Farmer Management of Groundwater Irrigation in Asia

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Selected Papers from a South Asian Regional Workshop on Groundwater Farmer-Managed Irrigation Systems and Sustainable Groundwater Management, held in Dhaka, Bangladesh from 18 to 21 May 1992

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INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

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Cover photograph by John Colmey: Tubewell water entering a field canal during irrigation, Punjab, Pakistan.

Preface

WIDESPREAD GROUNDWATER IRRIGATION in Asia is relatively new. The rapid proliferation of groundwater irrigation systems in many areas of Asia, and especially South Asia, over the last three decades has mainly been at the initiative of farmers. Farmers have invested extensively in equipment, fuel and labor in order to have access to water when and where they need it. In order to have this control over water delivery they are often willing to pay several times more for lift irrigation water than for water from large canal systems. They conduct trial and error digging and drilling to locate favorable sites for lifting water.

The extraction, distribution and application of groundwater often involves complex challenges in social and agrarian relations. It involves economic tradeoffs between short- and long-term costs, risks and benefits. It often has management tradeoffs between local farmer objectives and broader sustainable use of aquifers. Environmental problems of waterlogging, salinity, decline in water quality and aquifer drawdown are advancing in many places where groundwater institutions and water laws are weak or non-existent. Governments seem unable to measure or regulate the use of groundwater for irrigation. It is becoming increasingly apparent that farmer organizations will also have to bear the main burden for achieving sustainable management of groundwater for irrigation, if it is to be achieved at all. Several members of the Farmer-Managed Irrigation Systems Network and Advisory Committee recognized the rising importance of groundwater irrigation in South Asia for meeting the needs of farmers and consumers for food and income. It was primarily because of their strong recommendations that the Workshop on Groundwater Farmer-Managed Irrigation Systems and Sustainable Groundwater Management was held in Dhaka, Bangladesh in May 1992. We sincerely hope that this publication of selected papers from the Workshop will further the awareness among government officials, researchers and others about the challenges of farmer-managed groundwater irrigation—be they technical, economic, agricultural or institutional.

In the Workshop, the participants identified five priority areas of concern relative to sustainable management of groundwater irrigation by farmers. These are: (i) aquifer drawdown, (ii) FMIS groundwater support services, (iii) management problems under water-surplus conditions, (iv) management problems under water-deficit conditions, and (v) management problems in conjunctive use areas (i.e., joint surface water and groundwater irrigated lands). A synthesis of the topic discussion group conclusions and recommendations is provided in the *Overview* by Sakthivadivel, Parker and Manor. Papers which emphasize management issues at the level of the resource base are included in the section entitled, *Resource Development and Use*. Papers emphasizing system-level management are included in the section entitled, *System Management and Performance*.

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THE INTERNATIONAL IRRIGATION Management Institute (IIMI) wishes to acknowledge the contributions of all those who participated in the planning and implementation of the South Asian Regional Workshop on Groundwater Farmer-Managed Irrigation Systems and Sustainable Groundwater Management, held in Dhaka, Bangladesh, from 18 to 21 May 1992.

We are grateful to all the dedicated professionals who prepared and presented papers, who participated in session discussions and field trips and who helped prepare topical recommendations on farmer-managed groundwater irrigation development and management in Asia. The sessions were lively and resulted in a very beneficial exchange of experiences and ideas. We thank all those who helped provide logistical arrangements, transport, food and lodging, workshop facilities and materials and secretarial support.

IIMI especially acknowledges the support and interest shown in this Workshop by the Bangladesh Agricultural Research Council, the Bangladesh Agricultural Development Corporation, the Bangladesh Rice Research Institute, the Ministry of Agriculture and the Bangladesh Agricultural University.

Finally, we thank the International Fund for Agricultural Development (IFAD) and the German Federal Ministry for Economic Cooperation (BMZ) for their generous financial support for producing this publication.

OVERVIEW

Overview of Workshop Activities, Issues and Recommendations

R. Sakthivadivel,[1] D. Parker[2] and S. Manor[3]

ARRANGEMENTS AND OBJECTIVES

THE FOUR-DAY South Asian Regional Workshop on Groundwater Farmer-Managed Irrigation Systems and Sustainable Groundwater Management was held in Dhaka, Bangladesh from 18 to 21 May 1992. Fifty-seven participants from 10 countries including 5 International Irrigation Management Institute (IIMI) professional staff, attended the workshop. Five Indonesian participants who attended the workshop were taken on a one-week field trip after the workshop.

The objectives of the workshop were to: (i) provide a forum for professionals concerned with groundwater irrigation management in South Asia to exchange experiences and ideas, (ii) provide an opportunity for the professionals to jointly observe in the field in Bangladesh problems and challenges of groundwater irrigation management, and (iii) for a group of experts to jointly identify priorities and recommendations for research and development action on groundwater irrigation management in South Asia.

SUMMARY OF PROCEEDINGS

The first day's activities began with an inaugural session followed by presentations of syntheses of the papers that had been prepared. Discussion groups were then formed and assigned the task of identifying issues of particular concern for further exploration during the remainder of the workshop. These discussion groups were organized around the topics of:

i) Aquifer and drawdown conditions.

ii) FMIS groundwater support services.

iii) FMIS sustainability under water surplus conditions.

iv) FMIS sustainability under water-deficit conditions.

v) FMIS sustainability within surface irrigation systems.

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The second and the third day were devoted to field visits to see the working of various types of farmer-managed irrigation systems (FMIS) under different management conditions in the northern part of Bangladesh. On the final day there were again small group discussions—this time set up to address and make recommendations about some of the areas of concern identified earlier. These three groups focused on technical considerations, institutional issues, and socioeconomic aspects, respectively.

SYNTHESIS OF ISSUES

The five discussion groups on the first day came up with a number of concerns for further exploration. These issues are listed below by discussion-group topic.

Aquifer and Drawdown Issues

There is an urgent need to collect and disseminate technical information on aquifer characteristics, groundwater quantity and quality, and drawdown conditions; on groundwater table variation in response to rainfall, surface water recharge and pumping; and on micro-level groundwater mapping and information system on groundwater availability and abstraction mechanisms. Organizational aspects of groundwater information collection and dissemination are also important.

Overdevelopment of groundwater and its utilization result in depressed water tables, interaction between shallow and deep aquifers, and imbalances between fresh and salt water interfaces. This leads to problems of inequity and lack of sustainability and increases cost of groundwater abstraction. Therefore, it is necessary to initiate careful monitoring of groundwater table fluctuations and introduce proper regulatory mechanisms for sinking and spacing of shallow tubewells (STWs) and deep tubewells (DTWs).

Valuable groundwater is often used inefficiently and at times wasted. Therefore, integration of efficient utilization of groundwater through better water management practices in conjunction with rainfall and surface water is necessary.

Selection of type of tubewells, their installation, operation and management are to be matched to meet the aquifer characteristics and drawdown conditions.

There is a need to enact proper groundwater regulatory mechanisms through a proper mix of technology and management for groundwater utilization so as to maintain groundwater at desired levels and prevent environmental degradation.

Solutions especially need to be found to problems associated with the following:

i) The increasing costs of construction, replacement and operation and maintenance.

ii) The deterioration of water quality.

iii) The differential effects of water markets on the poor.

Research is needed on the impact of withdrawing state assistance for groundwater development and on how measures can be developed to improve the performance of groundwater development.

Groundwater Support Services Issues

There is a need to provide support services for groundwater FMIS in the following areas:

i) Easily available credit for construction of wells, purchase of equipment and spare parts and operation and maintenance.

ii) Price support, market information and marketing facilities and storage and transport facilities for their produce.

iii) Subsidies for operation, maintenance and replacement.

For these support services to be effective it will be necessary to:

i) Develop an institutional framework for group formation, partnership and legal framework for groundwater group.

ii) Provide training for management support, recordkeeping, accounting and on-farm management.

iii) Provide technical support services on information of groundwater resources available, selection criteria, on-farm water management; and well maintenance and mechanic support.

iv) Provide spare parts during the recommended life span of the tubewell.

v) Analyze and identify the impact of groundwater support services on the following:

  a) technical performance of groundwater utilization in improving command area, pump operation efficiency, recovery of water charges, loan recovery and rates of return to investment;

  b) macro-economic policies (protection versus free market, pricing policies including energy cost and subsidies for groundwater development);

  c) management/organization style (ownership issue—individual versus group management and public versus private);

  d) role of private sector; poverty alleviation through credit and water markets; role of STW/manually operated pumps.

Sustainability Issues of Groundwater FMIS in Water Surplus Areas

There is a need to improve economic efficiency and profitability of groundwater irrigation. Therefore, it is necessary to:

i) Introduce macro-economic policies for profitable and efficient groundwater irrigation.

ii) Provide groundwater development subsidies (increase output price, input subsidy, credit and insurance).

iii) Balance surface water and groundwater development for their optimal utilization.

iv) Encourage local manufacturing of groundwater development equipment.

v) Ensure economic growth through better performance of water markets and improved access to water and credit markets for the poor.

vi) Define and demarcate objectives of groundwater development in relation to growth, sustainability, equity, poverty alleviation and gender issues.

vii) Discuss and identify the conditions under which drawdown issues assume importance in the short run and in the long run; there is a need to study agro-chemical pollution of groundwater and resource degradation.

Sustainability Issues of Groundwater FMIS in Water Deficit Areas

It is necessary for policy makers to recognize that priorities may be different between lift technologies under different groundwater environments and socioeconomic conditions. The level of resource management and institutional development necessary for different regions needs to be better understood in order to develop appropriate institutional objectives and management organizations relevant to farmers' interests. Through an improved information base governments need to better understand and plan for water conservation, improved recharge and conjunctive use. The social and economic implications of groundwater depletion need to be monitored by research or planning organizations. New mechanisms to improve the sustainability of resource management, including the study of the relative efficacy of water markets, regulation and control need to be identified.

There is a need for agencies and farmers to develop partner *not* client relationships, to strengthen the capacity of organizations (farmers, state agencies) to adapt and innovate for different groundwater conditions, to train farmers and tubewell operators, and to improve, reform or possibly privatize extension services (such as in Mexico) to make them more responsive to farmer interests. Groundwater irrigation activities should be integrated institutionally and sectorially (agriculture, energy and transport) for sustainable use of groundwater and other resources. Many countries in South Asia urgently need to collect and compile reliable information techniques for technology management, farmer needs and resource management, and to improve accessibility of the public to this information.

Sustainability Issues of Farmer-Managed Groundwater Irrigation Within Large-Scale Canal Irrigation Systems

Workshop participants agreed that more conjunctive management of surface water and groundwater resources was needed in many parts of South Asia. Groundwater irrigation within command areas of large-scale canal irrigation systems is now very prevalent in South Asia and has the potential, if uncontrolled, to lead to serious environmental problems such as waterlogging and salinization of water and soils. More sustainable conjunctive management of water will require the following actions:

i) Development of methodologies and techniques for efficient resource management through conservation and utilization; select appropriate tubewell technology (deep versus shallow tubewells) for conjunctive use of groundwater with surface water; integrate groundwater activities with surface water utilization; treat groundwater as a common property resource through legal provisions and sanctions.

ii) Assess the interaction between groundwater and surface water recharge in terms of groundwater abstraction and water quality, and suggest measures to control them.

iii) Identify sources of pollution of surface water and groundwater and arrest deterioration of water quality.

iv) Assess the linkages existing among groundwater user groups, surface water FMIS and public agencies, and suggest measures to improve their linkages and performance.

v) Develop and field test a suitable organizational structure for conjunctive use of surface water and groundwater systems.

vi) Stipulate proper regulatory and control mechanisms for water table control, and to prevent waterlogging and pollution.

vii) Provide adequate training, cost-effective technology, adequate input services, market and credit facilities.

As an integral part of the FMIS Network Workshop on Groundwater FMIS and Sustainability of Groundwater, a field trip was organized to FMIS of groundwater at five locations in Rajashahi and Bogara districts. Of these, six were deep tubewells managed by various agencies of the Government of Bangladesh and one well was managed by a voluntary organization called Proshika. One well which was managed earlier by BARC is presently owned by a farmer.

Of all the problems, frequent mechanical failures and disruption in supply of electricity can be regarded as those which are beyond the organizational capability of FMIS. These problems have the potential to offset the planned distribution of water and thereby affect the uniformity in productivity levels (Well No.2). This can induce each member to withhold or delay payment, especially because of two attitudes: First, allowing those who are greatly benefitted pay, and second, the payment not being worth the facilities provided by the FMIS. Due to such attitudes FMIS will run short of funds to meet O&M costs and ultimately, fail to supply water in time and at equal quantum. This will force resourceful members to opt out of the FMIS (Well No.6).

A deeper analysis shows that all the problems identified arise from the inability of FMIS to: (i) expand its objectives beyond water supply for irrigation, (ii) identify alternative solutions to issues that plague them constantly, (iii) develop multi-tier leadership as an alternative, and (iv) strengthen support systems.

For almost all the FMIS that were visited, the objective is only to supply water even after many years of existence. With the extension of irrigation facilities there is a need to invest recurrently on inputs like animal power, seeds, pesticides, manure, labor and marketing. The poor opt for investment instead of paying operation and maintenance costs. In such cases, reduction of time and labor invested to procure inputs and a well-developed organizational mechanism for marketing can prevent distress sales and exploitation at the hands of middlemen. Probably the profits and savings from activities can help the poor in paying the operation and maintenance costs in time. Unfortunately, we tend to categorize these services as support systems and tend to play them down.

Problems that are universal to all FMIS are frequent mechanical failures. To overcome the lack of technicians, each FMIS can identify a few youngsters to undergo training in management of pump and other infrastructural facilities. The cost of training and payment can be borne by all the beneficiaries.

In situations where availability of spare parts is a big question, it is advisable to have a contract with a local supplier or a tool maker who can supply them. The other solution can be to identify those spares which are constantly required and to hold a stock of them. One of the best solutions is to store water in the form of ponds at various strategic places so as to meet contingencies.

It seems that on behalf of all the beneficiaries only the manager or the president carries out all the activities. In such situations, there is a greater chance of losing out the initial enthusiasm and dynamism of a leader, if he withdraws (Well No.6). Even in the absence of complementary objectives, subcommittees can be formed to look after distribution of water, procurement of spares, collection of irrigation fee, etc. Such subcommittees can expand the space for larger participation and the emergence of alternate leaders.

SYNTHESIS OF DISCUSSIONS AND RECOMMENDATIONS

The main technical issues were grouped by participants into the following categories: (i) groundwater resource assessment; (ii) groundwater exploration; (iii) water conservation and management; and (iv) environmental considerations in groundwater abstractions.

Under the existing methods of groundwater assessment and data collection, objectives and review of assessment and data collection are not well defined in most of the countries. Also, most of the data collection is at a macro level and is not readily usable at micro level by the farmers who need it most. Therefore, discussants recommended the following:

i) The objectives of data collection and mapping groundwater resources and review mechanisms must be clearly defined.

ii) Groundwater data and their assessment are not readily available at the micro-aquifer level (at the village level) for the farmers to use it. Attempts must be made to collect micro-aquifer data within the existing agro-ecological unit through cost-effective procedures and using the local knowledge of the farmers. Also, mechanisms must be developed to make it available to the farmers when they need it. Participatory research data collection should be promoted.

iii) Existing data should be synthesized; attempts must be made to collect additional data to fill in gaps, to update the database and to analyze the data to bring them to a usable form and make them available to farmers, agencies and planners.

iv) At present, many national governments rely upon foreign experts and assistance to develop requisite databases and to assess groundwater resources. It is necessary to develop local capability to undertake these assignments.

On the topic of groundwater exploitation, it was recommended that groundwater zoning be introduced into areas where only shallow tubewells can be used, areas where only deep tubewells can be allowed, and areas where both shallow and deep tubewells can be allowed, for groundwater extraction. Based on relevant environmental data and agro-ecological zones, appropriate groundwater extraction guidelines should be developed and disseminated, which are suited to the location through technology policy for groundwater extraction.

There was a lively discussion on the use of shallow and deep tubewells as extraction devices. Arguments were put forward for and against the use of deep tubewells. While discussing deep tubewells, two sets of issues were identified. The first set is with regard to existing deep tubewells. In Bangladesh itself there are more than 30,000 deep tubewells. The process and results of turnover and local management of these tubewells need to be looked into. Ultimately, most of these tubewells are likely to be owned by selected individual farmers who will be invariably well-to-do. The second set of issues is with regard to the installation of new deep tubewells. There was forceful argument to ban turbine pumps for installation of deep tubewells. It was also argued that in view of these large deep tubewells in water deficit areas such as hard rock areas, groundwater levels are receding fast, requiring innumerable shallow well owners either to deepen the wells or to abandon them. Therefore, there is an urgent need to regulate the use of deep tubewells in these areas too.

At the end, it was recommended that a three-phase approach be adopted which initially emphasizes shallow tubewells and groundwater management for stabilizing the drawdown level at an appropriate depth by regulating the use of shallow tubewells; second, to go for deep-set shallow tubewells and, finally, attempts may be made to go for deep tubewells where other methods of extraction have failed or are inefficient.

Under watershed conservation and management, it was recommended that the micro-aquifer should be the unit for groundwater conservation. It was suggested that a water balance study of the micro-aquifer be carried out to study the impact of surface water on groundwater and to design appropriate extraction mechanisms.

The key requirements in order to improve the efficiency of groundwater use and to manage the groundwater resources in a sustainable manner are as follows:

i) Provide adequate technical extension services.

ii) Establish a strong unit for maintenance of groundwater structures.

iii) Provide adequate energy and energy distribution.

iv) Diversify crops for efficient water use.

v) Provide adequate credit facilities.

vi) Carry out proper monitoring and evaluation.

vii) Improve distribution systems and on-farm water management.

viii) Carry out research on equity of distribution.

Under environmental considerations, it was recommended that in all irrigation systems, groundwater extraction and use should be controlled so as to minimize environmental problems, such as waterlogging and salinization, sea water intrusion, reduction in agricultural productivity, health hazards, groundwater deterioration due to pesticides and fertilizers, land subsidence, etc. It was also suggested that ecological balances need to be maintained for sustainability of groundwater irrigation systems.

Institutional and Organizational Considerations

Six functional issues were identified under this topic: (i) policy and legal aspects; (ii) planning; (iii) cost-sharing, resource mobilization and investment; (iv) creating appropriate groundwater infrastructure; (v) management of operation and maintenance; and (vi) agricultural production and marketing. Policy dialogues, workshops, pilot experiments and research were strategies suggested for developing appropriate institutional and organizational mechanisms.

Under policy and legal aspects, it was recommended that necessary institutions be developed and policies formulated with respect to integrating surface water and groundwater; and ensuring regulatory mechanisms, providing legal status to farmers' organizations (FOs), providing incentives, involving landless laborers and enacting strong legal provisions for considering groundwater as a common property resource.

Planning of groundwater resources needs assessment of potential and demand. A very strong participatory approach involving beneficiary farmers is recommended. Organizational strengthening of agencies, nongovernment-organizations (NGOs) and FOs is stressed. Coördination arrangements among agencies, NGOs and FOs is suggested.

Under supply and installation of extraction equipment, it was recommended that competition in adopting technology be permitted to allow involvement of private organizations in the above activities and to provide necessary training to FOs. There should be legal provision to ensure availability of spare parts for imported equipment.

Under management of operation and maintenance, it was recommended that both groundwater resource management and management of extraction technology be given due consideration. In addition, in those areas where surface water is available, conjunctive use and management are necessary. While beneficiaries are accountable for proper operation and management, agencies need to be made responsible for proper energy supply.

Under agricultural production, proper institutions are recommended for crop diversification, credit and marketing mechanisms. There is a need for inter-ministry collaboration between ministries dealing with groundwater, agriculture and other allied areas.

Socioeconomic Considerations

In order to make groundwater agriculture economically viable, groundwater extraction and utilization have to be effectively integrated into the larger national macro economy. In this endeavor, the group considered the following as important:

i) Infrastructural facilities should be made available. Under infrastructural facilities, some of the areas recommended to be adequately developed were rural electrification, transportation and storage facilities, supply of equipment and spares, agro-processing industries, legal and administration framework of groundwater utilization and management and stabilization of exchange rates.

ii) Pricing policies often need to be updated. Under pricing policy it was recommended to provide a selective subsidy for irrigation well equipment, appropriate pricing for surface water and groundwater, power, input and output pricing policies and reforms in credit policies.

iii) Groundwater and surface water interaction need to be considered for optimal conjunctive use of surface water and groundwater.

iv) Under institutional arrangements, it was recommended that water markets be promoted. However, institutions need to be created and strengthened to help regulate both sellers and buyers. Institutions for efficient conjunctive use and management need to be established.

The following recommendations emerged in the final plenary session:

i) Groundwater should be considered as a common property resource. Groundwater and surface water must be integrated into a unified legal framework. All, including landless people, should have *inalienable* rights to water for drinking and religious purposes, followed by agricultural and industrial uses, in a hierarchical order. Groundwater should be considered a legally tradable commodity subject to regulation against over-exploitation. Groundwater use should be planned in conjunction with surface water.

ii) Deep tubewells are costly and nearly universally controlled by large farmers. Appropriate institutional mechanisms should be in place before this technology is developed.

iii) Banning of deep tubewells is not a possible solution. But their use should be regulated through viable local institutional arrangements.

iv) Landless laborers should be given preference to manage tubewells in a sustainable manner.

v) Some of the Aquifers extend over more than one nation (for example the Gangetic Aquifer). Regional efforts are necessary to assess groundwater potential and interconnectedness.

vi) State policies toward groundwater management should target not only the individual pump owner but the network of wells that will interact now or in the future.

vii) Well ownership may be individual, but communities in an area should be organized and be invested with the right of taking decisions on new individual investments in wells in their area. Conservation technologies must be adopted by all well owners. Group purchase and distribution of power to well owners and enforcement of collection/loan repayment for credit provided to well owners are needed.

viii) Aquifer characteristics, and recharge rates vary greatly within even small areas; therefore, state policies should be tailored to the nature of each ecological zone, (i.e., a groundwater resource endowment region). Blanket countrywide or statewide policies for areas of high ecological heterogeneity are likely to be inefficient and wasteful of state capital when direct subsidies are involved.

ix) When the cost of pumping exceeds publicized and agreed-upon locally defined limits, all further official credit for extractive investments should be cut off. These include investments in well deepening, pump energizing, new well construction, etc.

x) Choice of technology should be such that small groundwater groups are preferred over large groups when the resource base so permits. If shallow groundwater exists, then shallow tubewells are to be promoted rather than deep tubewells.

RESOURCE DEVELOPMENT AND USE

Hydrogeological Potentiality of Intensive Farmer-Managed Tubewell Irrigation Systems in Bangladesh: A Case Study

M.A. Sattar[4] and K.A. Haq[5]

ABSTRACT

A FIELD STUDY was conducted in 10 farmer-managed deep and shallow tubewell irrigated areas of Barind Tract Groundwater Basin, Bogra, Bangladesh. This had the specific objectives of: (i) assessing the groundwater recharge in the study area, (ii) evaluating the fluctuation of groundwater table of aquifers and its response on rainfall and river water levels in the vicinity, (iii) evaluating the aquifer characteristics and properties, and (iv) recommending the safe utilization of tubewells based on discharge-drawdown relationship and well spacing for sustainable groundwater management in crop production.

The study indicated that the intensity of tubewells at present are 5 per square kilometer (km^2) with an average discharge capacity of about 56 liters per second (lps). The average irrigated acreage of all the tubewells was 0.83 hectare/lps under the rice crop which was much above the national average (0.40 ha/lps). During the 10 years from 1977 to 1986, the groundwater table was lowered indicating the highest lowering upto 7.87 meters (m) in the month of March. This was below the operation level of shallow tubewells. A multiple regression relationship with groundwater table (Y) as dependable variable, and rainfall (X1) and river stage (X2) as independent variables was accomplished. The study revealed that there is a significant direct relationship among rainfall, groundwater table fluctuation and stream flow. The lithological investigations indicated that 100 percent screenable materials were available from a depth of 12 m and beyond. The average transmissivity and storage coefficient values were 4,388 square meters per day (m^2/day) and 0.000587, respectively, which indicated that the study area has potential for tubewell utilization. A model for safe well spacing was developed between discharge versus spacing of wells. The findings indicated that for shallow wells with a discharge rate from 11 to 20 lps, the spacing was in the range of 122 to 250 m. However, for deep tubewells with discharge capacities of 47 to 54 lps the spacing was in the range of 300 to 390 m for safe and sustainable utilization of groundwater.

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INTRODUCTION

Groundwater in Bangladesh generally occurs under normal water table conditions, but in some areas, particularly in deeper aquifer, the water may be under semi-artisan or artisan conditions. The depth of the water table varies from zero to more than 15 m below the ground surface depending upon the location and season. Hydrogeologically, the upper fine sand and lower medium sand from one hydraulically interconnected aquifer was covered by a semi-permeable, semi-confining layer of silt and clay (Master Plàn Organization [MPO] 1984). The static water level generally lies within the semi-confining layer. The deep tubewells (DTWs) and shallow tubewells (STWs), all extract water from a common aquifer, although from different but hydraulically connected layers.

Bangladesh can be divided into four major groundwater zones: (i) younger alluvium, (ii) complex geology, (iii) older alluvium, and (iv) coastal area (Jones 1972). Among the older alluvium, surface deposits in the area consist of fine grained older alluvium, chiefly the pleistocene Madhupur clay formation. The finer material is extended to great depths in some areas and therefore very little attempt has been made to develop large-capacity wells. Geophysical investigations indicate that there are some relatively good prospects of groundwater development in Bogra District and in the southern part of Tangail District.

Surface water is scarce in many parts of Bangladesh (mainly North and North West part of Bangladesh) during the irrigation season, so that groundwater has to be developed as an alternate and dependable source. But groundwater is also limited and there exists many constraints for its development. Therefore, it is essential to determine the quantity of groundwater that can be withdrawn safely for different uses. Groundwater withdrawal causes large decline in groundwater levels during the dry season in some typical areas where use has increased greatly in recent years (MPO 1984). The areas are Bogra, Rajshahi, Comilla, Dhaka and Mymensingh districts. Haq and Sattar's (1986) study at Bangladesh Rice Research Institute, Gazipur, indicated that the groundwater table during the dry season over a six-year period progressively declined and was close to 1.7 m per year. This yearly lowering of the groundwater table could be an indication that the annual rates of withdrawal from the groundwater basin has been greater than the yearly rates of recharge. The present study aims to find out the geohydrological potentiality of intensive deep and shallow tubewell farmer-managed irrigation systems for the safe utilization of groundwater.

The specific objectives of the study were as follows:

i) To assess the groundwater recharge in the study area.

ii) To evaluate the fluctuation of groundwater table of aquifer and its response on rainfall and river levels in the vicinity.

iii) To find out the aquifer characteristics and properties.

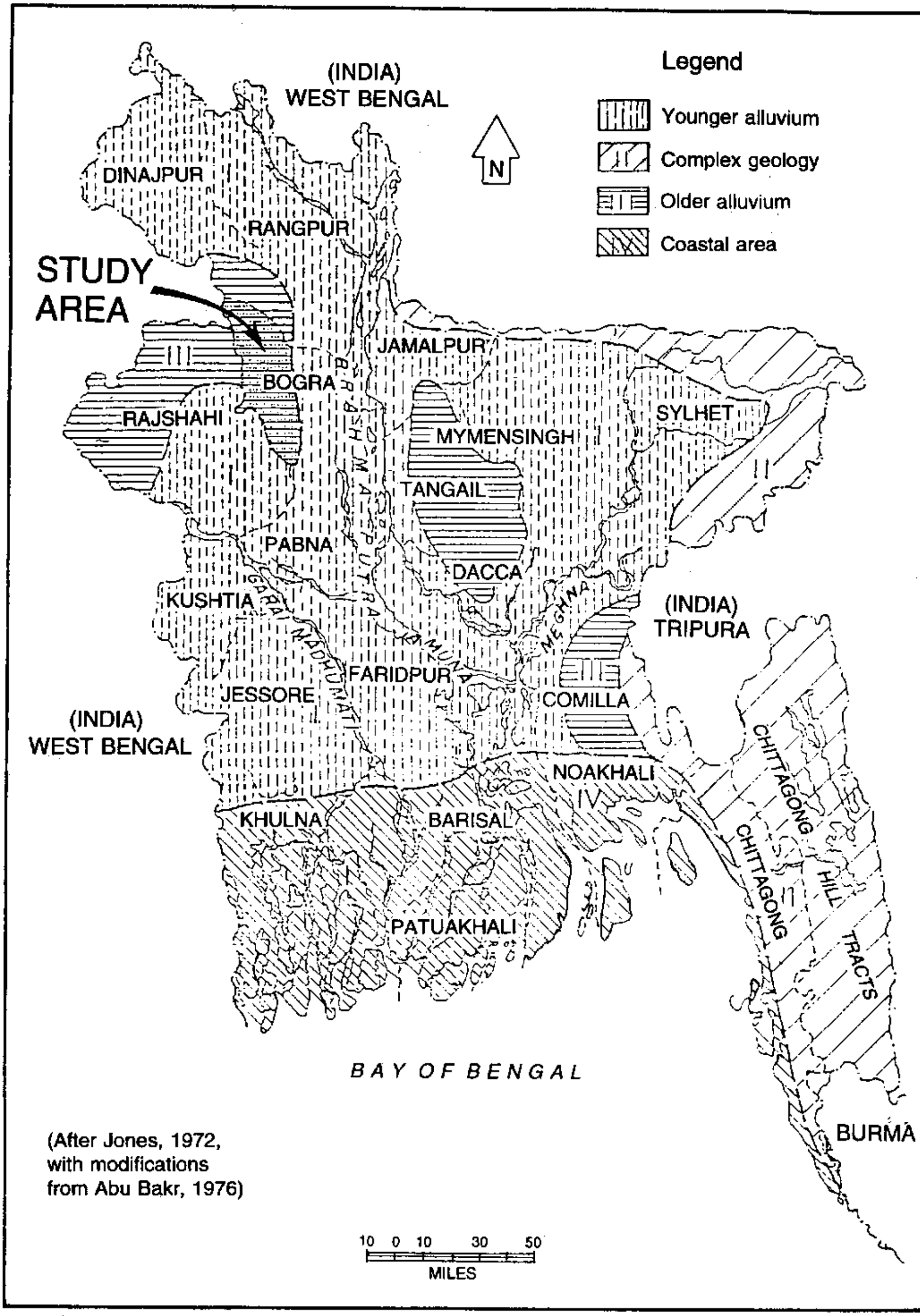
iv) To determine the safe utilization of tubewells for sustainable groundwater management.

MATERIALS AND METHODS

Selection of the Study Area

The study area has been selected based on the geohydrological zones of Bangladesh (Figure 1.1). It is mainly occupied by pleistocene deposits, i.e., Barind Tract of Bogra District (Morgan and

Figure 1.1. Approximate boundaries of groundwater areas.

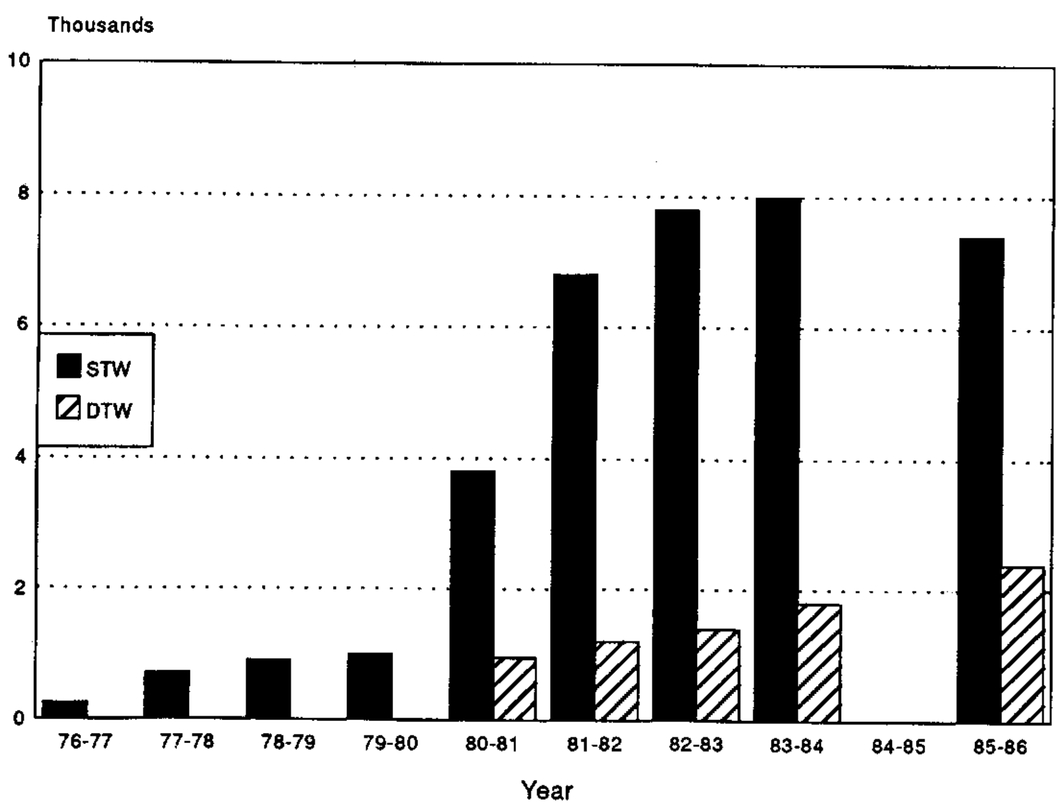


McIntire 1959). The Karatoa River flowing toward the south-west at the western margin of Kahalu Upazilla has a great effect on the groundwater reserve. To fulfill the objectives of the study a pilot area has been selected in Kahalu Upazilla covering 10.10 km^2, which has one of the most intensive DTWs and STWs in the Bogra District. The deep tubewell location map upazilla-wise, and the location of shallow wells within the study region were obtained from the Bangladesh Agricultural Development Corporation (BADC) local office. Annual increment of DTWs and STWs for greater Bogra District from 1976/77 to 1983/84 together with the 1985/86 tubewell status of present Bogra District are shown in Figure 1.2.

Farmer-Managed Irrigation System (FMIS)

Ten DTWs and STWs which are farmer-managed were selected for this study. The DTWs have been mainly implemented by the Bangladesh Agricultural Development Corporation (BADC) since 1977, and groups of farmers enjoy the use of the DTWs on a rental basis of taka (Tk) 3,500 (approximately US$145) per year. However, by 1981 rental procedures were discontinued and DTWs were sold for Tk 70,000 (approximately US$3,000) to the farmer groups. The procedures to procure deep tubewells begin with farmers who either organize themselves or are organized into user groups. Mandal (1982) provides examples in which the farmers themselves took the initiative to form a management committee to procure a deep tubewell and to manage the wells by themselves. The shallow tubewells are mainly procured and managed by the individual farmers.

Figure 1.2. Yearwise increment of STWs and DTWs in Bogra District, from 1976 to 1986.



Hydrogeological Information

The groundwater table was measured daily by using the electric probe method from seven production wells (DTWs) and eight installed observation wells for monitoring the groundwater table in the study area. Rainfall data and river water levels were collected from the local Bangladesh Water Development Board (BWDB) office for a period of 10 years from three gauging stations of major rivers; namely, Nagor, Karotoa and Katakhali, which are the main aquifer-connected rivers within the study basin. Eight available deepwell logs were analyzed on the basis of soil texture. These were plotted on positive and negative axes of aquifer as probability of occurrence of hydrogeology. The aquifer characteristics were determined through a pumping test using Jacob's method with the approaches of time-drawdown, distance-drawdown and recovery method. An attempt was made to find out the safe distance from DTW to STW by step drawdown test through the relationship between discharge (Q) versus radius of interference (R). Two deep tubewells and one shallow tubewell were selected for the test. The production wells were pumped at several successively higher pumping rates and drawdown for each rate was measured in each observation well. In each step, the radius of interference was determined from the drawdown curve. Each of the tubewell discharge was measured by horizontal scale (L-Scale) and their respective service area was recorded.

RESULTS AND DISCUSSION

Seasonal Fluctuation of Groundwater Table

Measurement of depth to water table in tubewells provides the record of change in the groundwater storage. Some records aid in determining the relationship of various facts such as the recharge of the groundwater reservoir. Weekly water table data were compiled for the analysis. The groundwater level starts rising from the latter part of May or June and it rises until the beginning of October. Ten-year secondary groundwater monitoring data have been used to show the behavior of the groundwater table (see Figure 1.3).

Rainfall Pattern

Annual rainfall of Bogra District from the year 1977 to 1986 indicates that 92 percent of the annual rainfall occurred from May to October and the rest from November to April. These rainfall variations directly affect groundwater recharge (see Figure 1.3).

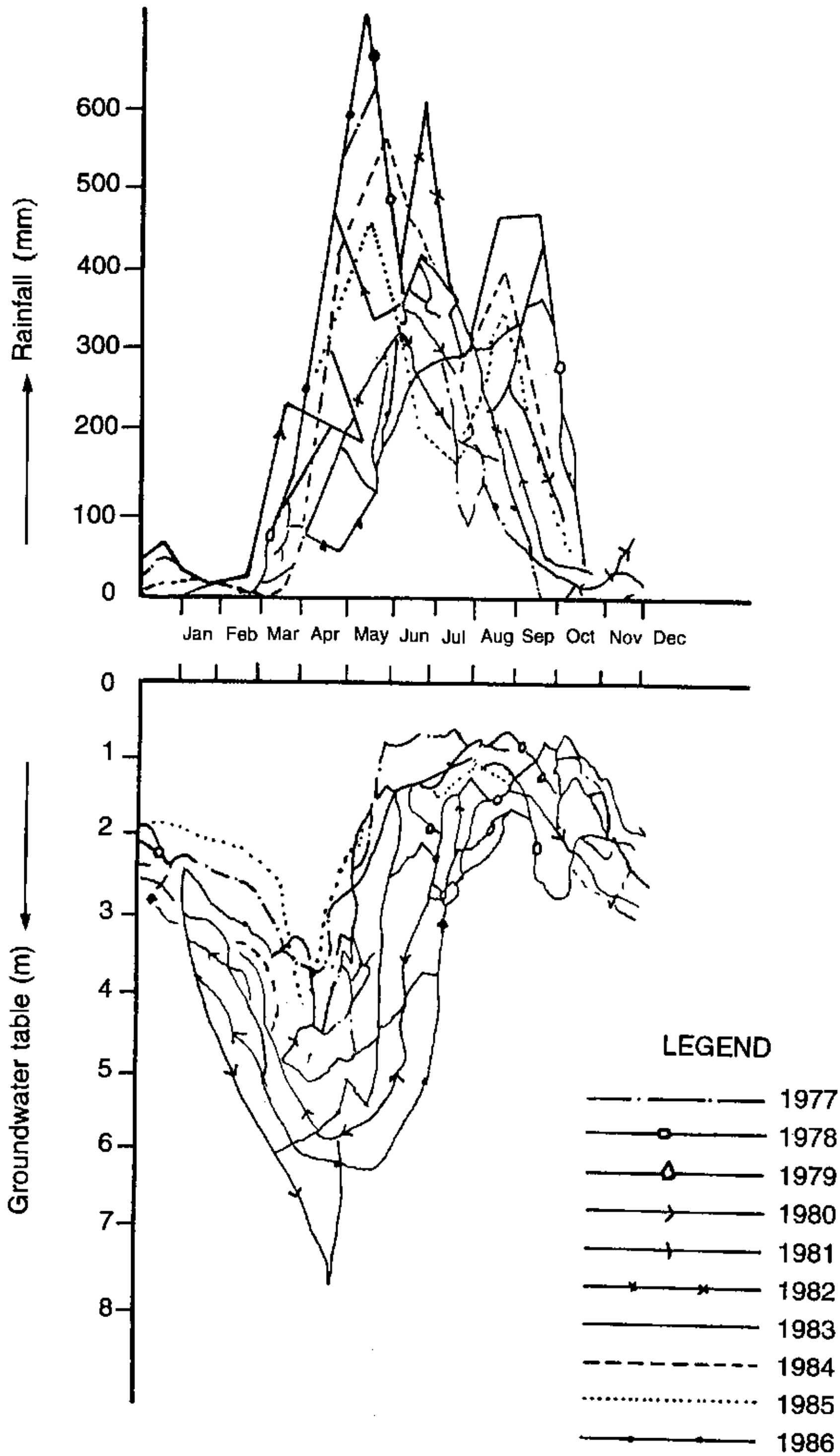
Assessment of Surface Water

The river water level data of Bogra District showed the maximum flow from June to October and the minimum in the month of April. The highest and lowest river water levels were 15.75 m and 11.21 m in the year 1984 and 1983, respectively (see Figure 1.4).

Relationship between Rainfall, River Level and Groundwater Table

An investigation was carried out to analyze the interrelationship between rainfall and groundwater table as well as river level data, within the few selected sites of the study area. The analysis was made on the basis of monthly records of rainfall, groundwater table and river level. A multiple

Figure 1.3. Fluctuation of groundwater table and the rainfall pattern, from 1977 to 1986.

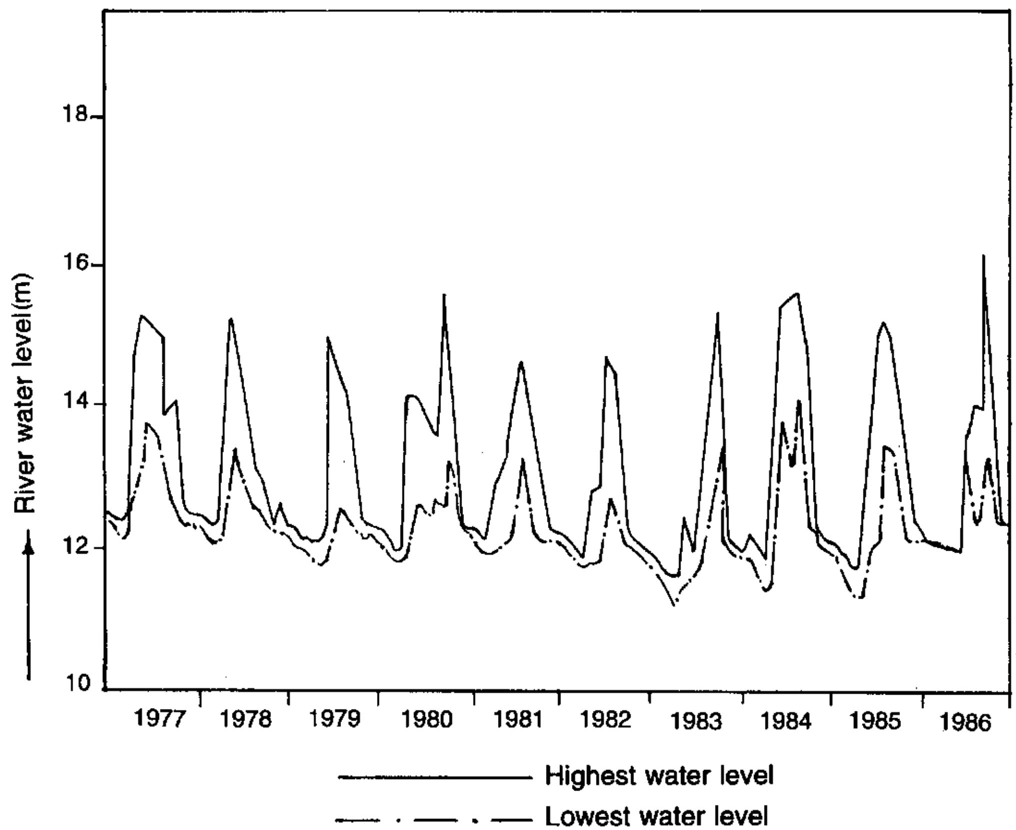


correlation analysis was made to establish the response of groundwater table (Y) to rainfall (X1) and river level (X2) and is given by the following equation:

$$Y = 12.5647 + 0.0399 X_1 + 0.7675 X_2 \quad (r^2 = 0.60^*)$$

The equation indicates a significant relationship between groundwater table, rainfall and river level, and shows that the rise in both groundwater table and surface water levels are influenced directly by rainfall. The river water level starts rising from the latter part of April upto the first part of August and it falls sharply at the end of the monsoon (September/October). The groundwater level, on the other hand, starts to rise from the latter part of April upto October and then declines until April of next year.

Figure 1.4. Hydrographs showing the highest and lowest water levels of Karatoa River, from 1977 to 1986.



Lithological Characteristics

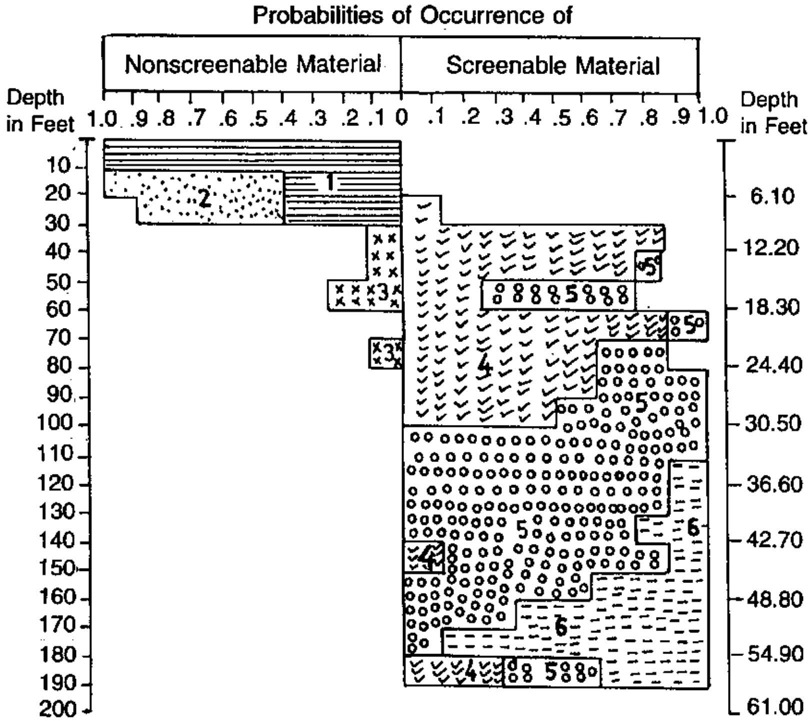
One test boring of 3.8 cm diameter was done upto a depth of 60 m to determine the continuity of aquifer depth on the study area. Samples were taken at every 1.5 m intervals to observe the lithology of subsurface formation. The stratigraphic views of lithological log of underground soil formation consists of clay, silt, very fine sand, fine sand, medium sand, coarse sand and gravel. From the lithological investigation it was found that the first screenable material begins from a depth of 12 m. The extent of this screenable material could not be identified since the bore log information beyond a depth of 60 m is not available. On the other hand, the BADC bore log analysis reveals that the first possible screenable aquifer can be expected with a 12 percent probability at a 9 m depth. Below a 9 m depth, the percent of nonscreenable material reduces sharply and varies from 12 to 15 percent (Figure 1.5). From 21 m upto a depth of 58 m, the probability of screenable material is 100 percent and suitable for installing both shallow and deep tubewells. The test boring indicated that 100 percent screenable material was available from a depth of 12 m and above, whereas, BADC boring logs indicated that 100 percent screenable material is obtainable from a depth of 21 m and beyond.

Determination of Aquifer Characteristics

The yield of a well depends on the characteristics of the aquifer formation such as transmissivity (T) and the storage coefficients (S) as well as the design and construction of the well. Transmissivity indicates how much water will move through the water bearing formation. Water storage coefficient is the volume of water that the aquifer releases from or takes into storage per unit surface area (Michael 1985). Transmissivity and storage coefficient are two important parameters for estimation of groundwater resources of an area. Johnson (1986) stated that transmissivity and storage coefficient are especially important because they define the hydraulic characteristics of the water bearing formation. If these two coefficients can be determined for a particular aquifer, predictions of great significance can usually be made.

The aquifer characteristics were determined through a pumping test using Jacob's method. Three types of analyses were performed, these are: (i) time drawdown, (ii) distance drawdown, and (iii) recovery methods. One deep tubewell was selected for the pump test. Five observation wells were installed radially in a straight line to record water response to pumping. The distance of the observation wells were from 10 m to 360 m. To estimate the aquifer properties (T&S), mathematical and graphical solutions for one set of data were made. Transmissivity values were 4,562 m^2/day, 4,214 m^2/day by time drawdown method (Figures 1.6a, 1.6b, and 1.6c). The storage values were 0.000648 and 0.000527 by time drawdown and distance drawdown methods, respectively. These values are much higher than the values obtained by Sir MacDonald and Partners (1977). The values indicate that the aquifer has good potential for groundwater development.

Figure 1.5. Probability of occurrence of hydrogeology interpretation (based on 8 wells).



CODE	LITHOLOGY
1	Clay, silty clay
2	Silt, silty and sandy clay
3	Very fine sand, very fine to fine sand
4	Fine sand, fine to medium sand
5	Medium sand, medium to coarse sand
6	Coarse sand, coarse sand with gravel

Figure 1.6a. Time drawdown analysis by Jacob's method.

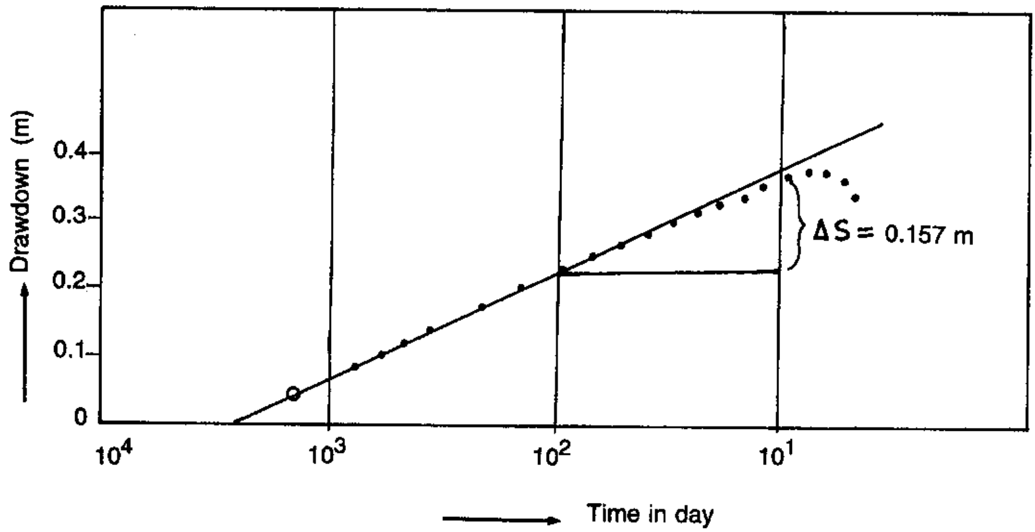


Figure 1.6b. Recovery solution for transmissivity.

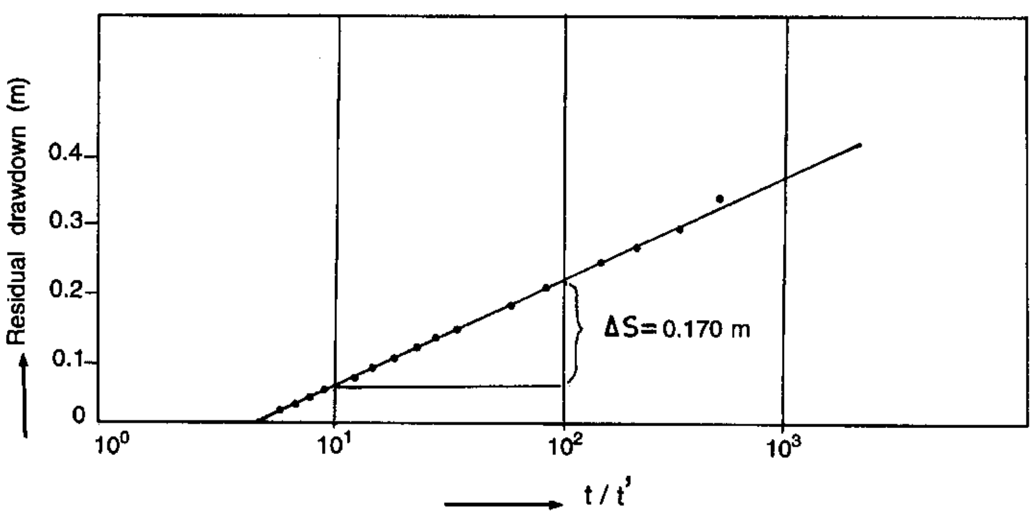
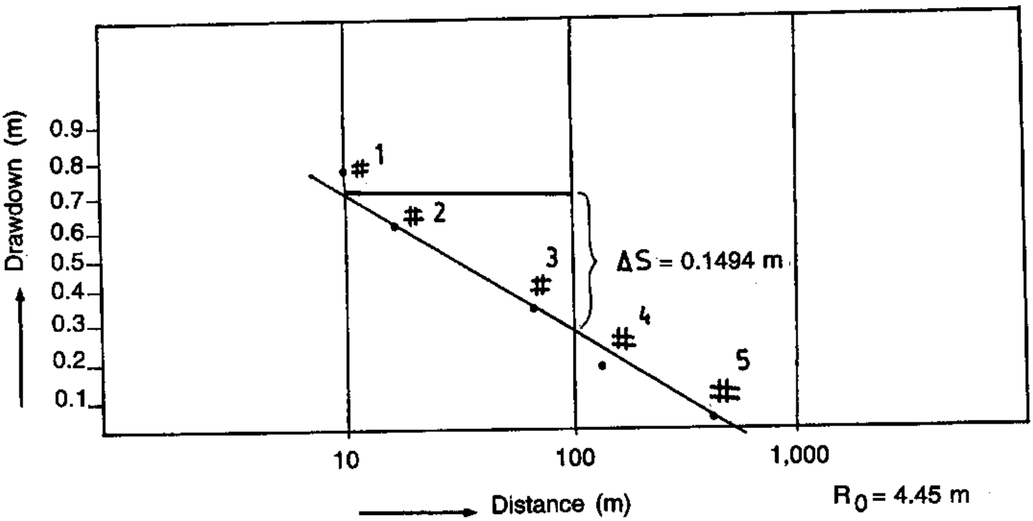


Figure 1.6c. Distance drawdown analysis by Jacob's method.



Model for Safe Well Spacing

A linear regression model was developed between discharge versus radius of interference. The model shows that there is a significant relationship between discharge and radius of interference. At the higher discharge rate the spacing of wells will also be higher as compared to the lower discharge rate (Table 1.1). A type curve has also been developed by plotting discharge (Q) versus radius of interference (R) on normal graph paper (Bangladesh Rice Research Institute [BRRI] 1989). From the type curve the spacing for any particular discharge rate can be estimated (Figure 1.7).

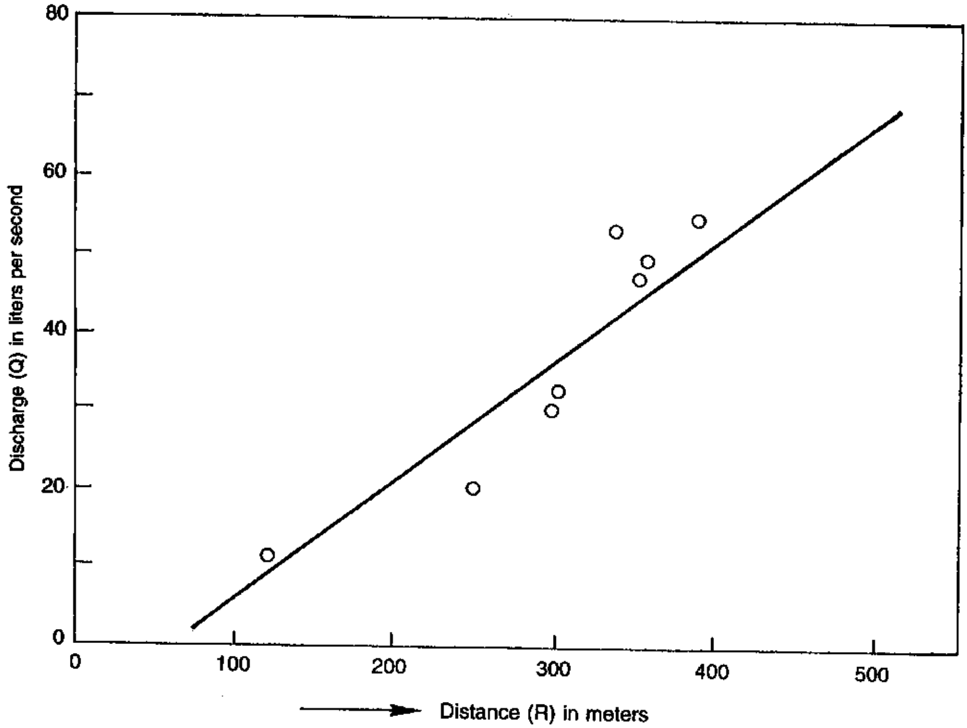
Table 1.1. Discharge versus spacing for deep and shallow tubewells at Kahalu Upazilla, Bogra.

Sl. number	Discharge (lps)	Spacing (m)
1	11[a]	120
2	20[a]	250
3	47[b]	355
4	57[b]	390
5	30[b]	300
6	50[b]	360
7	32[b]	305
8	54[b]	340

[a] Indicates the discharge of shallow wells.

[b] Indicates the discharge of deep wells.

Figure 1.7. A type curve of discharge versus distance for production wells.



Tubewell Performance and Utilization

The irrigated hectarage of the tubewell (area irrigated per unit time), discharge per unit time and the total amount of water applied are shown in Table 1.2. A maximum of 1.24 ha/lps was drawn from DTW No. 10 by operating the pump for 1,660 hrs, and a minimum of 0.56 ha/lps was drawn from DTW No. 5 by operating the pump for 1,583 hrs, during the dry season for rice cultivation. On average, irrigated hectarage of all tubewells was 0.83 ha/lps. Therefore, the tubewells under study were utilized upto their optimum level.

Advantages and Disadvantages of Intensive DTWs and STWs

The advantages of intensive DTWs and STWs are as follows: (i) can be used as a supplementary irrigation source during high water demand of the crop, (ii) allows to increase cropping intensity by alternative sources of water, (iii) permits an increase of the service area through a combination of deep and shallow wells even if the topography of the service area is not level, and (iv) enables more economic use of water by DTWs and STWs where the water table is near the ground surface.

The disadvantages are as follows: (i) low discharge of wells if there is interference of DTWs and STWs located in the same vicinity which increases the cost of operation, and (ii) high risk of crop production during the dry season, particularly under STWs if the water table goes below the operation level.

Table 1.2. Water utilization in selected deep tubewells at Kahalu Upazilla, Bogra.

Deep tubewell number	Location (village)	Total operating hours	Discharge of pump (lps)	Total area irrigated (ha)	Area irrigated per unit discharge (ha/lps)
1	Narhatta	1,390	74.00	44.20	0.60
2	Buril	1,316	42.00	35.51	0.85
3	Damai	1,350	39.10	29.15	0.75
4	Raushan Chapor	1,349	39.37	38.92	0.99
5	Katnahar	1,583	39.84	22.27	0.56
6	Kait	1,152	34.5	26.87	0.78
7	Vagdubra	1,500	40.55	28.34	0.70
8	Muril	1,620	38.50	40.49	1.05
9	Vishropur	1,620	41.42	30.36	0.73
10	Bokra	1,660	45.62	56.41	1.24

Note: Command area of shallow tubewells was not included.

SUMMARY AND CONCLUSION

The study area has an intensive development of tubewells for crop production. The intensity of tubewells per km^2 is 4 to 5 with discharge capacities ranging from 11 to 57 lps. The increasing number of DTWs and STWs may lower the groundwater table further in the study area from year to year, due to overdraft which was observed during the course of the study. There is a significant relationship between rainfall, groundwater table fluctuation and stream flow in the vicinity. The groundwater level started to rise after one month from the commencement of rains when the cumulative total of rainfall reached 15 cm. The study also indicated that the stream flow influences groundwater recharge favorably. The lithological investigation showed that the 100 percent screenable material lie 12 m from the ground surface and extend up to a 60 m depth. The aquifer characteristics such as transmissivity and storage coefficient were determined from pump test data. The results indicated that the aquifer has good potential for groundwater development. But the present trend of increasing the number of deep tubewells and shallow tubewells installed every year in the study area may lower the groundwater table below the operation level. This was indicated during the test of radius of interference between deep and shallow wells at full operation time. However, this issue can be solved technically from the findings of the study by using the distance drawdown and spacing relationships. Hence, a proper policy should be implemented in future for installation of wells in farmer-managed tubewell irrigation systems, with a view to attaining sustainability in groundwater management.

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Farmer-Managed Irrigation Systems and Sustainable Groundwater Management: An Endeavor of Proshika Target Groups[6] to Ensure Sustainability of Groundwater Management

S.C. Sarker[7]

ABSTRACT

PROSHIKA MANOBIK UNNAYAN KENDRA, a nongovernment rural development organization in Bangladesh, initiated its irrigation program based on groundwater in 1980. The projects are being implemented by landless and marginal farmer groups. The major objectives of these projects are to establish rights on groundwater resources, to develop a sustainable alternative project management system in the irrigation sector, to create a bargaining situation between the landless and landlord farmers, to transfer ownership of the irrigation equipment to the target groups and to promote irrigation project management by women groups as a significant and prospective counterpart in groundwater development.

To achieve these objectives in particular, and to ensure the attainment of the goal of rural development in general, Proshika endeavors sustainable groundwater management through rural target groups. Attempts made to realize the objectives outlined above are diverse in nature. This paper focuses on some specific interventions by Proshika with reference to two case studies; i.e., (i) where beneficiaries have adopted management innovations successfully in Bastail—a village in Tangail District, and (ii) where the target group has failed to manage the tubewell in Baoni—a village in Gazipur District.

INTRODUCTION

Bangladesh is one of the least developed countries in the world. The estimated current population of the country is 108.8 million and it is expanding at a rate of 2.17 percent per year (Statistical Year Book 1991). The sex ratio of the population is 106 males per 100 females. The literacy rate is 24.8 percent for the population of 5 years and above. About 85 percent of the total population lives in the rural areas and 80 percent is engaged in agricultural professions. Basically, the

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6 Landless and marginal peasants.

7 Irrigation Programme Coordinator, *Proshika Manobik Unnayan Kendra,* Dhaka, Bangladesh.

country's economy is predominantly agrarian, the cultivable land and the water resources are the principal assets of the country.

The total cultivable land in the country is 903,000 hectares (ha). There are three main rice crops cultivated in the country, which are aush, aman and boro. The boro rice is cultivated in the drought season, that is in between the period of aush and aman. These three rice crops cover an area of 222,189 ha and the crops other than rice cover 516,644 ha. The groundwater irrigation facilities were supplied by 22,510 deep tubewells, 81,511 shallow tubewells and 123,051 hand tubewells in 1990/1991, covering approximately a total area of 1,020,000 ha.

This paper attempts to present a synthesis of the experiences of both Proshika and of the groups of rural poor involved in groundwater irrigation management. It outlines the total mechanisms of the implementation processes including the management system through which the groups have been sustaining themselves over the last decade.

Proshika and its Experience

Proshika Manobik Unnayan Kendra is a National Nongovernment Organization in Bangladesh. Since 1976, it has been involved in organizing both the urban and rural poor for development through education, training and support services including credit. From 1989, a similar process has been initiated in the urban areas to provide development services to the urban poor. From its inception it has incorporated a sustainable development approach which is economically viable, ecologically sound, socially just and culturally appropriate.

Over time, Proshika's development activities have extended to 3,415 villages of 429 unions under 70 upazillas in 26 districts. Presently, the total number of groups are 23,252 of which 11,615 are male and 11,637 are female. It is notable that each group consists of 15 to 20 members.

Proshika's work priorities are defined by themes that refer to some of the topical concerns in rural development. And, the priorities cut across its programs, projects and activities in alternative development endeavors which can be grouped into several major areas. These are as follows: (i) organization of the rural poor, (ii) development education, (iii) employment and income generating activities, (iv) rural health infrastructure, (v) social forestry, (vi) ecological agriculture, (vii) Urban Poor Development Programme, and last, (viii) disaster management.

PROSHIKA'S ENDEAVORS TOWARD SUSTAINABLE GROUND-WATER MANAGEMENT BY THE RURAL TARGET GROUPS

Context

Groundwater Irrigation Project Management by the target groups as water selling enterprises, is an alternative development approach, because the members of the groups sell irrigation water to the fields of landlords under some agreed terms and conditions. But the tradition is, the landowners possess the equipment and use irrigation water to their agricultural land. In some cases the landowners sell water to other fields so that any losses from their own fields can be compensated by the additional income derived. The ultimate aim of the involved groups in groundwater irrigation management is to balance the social inequality between the rich and the poor.

Thus, Proshika Irrigation Programme forms a cycle of beneficiaries, starting with the landless who earn an income through the selling of irrigation water to the land owners, who in turn, are making a profit by raising the productivity of crops which again benefit the economy of the country.

CASE STUDIES

The following two case studies will help to illustrate the total implementation processes starting from initiating a proposal for a project up to its closing. These include group selection, farmers' motivation, credit support, training, technical assistance, share fixation and collection, marketing, etc. The first case study is one of success and the second is a story of mismanagement.

First Case Study

Bastail is a village of Mirzapur Upazilla in Tangail District, where a Bastail *Bhumihim Samity* (landless group) was formed 3 years back. The group consists of 30 members and they hold meetings twice a month. During the last three years they had been utilizing their own savings satisfactorily.

There was an old deep tubewell (DTW) installed in 1974 within the periphery of the residences of the group. The *Krishak* (landowners) Group could not operate the tubewell satisfactorily from the beginning as the manager was functioning individually, taking the full responsibility on his shoulder. He was facing credit, technical assistance and water charge collection problems without any consultation with the group. Three years after its commencement, the project ceased to operate. In 1985/1986, Bangladesh Agricultural Development Corporation (BADC) issued a circular allowing the sale of all the old deep tubewells to the formal/nonformal groups or individuals.

Depending on the above circular the landowning farmers requested the group to take the responsibility of the said deep tubewell project. The group then expressed its desire to Proshika of undertaking the maintenance of the abandoned DTW in their locality. The respective animator who organized the group and the Irrigation Technical Worker (Irrigation Engineer) discussed with the group members in a formal meeting the social, financial and technical advantages and disadvantages, obligations of the group members and the farmers toward the project, Proshika credit norms, etc. The group was hopeful and ensured their sincerity and confidence. They also conducted a group feasibility survey through indepth discussions to judge the uniformity of the group by class and by profession, age of the group members, amount of savings of the members and the performance of their own savings management, etc., and found the group to be feasible to operate the particular irrigation project. The Irrigation Technical Worker then conducted a technical feasibility survey along with the group leaders and the farmers, and found the command area of more than 45 ha to be most suitable.

Then, Proshika, the group, the ex-farmer's group and the Bangladesh Agricultural Development Corporation held a formal meeting where all four parties agreed to transfer the said DTW to the newly formed group on a cash sale basis. Subsequently, former group members and present farmers sat together for share fixation and agreed to fix up a crop share of 33 percent, and both parties concluded a sales agreement. The farmers could use irrigation water for five years with renewal of agreement every year. The group then purchased that DTW for taka (Tk) 52,800[8] (US$1,364) in cash. When all preparatory work was accomplished a seven-member management committee was formed by the group and the members were sent to receive training on irrigation project management in the local Area Development Center (field office). At the same time, an engine and pump operator and a water distributor were employed by the management committee and they were sent to receive training on engine and pump operation and water distribution at the

8 US$1.00 = Tk 38.70.

Proshika Central Training Center, Koitta, Manikgonj. During the first year, the command area was restricted to 18 ha and an operational loan of Tk 50,000 (US$1,292) was given to cover costs of fuel and oil, spare parts, wages, etc. After completing the first year of operation successfully, the group earned Tk 87,192 (US$2,253). They sold rough rice to cover the total loan received from Proshika and whatever that was left was evenly distributed among the group members.

During this period the pump broke down three times and was repaired by the mechanics from BADC along with the Irrigation Technical Worker. For better implementation of the project, the group followed the procedures indicated below. The management committee was expected to hold weekly meetings to approve the expenditures already incurred and to give prior approval for forthcoming expenditures. The management committee had to present all the expenditures incurred during last four weeks and raise other relevant crucial management issues in the general group meeting for approval and rectification, respectively. The above systems were followed regularly for controlling operational expenditures, conflict minimizations amongst the groups and the farmers pertaining to irrigation water distribution, etc. During share collections, the group was subdivided into 4 or 5 sub-groups with management committee members as the team leaders. Each individual sub-group was responsible for the successful collection of shares and for making the accounts available to the group on a regular basis. This system committed them to a serious obligation which led to successful share collections. Another important factor is that the system helped the group to maintain group solidarity which paved the way for democratic leadership rotation among the group members. During the season, they sat twice along with the Proshika personnel for mid-term and final evaluations of their project. During the ongoing operational period, the Irrigation Technical Worker and other related Proshika field personnel provided close monitoring.

In this way, the group operated their irrigation project of 30 ha and earned Tk 119,200 (US$3,080) in 1986/1987, of 25 ha and earned Tk 121,100 (US$3,129) in 1987/1988, of 31 ha and earned Tk 124,033 (US$3,205) in 1988/1989. The project got an electric connection in 1989 and the group immediately responded by decreasing the share rate from 33 percent to 25 percent, an action by which the group won the added confidence of the farmers. As a result, the command area increased to 33 ha in 1989/1990, and to 55 ha in 1990/1991, raising the earnings to Tk 206,032 (US$5,324). This year too, the group has planned to irrigate 55 ha of land with an agreed crop share rate of 25 percent.

Second Case Study

Baoni is a village of Sreepur Upazilla in Gazipur District, where a *Jonodorodi Samity* (comprising 26 members) was organized in 1982. This group functioned with regular meetings, managing its own savings, and participating in the social activities. Similar to the first successful case discussed above, the group got the project and started operation with a command area of 16 ha in the year 1985/1986.

When the group's feasibility was examined, all the group members were found to be belonging to the same category in terms of class and profession with the exception of one member named Abdul Malek. Proshika advised the group to terminate the latter's membership from the group because he possessed 6 ha of land under the scheme, thus making the group heterogeneous in category. Accordingly, the group requested Malek to withdraw his membership from the group. But Abdul Malek had been rendering services voluntarily, staying outside the group during the season, and in this way he had made the group members become obliged to him. He utilized the absence of group members at meetings (as many of them very often had to go elsewhere in search of jobs) to his own advantage. Besides, he also created conflicts among the group members and the farmers without their knowledge, and subsequently, he himself mediated in resolving such conflicts. As a result, the group felt that Abdul Malek was indispensable to the group and to the smooth functioning of their project. Accordingly the group convinced Proshika field personnel that Malek should be included in the group.

Abdul Malek diplomatically created frustration among the majority of the group members by convincing them that the project was a failure. As a result, many group members were alienated from the project. The main intention of Abdul Malek was to cultivate his land without paying a share and he was successful in doing so. On the whole, misappropriations and the blackmailing strategies of Abdul Malek disheartened the group members to a great extent. Ultimately the project had to be terminated after running for 4 years after reporting severe losses, though the general opinion of the group as well as the farmers is that the project did not incur losses. The group then took a decision to sell the DTW and pay the outstanding loan to Proshika.

SOME MAJOR FINDINGS OF THE ABOVE TWO CASE STUDIES

Conditions Necessary for Success of Project

First, the selected group must be free from heterogeneity (in terms of class and profession), and the leadership should follow a democratic process so that each group member can get the opportunity to exercise his responsibility. Second, the organization should pass through a reasonable span of time for strengthening the unity of the members and there should be enough evidence to show successful savings utilization. Third, project expenditures must be reviewed periodically and any problems should be solved immediately as they occur. Fourth, there should be no confusions regarding ownership of the project. Fifth, maximum participation must be ensured and the involved group members should not be kept unnecessarily busy all the time for official purposes. Sixth, the project benefits must be distributed evenly among the group members and impartial attention must be given to the interests of the group and the farmers. And finally, accountability and obligations toward the project are to be enhanced through an appropriate training process.

Promotion of Irrigation by the Rural Poor

Irrigation water is as important a resource as land for agricultural production. The mainstream government strategy for agricultural development is to support those who have land to acquire ownership of irrigation resources as well. This has led to further social and economic polarization and made the landlords "waterlords" as well, while making the conditions of the rural poor more vulnerable. This unbalanced resource endowment in favor of the rural elite has not led to better and efficient management of irrigation systems. In fact, there are countless examples of unsuccessful irrigation projects owing to factors such as small command areas, faulty and biased water management, corruption, etc. In order to address the issues of equity and better management, Proshika undertook a pioneering irrigation strategy through which the rural poor are assisted to acquire control and manage irrigation resources enabling them to contribute to increased productivity while enjoying a fair share of the benefits. This has led the rural poor to wield more social and economic power simultaneously improving the management of the water resources without Proshika credit.

Proshika has supported 744 groups with credit, training and extension services so that they can sell irrigation water to landowners. Around 80 percent of the projects are successful from an economic, social and managerial point of view. Out of those projects, 78 have become completely self-reliant requiring no further credit and training support from Proshika (Table 2.1). However, some technical assistance is provided and communication is still maintained by the field workers

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