methodology is the backbone of a research, maintain the expected outcome. The researcher has given a careful attention for a logical methodology which always supportive for the research. Therefore, this chapter is carefully focused to adopt a suitable methodology for present study. The next chapter is devoted in narrating the community participation process in the study area.

Chapter 4

COMMUNITY PARTICIPATION PROCESS OF GROUNDWATER MANAGEMENT

4.1 Introduction

Groundwater is a shared, local resource, and collaboration and robust participation of community members and leadership overlying the aquifer system, including stewards of the environment, provide invaluable tools and a pathway toward the collective action needed to manage groundwater resources sustainably (Foster *et al.*, 2007). Community engagement is an important social tool and can be a driving force for fostering trust, acceptance, and support for the management actions and costs, and ultimate compliance to adhere to the actions implemented. This chapter intends to document tube well specific managerial practices to assess communities' decision and involvement process of groundwater management in the village of Ajhoir and Alokchattra under Nachole and Kahaloo upazilla, respectively. This chapter tries to document the ownership and controller of irrigation tube-wells and resources in connection to social capital and community participation in groundwater management.

4.2 Community Participation

"Community participation refers to the process by which community benefit organizations and individuals build ongoing, permanent relationships for the purpose of applying a collective vision for the benefit of a community" (Maheshwari *et al.*, 2014). Community participation should include encouraging local leadership in key roles to nurture sound decisions and promote compliance with needed actions. Management institutions will need to identify and engage these varied interests and determine how their involvement will be integrated into the decision-making, coordination, and implementation processes that are necessary to achieve groundwater sustainability. Further, 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.

The exception occurs where historic events have underscored the importance of groundwater and charismatic local leadership has arisen to address the issue. In other word, the process is likely to be considerably longer and the set-up costs higher, since there may be no acute awareness of the threats to the groundwater and many unconnected users. In principle, it has to be in the interest of groundwater users that the resource base is conserved. Moreover, the limits set to groundwater use under resource management plans do not necessarily imply that economic benefits are jeopardized. There is often scope for increasing productivity of groundwater use to compensate for less being abstracted-by using appropriate soil moisture management, improved crop selection and irrigation techniques, that lead to real water-resource saving. The implementation of such measures, however, needs to be triggered by stakeholder participation in groundwater management, and there may even be scope for successful community action on aquifer recharge enhancement (Garduno *et al.*, 2010). From empirical investigation shows community possess different forms of participation in groundwater management. In some cases, community participate in groundwater management by forming group or irrigation management committee. This committee generally demarked the command area of each tube-wells. For determining the irrigation charge some sort of negotiation taken place between water buyers and sellers. Both cash and kind payment were observed in the study villages.

4.3 Tube-well Specific Managerial Practices

Usually, all managerial activities of different organizations are performed by the manager for successful running the irrigation business. In fact, manager has to satisfy both sides the water buyers and the organization (water seller). The ability of the manager to coordinate those at other levels influences the extent of the success or failure in achieving the agreed management objectives. Thus, managerial power refers to the coordination that exists between all management levels in a particular sector creating a good working relationship with other organizations (Carter *et al.*, 2005). Consequently, managers can fall under two categories. Those that recognize problems and effectively implement solutions and those who are unwilling to do so. Some managing authorities work in close collaboration with communities but others not. It

was observed that BMDA, BADC, RDA and individual installed tube-wells were maintained different kinds of managerial practices for groundwater management. Good management practices depend on various managerial tools includes administration, communication, finance and accounts, human resource, monitoring and operating system of tube-wells that examined based on ownership and community participation. Managerial practices of different authorities are gathered from direct field observation and FGDs with the tube well owners or irrigation water sellers, water buyers' communities, deep tube well managers, operators, irrigation committees and other participants. It was observed that different organizations practice different types of managerial strategies. The operator of BMDA installed tube-well do the managerial tasks and the operators are selected by the BMDA authority. Through field observation, it was found that community or groundwater users mostly depend on the operators for irrigation and its related issues. In contrast, BADC and RDA installed tube-well authority set up a tube-well specific irrigation committee and all kind of managerial activity perform by this committee. Committee members communicate with farmers for groundwater irrigation. Most of these tube-wells are connected with "*Polli biddut*" (rural electrification board) and have the load-shading problem. BMDA and RDA authority sometimes monitor and visit their installed tube-wells. In Kahaloo location, BADC authority selected a person who got responsibility as operator cum manager. In the field level all kind of managerial activities are performed by the operator and official members only manage their human resources as well as desk work. In case of individual owner, all kind of managerial activities are done by tube-well owner and him/her borne all sorts of operational expenses, negotiate with water buyers, manage machinery equipment etc. It is observed that most of the farmers preferred to buy water from the individual tube-well owners. Hence, overall the commend area of BMDA, BADC and RDA have been decreased due to managerial constraints. Managerial practices of different installed tube-wells authority are presented in table 4.3

Table 4.3: Managerial practices of different irrigation tube-wells

Managerial Practices	BMDA tube well	BADC tube well	RDA tube well	Individual tube well
Administration unit	• BMDA staffs provide information and technology • New innovative project is implemented	• BADC authority maintain the administrative roles • Irrigation committee is also responsible in field level	• RDA water management department control this unit	• Tube well owner controls this unit
Communication	• Communicate with their tube well operators • Deep tube well operators communicate with the farmers for sound management	• BADC authority create an irrigation committee for better management • This committee communicate with farmers	• RDA authority established an irrigation committee • Water users or community are communicate with them	• Owner give information to the community • Farmers 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 consider an one hour	• Financial management done by committee • RDA collect tk28 per decimal land	• Individual owner collects money an hour basis
Human Resources	• BMDA control resources • This authority appointed on operator for community management	• BADC have water management board and usually they set up a committee consisting eighteen members	• Irrigation committee manage the water users or communities	• For community participation tube-well owner maintain all activity
Monitoring system	• Authority monitor tube wells and operators • Tube-well operators maintain the specific farmers or communities	• BADC appointed a manager and operator who monitor the field level operations • Authority sometimes monitor the tube well and community involvement	• Specific tube well committee monitoring the community for irrigation water	• Only tube well owner is responsible for monitoring
Operating System	• Only operator deals with the community for irrigation water • Operator repair the machinery with the involvement of community	• Tube well operator done this work • Irrigation committee also responsible for any recovery cost	• An operator selected from this committee and he/she is responsible for operation	• Owner operate his own tube well

4.4 Community Involvement Process for Groundwater Management

Participation brings a discipline into this process of management. It brings users together to arrive at mutually agreed decisions on usage and recharge. Simultaneously, it builds in an ethos of self-regulation and sustainable use of groundwater to be followed by all. Community participation involves holding discussions and open forums between community members and with government authorities or non-governmental organizations involved in advocacy so as to contribute ideas for inclusion in policy development and change in operation strategy. They help to achieve the implementation of management, making decisions on how to use the available water resources, transfer of relevant management technologies and dissemination of information. The process of community consultation helps in the planning process and may take different approaches like ground water management. The participation of communities in decision making process and therefore governance of water resources is a critical strategy in ensuring the sustainability of groundwater management. In the study villages, it was observed that different tube-well irrigation committee provide space to the community to discuss and exchange ideas on how to manage their irrigation for crop farming. Water users or communities have common interests such as living near an irrigation scheme, living near water wells. Basically, community mostly manage their irrigation water for agriculture and they decide where/whom to buy water i.e. BMDA or BADC or RDA or individual tube-wells. As per response of an individual tube-well owner who was the buyer of BMDA tube-well before installation of his tube-well. At present his command area estimated about 30 acres. He mentioned that, *"for groundwater irrigation farmers mainly contact with the tube-well owners in case of individual owner while for BMDA, RDA and BADC farmers contact with the operator or manager."* In fact, irrigation water buying decision depends on physical, social, economic, technical, and cultural aspects. For example, there are some physical setting farmers cannot buy water from an individual owner due to absence of individual owner. Similarly, a farmer cannot buy water from BMDA installed tube-well if there is no BMDA installed tube-wells. If there is multiple water sellers, then community settled the command area for each entity (tube-well

owners). However, individual buyer also get preference to buy water for his/her land. Basically, this is mutual understating among water seller, buyer and the community.

4.5 Patterns of Participation

Community participation for groundwater management is in different forms including functional participation, interactive and self–mobilization patterns. It is observed that people form groups to meet their irrigation water requirement as well as household activities. In such cases, interactive and shared decisions were made by the group but in some cases external support is also required to fulfill the goal. The process of community involvement seeks for multiple perspectives and makes use of systemic and timely access of water. People participate willingly by taking information from external authorities to ensure sustainable groundwater utilization. They want to develop contacts with such institutions for resources and technical advice they need, but retain control over how resources are used. Such kind of self-motivated participation may or may not challenge existing distributions of irrigation water. Farmers reported that they join these organizations for their own choice and the process was crucial for dry season farming. At the initial phase of groundwater irrigation in the Barind tract, BMDA and BADC authority installed tube-wells and community people solely depends on them for irrigating their land. The community got involved with the BMDA and BADC in a group to have the access to water. Interestingly, they were flexible to be engaged in irrigation business. Gradually, individual tube-well ownership emerged and they started irrigation business as themselves without the mentioned institutions. Thus, community got little reluctant to form group for running irrigation business. However, BMDA, BADC, RDA still dominate the irrigation sector in the Barind tract.

4.6 Tube-well Owners' Feedback

Evaluation of any development initiatives obviously requires an assessment of service delivery, their use and the effects (positive/negative) of the services offered (Kranti Associates Ltd., 2000). In northern part of Bangladesh, most of the land was fallow in *Rabi* season before intervention of different kinds of irrigation authorities such as

BMDA, BADC and RDA. Before evolved of these service providers, T. Aman was the only one and major crop. With the implementation of such project, double and triple cropping practices have replaced the age-old agricultural systems resulting in increased cropping intensity and enormous production gains. When groundwater irrigation system was introduced by different authorities, land owners and farmers started producing various crops like as Boro rice, mustard, wheat, maize, jute, potato, eggplant, tomato, chilly and vegetables. The groundwater irrigation got popularity as well as brought social and financial benefits. It was observed that in the augmented period, farmers were so happy due to cost effective groundwater supply that influence to move forward to crop diversification. Farmers appreciate the initiative and consider as blessing for them. However, the situation has changed now, one villager of Ajhoire village reported that," *BMDA acts like as business authority and they are getting more benefit than farmers. He also added, at that time this authority is not beneficial for them."* It is observed that BMDA, BADC, and RDA authority only receive cash/money from water buyers with different terms and conditions. However, individual owner receives both cash and crops from the water buyers. One water buyer of Ajhoire village said that "a*s a water buyer, I am happy with the existing system of groundwater irrigation."* He also added that, *"supply of groundwater for individual owner is better than that of BMDA, BADC and RDA installed tube-wells."* The situation can be explained in a way that water buyer get greater access in negotiating with individual owner so they could utilize that negotiation exercise to have regular irrigation in their plots. On the other hand, the operators or managers of BMDA, BADC and RDA consider themselves as government official and pay less attention to the common farmers need.

4.7 Social Capital Competences

Social capital is considered as key element for the human and economic development of a community. The social capital differentiates itself from other forms of capital primarily for two aspects. The first - unlike financial capital, it grows with its use. The second is that when not practiced or not used the social capital tends to decrease. This type of social capital may appear in several forms such as language, goals, values, shared narratives, friendship, trust, obligations and expectations, norms of

reciprocity, sense of gratitude, strong and weak ties within the network of relationships. (Macke *et al.,* 2010). Social capital competences is very much crucial for the community in order to groundwater management. The bonding social capital is characterized by strong relations of mutual aid in the local context and high levels of participation, which results in dense multi-functional ties and strong but localized trust. The competence found in people or in physical systems is easier to imitate than the competence found in managerial skills or the organizational culture. It was observed that, different tube-well authorities and the groundwater users or community have adopted little bit competences about different forms of social capital. From field observation, groundwater management authorities were not concerned about social capital competences. They preferred to communicate with an influential in a village to operate the tube-well smoothly. Accordingly, they select the operator or manager who had greater control and access to the community.

4.8 Conclusion

Sustainable groundwater management requires integrated management decisions. Effective community participation is necessary for managing such precious natural resources. It is observed that groundwater resources come under increasing pressure in respect to availability, allocation among water buyers and household uses. Different irrigation service providers set various management practices that should be evaluated thoroughly for managing groundwater resources. In fact, Barind tract regions mostly depend on groundwater that requires effective and efficient management for present and the future.

Chapter 5

EFFECTIVENESS OF GROUNDWATER MANAGEMENT

5.1 Introduction

Increased groundwater accessibility resulting from the expansion of deep and shallow tube-wells irrigation helped Bangladesh attain near self-sufficiency in rice, with national output increasing over 15 million tons in the last two decades (Dey *et al.,* 2013). In addition to supply-side solutions, water demand will need to be curtailed by increasing water use efficiency through adoption of water conserving management practices, for example reduced tillage and raised bed planting, and the right choice of appropriate crops (Qureshi *et al.,* 2015). This chapter intends to measure the managerial efficiency and financial efficiency based on tube-well owners' category with the help of in-depth interview and informative case studies. Good practice or successful case of community lead groundwater management and comparative effectiveness among different tube-wells were also explained in this chapter.

5.2 Importance of Effective Participation in Groundwater Management

Effective groundwater management is a complex subject involving experts in geology, engineering, economics, and ecology, the primary management task boils down to a simple concept of balancing long-term supply and demand (California Water Foundation, 2014). Groundwater is a critical component of northern parts water system and its effective management is vital to present and future generations. Historic challenges with sustainable management are complicated by a growing population, a more volatile and uncertain claim on groundwater, being a common resource accessible by every member of the community individually, requires a common approach to its management. Effective participation is important for groundwater management and in general it depends upon commitment rather than coercion and cannot be fully programmed or tightly controlled (Maheshwari *et al.,* 2014). Effective groundwater resource management requires an optimum balancing of the increasing demands of water and land users with the long-term maintenance of

the complex natural resource. Management of the resource in addition requires the groundwater managers to appreciate the policies which strongly influence water use and food production, regulatory provisions and their limits for conserving the resource, role of communities at different levels in decision making and the need for development of integrated approaches that balance the needs of the poor and the environment with economic development goals. (Villholth *et al.,* 2014). Groundwater is a key component of the water resources of research area as well as Bangladesh. As the country's people start depending more and more on groundwater, so the need grows to provide for the security of its supply. Protection of groundwater has, therefore, now become a national priority (Department of Water Affairs and Forestry, 2000). Significant benefits accrue from user participation in the planning, implementation, operational and maintenance of water works. Firstly, it achieves broad-based support for the project in the community and command area, and generates active interest in its operation and maintenance. Secondly, it reduces the financial and managerial burden on the government as users take on responsibility of managing considerable part of the operations and pay for the services they consider their own (Rashid *et al*., 1996). Groundwater is a major sources of irrigation in dry season for crop production. Participation is a part and parcel of effective management of common pool resources as like as groundwater. As per many scholars point of view, groundwater level is very low in northern Bangladesh. That's why it's crying need to effective management for now and future.

5.3 Managerial Efficiency

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 (Fernando *et al.,* 2016). The ownership/management picture is similar for tube-wells, including those under BMDA, BADC and RDA management. Those tube-wells were managed by the managers or operators acting as de facto owners, only individual installed tube wells were managed by individual owners. Based on field observation, community were

not happy of organizational installed tube-wells services. Most of the participants blamed the authority for their managerial performance and farmers were try to shift alternate sources of water sellers. In fact, manger failed to offer better service when farmers required. It can be explained in a way that every farmer asked for irrigation in the same time which was practically impossible for a manager to satisfy all. Furthermore, operation and maintenance got some institutional complexity as it has to be done by maintaining administrative procedure. In contrast, for individual tube-well owners maintain his/her machine/engine as his own and care about the business. Thus, individually owned tube-wells got less complexity in managing irrigation business, and owners could use the machines/engine more productively than the other organizations. The study considered effective groundwater management as crucial for field level managerial operations. This study explored some cases for identify managerial efficiency.

5.3.1 Case Study 1

Md. Suleman Ali is a BMDA tube-well operator in the village of Ajhoir under the Cosba union, Nachole upazila of Chapainawabganj district. He is 45 years old. He has four family members consisting one son and a daughter along with his wife. He has been operating tube-well since 2009 and he got lot of experience about operating BMDA installed tube-well. The authority appointed him in terms of some payment system.

"The authority selected me and my involvement process only depends on particular institution not tube-well users will."

He operated now very little portion of command area before it was very large. Lack of efficient management of irrigated tube-wells and water buyers or community and some other factors behind this situation.

"At first I operated 140 bigha irrigated land now it is declining day by day which is only 40 bigha command area of my control. High water scarcity, growing individual tube-well owners, lack of proper concentration by authority is main reason. Thus my income/earning also declined."

An operator payment system was an hour basis. He earns Tk.8 per hour for irrigation. Due to decrease command area, he is not getting enough money as like as the past. He said that, at the beginning time of appointment he earned approximately Tk. 28,000 per irrigation season and now it was only Tk. 15,000 per season.

"As an operator it was very hard to me for collect money from the water users for machinery and repair costs. On the other hand, if I want any institutional support/mechanic, the procedure is complex and time consuming too. This is the greatest challenge for me to satisfy both the institution as well as the water buyers."

And he also added that,*" farmers were not happy for paying the operation and maintenance cost under this arrangement."*

As like as water users he is expected that all kind of repairing and maintenance cost should be borne by the authority. Collection of money from farmers considered as difficult task sometimes it lead to conflict between operators and farmers or users.

"He prefers monthly payment instead of end of the season for bearing his family expenses. Some water buyers prefer to pay at the end of season @ five kg rice per however he found collection of paddy is very difficult."

Although he recruited as operator but he has to do all kind of managerial activities are at field level. Selection of tube-well user, irrigating crop land, collection of money for the water buyers' whole bunch of work done by him/her. *"Both operational and managerial work in the field of agriculture are done by me though I am appointed just an operator."* However, he still considered BMDA installed tube-well as beneficial for him as well as community members or water users. Farmers could produce various crops with the help of BMDA supported tube-wells.

"I feel proud to be engaged with this organization i.e. BMDA. It has enhance my social status within the community."

He also added that,

"If I want to continue my job as operator it is necessary to pay Tk. 5,00 per year to the authority for job update."

To be effective, control of water resources must be optimally consistent with the growing seasons for different types of crops, with attention to specific needs for water and its distribution at the stage of irrigation. It is only through the dominant use of groundwater, either alone or in conjunction with surface water, that the farmer can gain this control (Friedrich et al., 1993).

For doing such kind of irrigation business, operator got all sort of responsibilities and faced various pressure such as social, political, financial, maintaining serial and finally water users' pressure in irrigation period. On the other hand, it is not easy for doing all kind of managerial activity by an operator in the field level operations as well community or water user's management.

5.4 Operating System

People's participation in water resource planning, execution, operation and maintenance, monitoring and evaluation has been limited in Bangladesh, although there is good scope for this (Rashid *et al.,* 1996). Operation and maintenance of any organization needs to reflect the practical aspects of funding, equipment, regulation, administrative procedure and incentives to ensure proper delivery of services. Institutions have operated more or less in isolation, both in planning and implementation of schemes. From field observation all tube wells are operated electrically but at the beginning period tube wells was running with diesel. Irrigation water seller authority has appointed an operator for efficient water management. Identify tube-wells operating efficiency different cases would be explored in the field level observation. For irrigated water farmers were mostly depend on tube-well operators. One farmer said,

"BMDA tube-well operator act like as a second god. Operator does not perform their work timely and we are mostly suffered by them." (FGD respondent)

In case of BADC and RDA installed tube-wells, farmers claimed the same at field level. Most of the operators got responsibility for doing different kind of activities including tube-well specific management and repairing and maintenance. The cost involved in the process also borne by the farmers/water buyers. During FGD, it was reported that-

"We are not interested to pay for operation and maintenance cost of the machine/engine and they also claimed that operator illegally collect more money that is burden for us."

In this case farmers were interested/willing to pay only irrigation charge not any kind of repairing and maintenance cost and they were not happy with this arrangement but most of the cases no alternative.

For BADC installed tube-well, one person got responsibility for operational and managerial activity at field level. BADC authority had no existence in field level operation. Sometimes they visited the field. In order to getting irrigation water, water buyers or farmers preferred the individually owned tube-well because of easy terms and conditions. Community don't have to pay extra charges such as operation and maintenance cost (the cost bears by the tube-well owner) they only pay the water charges. Individual tube-well owner operates their tube wells timely and they provide irrigation water when farmers needed. In fact, timely and reliable supply of water motivate farmers to choose individual owned tube-wells. Better operation and maintenance of tube wells, operating the installed tube-wells under an appropriate system acceptable to farmers, improving the management efficiency, crop diversification, and increase in electrification of tube-wells may increase crop production as well as farmers welfare.

5.4.1 Case Study 2

Mr. Usuf Ali is only 32 years old farmer lives Ajhoir village under Nachole upazila. He is a young, energetic, and well-behaved man and he is the water buyer of BMDA installed tube-well. He has been buying water from this authority last nine years. He has 10 bighas of owned land. He produced T. aman and Boro rice. During Boro season water is mostly needed and he engaged with the BMDA water supply organization.

"It was very helpful for me when BMDA water pump installed. I have produced large amount of crop with the support of this authority."

As per his observation, at the initial period of intervention, operating system was very well. He could irrigate his land easily. At present, it is very tough for him to buy water the authority.

"I do not get proper services from tube-wells when water is needed. Operator is not available in the field that leads to delay of irrigation."

As like him large number of water buyers are engaged with BMDA tube-well, they had to wait longer period to irrigate their land. Thus, many farmers did not get water in time and at the same time crop production affected.

"I have paid Tk. 110 per hour for irrigation but water supply is not efficient that's why cost of irrigation is very high for me."

At beginning authority used six inch water pipe to provide irrigation water and now they use three inch pipe for irrigation because of water scarcity. However, water price per hour kept the same.

"We faced many challenges in buying water as operator seems to be autocratic, maintenance and repair cost of tube-well imposed on us."

He urged that this was the extra burden for him and also other water buyers. In fact, community have nothing to do under this operating system. Authority performed such kind of operation by the help of specific operator.

"My land is not so far from the institutional tube-well though I have faced some problems it was much helpful to me for irrigation and produced boro rice."

If tube-well operators careful about his duties and responsibilities then farmers could gain/harvest more benefit from BMDA installed tube-wells. In reality, operating efficiency depends on tube-well operators that's why community got interested to involve in selecting the operator.

5.5 Economic Efficiency

Economic efficiency in resource use is achieved when no rearrangement of resources between individuals or across time can improve the welfare of society. This general definition implies two aspects to economic efficiency: static efficiency (efficient allocation of resources between potential users) and dynamic efficiency (efficient allocation over time) (Koundouri and Groom, 2000). Both aspects can be brought to bear upon the management of groundwater resources and used as a benchmark for

management practices. The management of groundwater resources is deemed economically efficient when groundwater abstraction is chosen such that its allocation over time (time-path), exhaustion date, the stock and the impacts on conjoined resources and other third parties generate the maximum welfare to society. The economic value or social benefits of groundwater are derived from consumption over time by both conventional productive sectors of the economy; households, manufacturing, agricultural, recreational etc., and non-conventional sectors such as the environment (Koundouri and Groom, 2000).

Economic efficiency depends on ultimate benefit of supply- side and demand-side groups or community which they are expected. BMDA irrigated water users or community bear cost on the basis of hour. From the farmers point of view they paid 110tk/per hour for their agriculture irrigation. On an average it was 2500tk or 3000tk per bigha for every boro season. One farmer Abjal Ahamed Babul of Ajhoire village said that

"*At the initial period of implementation, BMDA authority uses six inch water pipe but now they use three inch water pipe for irrigation although water cost does not reduce whether price is increasing day by day and we are mostly helpless".* (FGD respondent)

Returns from irrigation are not high enough to make it economical for farmers to build systems that can deliver water to individual fields. Thus, groundwater utilization for agricultural purposes in the region is predominantly through private tube-wells. BADC and RDA installed tube-well authorities provide water for irrigation to the farmers on the basis of per decimal of agriculture land. From direct field observation RDA installed tube well users or farmers paid Tk. 28 per decimal in rabi season it was about Tk. 924 per bigha. At the same time BADC water users or community bear Tk. 37 per decimal and it was Tk. 1221 per bigha irrigation cost for agricultural operation. In this region where BADC and RDA authority supply large volume of water because they use eight inch irrigation pipe as well as water availability. In spite of well services provide by those authorities many tube-wells are now under control over the farmers' community. From the individual tube well owners point of view, an individual tube well owner supply irrigation water on the

basis of hour. Farmers were paid 90tk per hour and at the same time they also gave 5kg rice per bigha to the individual tube well owner. Water demand side are mostly wanted to getting water in timely. Except individual tube well owners in other irrigation water authority does not practices such kind of operation. Community are mostly economically sufferer when they bear all kind of repair and maintenance cost. This is clearly presented in the BMDA, BADC and RDA organization. One farmer Torikul Islam stated -

"I have no way to move from BMDA to other water supply authority I am bound to buying water this institution because of my land are very close. He added that BMDA getting more benefit then farmers it is not properly distributed water for irrigation and water pricing is also high." (FGD respondent)

Present situation indicates that most of the farmers want to be released from this authority. Such organizational behavior are not suitable for farmers to irrigate their land. Water is generally not perceived as an economic good and therefore revenue recovery from the users is only a small proportion of the cost, resulting in both a drain on government finances as well as deterioration in service. There is a need, both to recover cost and to raise the standard of the service in the water sector (Alam *et al.*, 2005).

Pricing of water for agricultural purposes is more difficult. Farmers in different areas may not be receiving the same level of service and metering is difficult. Besides, farmers whose land adjoin natural water bodies and conveyance facilities may feel it in their inherent right to have free access to the water. These and other political consideration may make recovery difficult. There are alternative methods for overcoming these problems to some extent, such as instituting cost recovery through user groups, and levying water charges on the basis of cultivated hectare of land and the type of crop. Besides being a social and environmental good, water is also an economic good that needs to be managed both quantitatively and qualitatively. In Bangladesh, particularly, where water is intricately linked with the economic lives of people, its value has increased with competing demand. Therefore, economic efficiency of water use is a major policy consideration (Rashid *et al.*, 1996).

5.5.1 Case Study 3

Mr. Kamrul Islam is one of the largest farmers in the village of Ajhoir Under Nachole upazila of Chapainawabganj district. He is 48 years old. He has two sons and one daughter total five members of his family. He has owned land near about 10 bighas and he produced Aman, boro rice and he has a mango garden also. Before the intervention of individual tube-well near his land he used to buy water from institutional tube-well (BMDA). Now he irrigated his all crop land with the help of individual owners' tube-well. He started business with the individual water seller last five years.

"I am not facing no more problem with the engagement of individual tube-well owner. When a tube-well was installed near my land then I decided to move from BMDA authority."

Economic point of view, he got more benefit in buying water from individual owners.

"If I want to pay at the end of irrigation season I can for individual tube-well but this kind of provision absent in case of BMDA installed tube-well."

However, they have faced a big problem of electricity supply. However, all sorts of maintenance and repairing cost of tube-well borne by owner in case of individual owner.

"I feel comfort to be engaged in individual owner because there is no pressure on me to bear any extra cost of irrigation."

All kind of operating and managerial activities are done by the tube-well owner. Owner is all in all at field level irrigation. Farmers are happy for getting services on time.

"When irrigation is necessary for my land I got it on time I have not faced any trouble."

There are many reasons for preferring individual installed tube-wells than that of institutional tube-wells. However, at the initial time of intervention institutional tube-wells, famers benefited most and BMDA and other authorities played a positive role that impacted on their livelihood. Recently, it has changed as per following statement-

"I have faced high cost of irrigation problem at the time of business with those authority. And now engaging of individual owner price is also high but extra charge reduced."

Everyone highly seeks to efficiently use of their resources for improving living standard as well as increasing crop production. Farmers or water buyers community mostly prefer economically viable institutions for doing such kind of business as well as receiving better services in field level operations. Most of all cases engaging an individual tube-well owners' preferences is rank first however, water buyer group also benefited from different institutional tube-wells at the beginning of intervention.

5.6 Control Group of Different Tube-wells

In the study region, there are equal chances for every farmer to access the common resources such as water, trees, shrubs, and land. However, there is generally very little control over the use of these resources by the peripheral farmers. Community participation involves holding discussions and open forums between community members themselves and with government authorities or non-governmental organizations involved in advocacy so as to contribute ideas for inclusion in policy development and change in operation strategy. They help achieve the implementation of management, making decisions on how to use the available water resources, transfer of relevant management technologies and dissemination of information (Otieno, 2005). In contrast, different organizations had different level of control and varies from tube-well specific operations. BMDA authority is all in all to control or manage the official activity even this authority decide where installation of tube-well is needed or not. From farmers point of view, at the augmented period of time this authority was brings to blessing for them. This organization has also appointed different kind of managerial or operational personnel. In the field observation it was seen that every tube-wells run with the help of an operator who was selected and directed by this authority. Most of the cases tube-well operator or driver control over the community who wanted to buy water to irrigate water for cultivation. BADC and RDA tube-wells authorities practice same patterns of controlling system to manage their tube-wells and also manage the users for irrigated water. Both authority maintain an irrigation water committee for performing the field

level operation and such organization also selected a tube-well operator from the committee members. Irrigation committee possess all kinds of controlling power for supplying water to the farmers as well as domestic purposes. 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. Though demand side have no any kind of control over the management and operation of tube-well water supply they are almost happy to the tube-well owner. Owners provide services to the farmers when they need it. This picture is not seen in other water seller's authorities. Access to an adequate supply of water by relatively weak farmers depends on such factors as nearness of the land to the tube-well, regularity of the payment of water charges and the social relationships of the purchasers with the tube-well owners or managers. Field studies show that water goes first to the owners or managers, 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 output is reduced. Considering the socioeconomic circumstances of the poor, it is probable that they are always last to have their lands irrigated. In the current situation it is almost impossible to ensure equity of access and control of groundwater and its abstraction technologies among farmers and also hard to regulate its use sustainably.

5.6.1 Case Study 4

Mr. Sikander Ali is a 65 years old farmer of Alokchattra village of Malancho union under Kahaloo upazila of Bogura district. He is a large farmer in his village. He buy water from BADC installed tube-well and he is the member of irrigation water committee as well. He owned about 12 bigha land and mostly produced aman and boro rice. In this village as like as other farmer he also depends on groundwater and which is extraction by formal organizations. BADC tube-well specific irrigation committee consist of 18 members and most of all members buy water from this institution.

"I have no rights to manage tube-well, all managerial works are done by tube-well specific operator and president of irrigation water committee."

In the field level BADC selected such committee and they have little control over the management of tube-well and authority.

"From the beginning, I have joined this authority and buy water in terms of some conditions and it was very efficient for me to growing crops."

As a member of water committee, he has no extra benefit. Besides, it's very effective for existing water committee. Committee have power to select water buyers or users as they likely most. At present he faces many problems with the participation of this organization.

"I have to pay extra charges for irrigation if any tube-well machinery or pipe line are damaged."

BADC appointed one person in this particular tube-well who is consider as an operator cum manager but BADC does not pay the salary. Water committee collect money from water users and committee members also pay some money as salary to the operator.

"I have no interest to pay such amount of money (salary of the operator) it was an extra burden for me. But you know that in case of individual installed tube-well this practice was absent. "

Command area of BADC installed tube-wells are decreasing day by day due to lack of sufficient managing system, operating system and comparatively high water pricing in the study area.

"If BADC ownership shifted to individual owners I think it would be better for me as well as others."

He mentioned that most of farmers were interested to buy water from individual owner.

"My land is not so far from this tube-well and I engaged with this organization for long time at this time I am not frustrated about their activity but it would be nice if they provide additional benefit to the farmers."

Although BADC collect direct incentives from government the irrigation committee have not taken any incentives or subsidies for irrigation.

In all cases irrigation water users' or community have no control over the tube-well specific operations and different water seller institutions. Owners' possess all kind of controlling power to provide irrigation water and selecting an operator or manager for doing their business. Sometimes irrigation water committee have make some decisions in the field level services.

5.7 Comparative Effectiveness among Different Tube-wells

Different water sellers' institution provide different kind of services in the field of agriculture. Developing several effectiveness criteria is to help identify comparative effectiveness among tube-well specific performance hence providing services in field level irrigation are presented below-

Table 5.7 Comparative Effectiveness among different tube-wells

Criteria	BMDA	BADC	RDA	Individual
Engagement process	At first authority influence to engage the community afterwards community got interest	Committee formulate and communication with farmers	Committee members communicate with users	Farmers communicate with owners
Water pricing	Tk. 110 per hour	Tk 37 per decimal	Tk 28 per decimal	Tk. 90 per hour
Payment system	Digital Card system	Electricity bill	Electricity bill	Direct payment
Access	Relatively high with some preferences	Committee led access to users	Committee led access to users	High accessibility
Control system	Owner led control & operator also highly responsible	Owner led control but committee led decision	Owner led control but committee led decision	Owner led decision & control
Managerial system	Water managed by operators	Appointed personnel & water committee managed resources	Appointed personnel & water committee managed resources	Owner managed water users & tube well
Operational & Maintenance	Operators led control	Operators & irrigation committee are responsible	Operators & irrigation committee are responsible	Tube-well owners responsibility

Criteria	BMDA	BADC	RDA	Individual
Communities preferences	Less preferences	Less preferences	Less preferences	High preferences
Beneficial groups	Authority benefited	BADC authority are mostly benefited	Supply side and demand side both are benefited	Both are benefited
Incentives intervention	No direct incentive for buyers and sellers	Direct incentive for seller	Direct incentive for irrigation water users	No incentive for users or buyers
Political interfere	Political involvement is present	Less political interfere but committee members	Less political interfere	No interference

5.8 Successful Case of Community Lead Groundwater Management

Researcher wanted to look some important stories of a particular community which differentiate them from others and which are so much motivational for other farmers to effective use and management of groundwater in the study area. This kind of successful cases are documented by different case studies and some key points behind their success are identified regarding groundwater management. Such kind of successful individual cases are taken into consideration.

5.8.1 Case Study 5

Md. Azizul Haque is an individual tube-well owner of 45 years old. He lives in the Ajhoire village. He is an energetic and well-behaved farmer in the village. Before the year 2012, he was the water buyer of the BMDA as like as other farmers. He is a large farmer and produced good amount of rice in Boro season.

"At the initial period BMDA helped us greatly but the management of BMDA was not so good thus I decided to install tube-well as my own. "

He emphasized the major reason for the transferring from MBDA to individual ownership tube-well was the inadequate management of groundwater and higher price. At present, not only him other farmers also trying to shifting from this organization. Before 2010, BMDA covered large volume of land on an average 350

bigha to 400 bigha in every tube-wells for supply irrigation water but now command area declined gradually. Poor management, lack of efficient operating system and water scarcity consider the main reason. Most of the farmers were not satisfied to business with this water selling authority.

"Now, I have 100 bigha command area. Water buyers willing to engage with my installed tube-well as they get timely irrigation."

Water price of his tube-well comparatively lower than that of institutional water supply providers. He charges Tk 90/hour as irrigation charge and in addition 5kg rice per bigha from every individual farmer. In most cease, this type of payment system is flexible to the farmers. One can pay, irrigation charge after harvesting the crops which is not common for other water supplying authorities.

Most of all cases water buyers happy to get involved into individual installed tube-well owners. At the same time, Mr. Haque got benefit and he earned about one lac (100,000) taka each year whereas he has to bear four lacs taka for installation tube well.

"I want to install more tube wells in future for better water management and provide irrigation water when needed. Small, marginal and large farmers are also getting benefit from my tube-well."

Individual tube-well owner performed an operational and managerial activity. People showed their happiness with engaging individual owned tube-wells. In fact, there found the good relation between water buyers and sellers. No significant blame was observed during field survey. BMDA started to concentrate on the surface water irrigation as groundwater scarcity emerged in the Nachole area. They implemented different surface water irrigation project in the research area because of less income from installed new tube-well for extraction groundwater. Farmers are also more interested to the *Mohananda project.*

During KII discussion, some prominent causes were identified for shifting institutional tube-wells to the individual tube-wells. The identified causes of farmer's transformation from institutional authority (BMDA, BADC and RDA) to the

individual installed tube-wells were higher irrigation charge, inadequate supply of water, biasness of the kin groups and local political leaders.

5.9 Conclusion

From the economic point of view, everyone tries to utilize their limited resource to get maximum profit to meet up their unlimited wants. Groundwater is such kind of resources and different organization provide services to get higher production on agriculture for communities or farmers. In the northern part of Bangladesh, sustainable use of groundwater is becoming critical and requires effective participation from local communities along with technical, social, economic, policy and political inputs. Farmers mostly interested purchase water from individual tube-well owners. Communities got frustrated on the imposed of extra cost for repairing and maintenance and higher water price of institutional tube-wells (BMDA, BADC and RDA). Operators play an autonomous role in the filed level services. However, there was concern expressed many others that water markets aggravate equities in rural areas, as it leads to monopoly of rich farmers and their control over the market. From actual understanding of effective management of groundwater among different effectiveness criteria water users or community 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. In fact, groundwater user's preferred individually installed tube well than that of BMDA, BADC and RDA installed tube-wells.

Chapter 6

PPOBLEMS AND CONSTRAINTS OF GROUNDWATER MANAGEMENT

6.1 Introduction

Water requirement in Bangladesh has continued to increase in all sectors. Bangladesh is a developing country with rising population, increased crop production and economic growth. Water sources remain constant, and water from the rivers originating from the Himalayas will continue to decrease as the ice glaciers get diminished (Mbugua, 2011). As the demand increases, the problem and constraint of collecting and using water also increases. The purpose of this chapter is to find out the problems and constraints faced by the community or groundwater users and groundwater service providing institution as well as individual water providers in the study area. In-depth interview and Focus Group Discussion were carried out to identify the problems and constraints on groundwater management.

6.2 Problems and Constraints on Groundwater Management for the Providers

The main objective of different groundwater service providers is to improve the quality of life of the people by ensuring year-round crop production through regular supply of irrigation water. Although, there are management staffs and farmers participate enthusiastically, owners faced many problems and constraints on groundwater management for farming as well as domestic purposes. Based on tube-well owners' category and management strategy, problems and constraints on ground water management are presented separately.

6.2.1 Barind Multipurpose Development Authority (BMDA)

- This autonomous body of groundwater service provider fall under direct supervision of the Ministry of Agriculture (MoA). It is reported that overexploitation of groundwater for irrigation and other purposes has lowered the water table in some part of the Barind tract regions particularly Nachole

upazilla. BMDA is no more interested to install tube-well for groundwater extraction. Thus, the authority highly concentrated on surface water irrigation project i.e., "*mahananda project* "in the study area;

- Water pricing reported another important constraint by BMDA as farmers do not like to pay for volumetric price;
- Irrigation water distribution among different farmers (small/medium/large) also reported as constraints due to maintaining sequence of irrigation;
- As per owner response, water users or buyers cooperate less in managing the groundwater supply;
- Appropriate management of operators, managers and technicians in BMDA installed tube-well considered as barriers smooth functioning of irrigation business;
- BMDA uses underground pipe which is good but repairing and maintenance is a hassle and costly;
- Political interfere at field level also identified as constrained.

From farmers' point of view, although, this autonomous authority faced various constraints and problems as mentioned above but BMDA got more benefit from irrigation business. It is imperative that farmers pay the true opportunity costs of irrigation water from the perspective of sustainable water use.

6.2.2 Bangladesh Agriculture Development Corporation (BADC)

- Availability of water in the peak period is one of the main concern for satisfying water buyers;
- Formation of water user committee for installation of tube-well considered as challenge for them;
- Inadequate supply of electricity during irrigation time;
- In many cases farmers switched off from institutional installed tube well to individually owned tube-wells. This is the constraint of organization to sustain in competitive water market.
- Lack of proper supervision at field level;
- Political and local leaders interfere in the process of irrigation business.

6.2.3 Rural Development Academy (RDA)

- Engagement of rural community and selection of committee members were main problems of RDA;
- Operation and maintenance cost of particular tube well is also considered as a problem;
- Due to load-shedding and low water level, timely water supply is considered as a great problem;
- Expansion of individual owners create competitive business.

6.2.4 Individual Owner

Not many but individual tube well owner faced some problems at field level. These are-

- Engagement village community as a group of water buyer;
- Comparatively lower command area for generating benefits;
- Higher cost for tube-well installation and other maintenance cost;
- Water pricing and collection from the farmers considered as great challenge;
- Laborious job as most has to stay in the field during irrigation season;
- Require high expenses to maintain the canal every year.

Consider the above discussion every water seller authority faced different kind of problems and constraints but the extent various. Despite the obstacles, they earned profit from irrigation activity. Farmers were bound to engage with tube wells for their crop production in dry season.

6.3 Problems and Constraints on Groundwater Management based on Community Perception

In Bangladesh informal water markets for irrigation have developed quickly with the rapid expansion of tube well irrigation over the last few decades. There is no single rate or uniform method for payment of irrigation water. Per hectare water rates vary not only from one area to another but also depend on the type of tube-well within a particular area (Biswas and Mandal, 1993). In competitive water market, community

people (water buyers) faced lot of problems and constraints. According to community perception, overall problems and constraints of groundwater irrigation is presented below;

- Most of the cases higher irrigation charges reported as major problems;
- During dry season water is crucial for every farmer for crop production but many farmers could not able to irrigate their land. However, individually owned tube-well owner could manage some extent as they have less command area;
- Rain, heat and natural calamity considered another problem that faced by the farmers during irrigation of land;
- In case of BMDA, BADC and RDA installed tube wells, repair and maintenance cost as well as all machinery cost of tube wells had to bear by the water buyers which considered as constraint;
- Maintaining long line for irrigating land reported major problem for water buyers;
- In case of BADC and RDA installed tube-well, users pay high charge for electricity consumed;
- Farmers do not get timely water to irrigate their crops;
- Operator misbehave with water buyers "*Tube-well operator act as like as second god*".
- Political interfere presents in every organizational level.

Among different groundwater service providers, farmers preferred individual installed tube-well though they have some problems. Many of farmers switched over to individual water suppliers as convenient to them.

6.4 Proposed Solution by the Community

In connection to the above constraints community people proposed several important solutions which is presented below-

- Irrigation water charge/unit charge should be reduced;
- Community preferred tube-well operator should be recruited;

- Maintenance and machinery cost should be borne by tube-well specific authority;
- Dissemination of a broad understanding of the groundwater resource situation;
- Promotion of measures to improve the groundwater resource balance, through reduced consumptive use and groundwater recharge enhancement;
- Provision of a conducive legal and institutional framework;
- Setting realistic management targets and monitoring progress;
- Promotion of the government incentive for farmers;

For successful groundwater management farmers suggestions can be taken into consideration.

6.5 Conclusion

Though groundwater is a common pool resources but scarcity is in everywhere in Bangladesh. For increasing demand of groundwater people are now doing business and abstraction process is not sustainable. That's why several problems and constraints are arise in use of this resources as well as management. For irrigation different institutions provide irrigated water in terms of various condition. Above all, water users mostly faced high irrigation water charges and mismanagement of particular institution in the field level operation. To overcome various problems effective administrative body and good governance along with community participation which was highly concentrated on farmer's welfare is needed for groundwater management.

Chapter 7

SUMMARY, CONCLUTION AND RECOMMENDATIONS

7.1 Introduction

The purpose of this study was to document community participation process in groundwater management, effectiveness and constraints of groundwater management of different groundwater service providers in the village of Ajhoire (Nachole upazila of Chapainawabganj district) and Alokchattra (Kahaloo upazila of Bogura district). Data and information were collected water buyer community and various water seller authorities including BMDA, BADC, RDA and individual owner. Study illustrated the community participation process and constraints of groundwater abstraction in the study area. Some PRA tools such as case studies, Focused Group Discussion (FGD), Key Informant Interviews (KIIs) and in-depth interviews were used for collecting relevant data and information. This chapter therefore articulates the summery of the study findings, conclusions and recommendations.

7.2 Summary of the Findings

The main objective of the study was to find out the community participation process, effectiveness of groundwater management based and problems and constraints of effectively use of groundwater of different ownership category of tube-wells in Nachole and Kahaloo upazila under the district of Chapainawabganj and Bogura, respectfully. Summary of the present study findings is presented according to the settled objectives.

At the initial stage of groundwater abstraction intervention, different irrigation service providers (BMDA, BADC, RDA) of Northern Bangladesh, started motivating community to grow dry season crops through purchasing water from them. In fact, these organizations show the pathways to improve the livelihood of the community people. Thus, many farmers got interested to engage in groundwater irrigation with active involvement with the groundwater service provider institutions. They got easy access to the institution. Afterwards, many farmers got enthusiastic to participate,

accordingly they formed water user group. The committee of the water user group manage groundwater abstraction and utilization. However, the situation has changed over the period. Every groundwater service providers got business motive and earn more profit. It does not mean that farmers are not getting benefit rather water seller are capturing the most benefits. There is allegation that they charge higher water price, imposed extra fee for irrigation and some complexities may impose some rules and regulations.

Regarding effectiveness, farmers mostly interested to purchase groundwater from individual tube well owners. They felt comfort to negotiate with the individual owner. In fact, water buyer got frustrated on imposed extra cost of repairing and maintenance of irrigation equipment by the different water seller institutions. Hence, many institutional tube-wells command areas shifted to individually owned tube-wells.

Moreover, some institutional installed tube-wells were sold to the particular community or individuals. This is happening because of reducing command area as well as difficulties to manage institutional tube-wells. Water buyer community faced many problems in irrigating their crops. Among them high cost of irrigation was reported the most. Lack of timely water supply (they had to wait for long) found to be another important constrain for the farmers. Farmers also reported mismanagement and operational inefficiency by the operator or manager.

7.3 Conclusion

Based on above summery findings, it can be concluded that the study has achieved its objectives. Following conclusions are drawn-

1. Community or water user group got involved with various water services providers to irrigate their land for crop production. Farmers mostly pay in cash for using the water in some cases they share the crop with water seller.
2. Water buyer mostly prefer to buy water from individual owner due to less complexity. In such arrangement, farmers only pay the fixed charge for irrigating but not operation and maintenance cost. In some cases, they could

pay irrigation charge after harvesting the crop. Thus, many farmers moved to individually owned tube-wells for irrigating their crops where it is available.

3. Among different constraint of groundwater irrigation, high irrigation charge was identified the most hence, farmers asked for a mechanism that can force water seller to reduce the irrigation charge. Farmers were not so happy with the management system of BMDA, BADC and RDA installed tube-wells.

7.4 Recommendation

The present study portrayed the effectiveness of groundwater management, participation process and some constraints faced by water buyers and owners in the study area. Based on above study findings, the following recommendations are proposed for the effective participation, management and finally improved living standard of farmers those are highly depended on groundwater for crop production.

1. Irrigation water charge should be reduced as long water buyers use groundwater effectively;
2. Water supply organizations should be more attentive in distribution and selection process of water buyers in groundwater management;
3. Community preferred tube-well operator should be appointed in the field level operations;
4. Maintenance and machinery cost should be borne tube-well specific authority or owners for enhance productivity and well-being of the farmers;
5. Alternative sources of irrigation water (surface water) should be introduced and ensure accessibility for all.

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APPENDIX

Effectiveness of Community Participation in Groundwater Management in Northern Bangladesh

Guide for conducting Focus Group Discussion

Study Area: Villages - **Upazila -** **District -**

Type of participant: Users/Owners/Operators/Officials

Name of the participants:

SL.NO.	Male	Female
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Checklist:

1. **Number of total population of villages, household size of the villages**
2. **Professions of the households**
3. **Religious and Educational status of the villagers**
4. **Housing conditions and patterns**
5. **Electricity, transportation and village status**
6. **Health and sanitation condition of the villagers**
7. **Source of irrigation water and drinking water**
8. **Identify tube wells (BMDA, BADC, RDA, Individual tube-wells)**
9. **Number of total tube wells**
10. **Who are mostly benefited group?**
11. **Performance of BMDA, BADC, RDA & individual tube-wells**
12. **Natural constraints**
13. **Disaster management process in the village**
14. **Problems faced in the agricultural activities**
15. **Ground water management problem**
16. **Effectiveness of different tube wells**
17. **Problem faced by the community**
18. **Relationship between farmers and others**
19. **Payment system**
20. **Operating system**
21. **Managerial system**
22. **Control system**

23. **Effectiveness of tube-well specific operations**

24. **Impact of BMDA over the community**

25. **Cost of irrigation**

26. **Engagement process of community for groundwater management**

27. **Influential factors to use BMDA installed tube well**

28. **Expectation of BMDA from groundwater users or farmers or specific community**

29. **Political intervention**

30. **Scope and Challenges of groundwater management**

Date: _____ _____

Name and Signature of the Facilitator