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GROUNDWATER IRRIGATION AND CROP ECONOMY IN THE LOWER GANGETIC PLAIN AT MATBARER CHAR, MADARIPUR, SOUTH-CENTRAL BANGLADESH

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Abstract

Attempts have been made in this paper to overview the present agricultural inputs for crop production and crop economy in the lower Gangetic plain. Results of the field survey show that the average labour requirement of Boro rice production is 35 person-days/acre. The fertilizer application by the farmers is not balanced and is well below the recommended doses. N, P_2O_5, K_2O ratio used by the farmers was 7:3:1 against the appropriate ratio of 5:4:3 for HYV Boro rice. The cost of Boro rice cultivation has been estimated on the basis of input use. The rice cultivation costs were Tk.14,335, Tk 13,875 and Tk. 11,271 per acre for the water buyer, water seller with diesel pump and water seller with electric pump respectively. Labour and irrigation costs together normally account for two- thirds of the total cost of production - increases in the prices of these inputs can greatly depress Boro rice profitability. Moreover, Gross income of the water sellers from major crops is about 32% higher than that of the water buyers. The study also shows that the total cost for a Shallow Tube Well (STW) run by diesel motive power is almost twice that for electric motive power. If groundwater irrigated agriculture system is framed in a comprehensive manner, this could play an important role in poverty alleviation.

Key words: Groundwater, irrigation, crop economy, lower Gangetic Plain.

Introduction

Bangladesh is a lower riparian country in the flood plains of three great rivers- the Ganges, the Bhramaputra and the Meghna, and their tributaries and distributaries. Water scarcity in the long dry season and sometimes drought even in the monsoon affects its agriculture, domestic and industrial water supply. This is primarily responsible for the shortage of water for agriculture. Moreover rural areas of Bangladesh suffer from lack of quality drinking water as surface water supplies are generally polluted and, therefore, have to depend on groundwater. Heavy withdrawals of groundwater for irrigation have also lowered the water table in many areas below the effective reach of suction mode tube wells including traditional hand tube wells. About 90% of irrigation water in Bangladesh is provided from groundwater (Zahid *et al.* 2008, 2009).

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Bangladesh is predominantly an agricultural country and its economy depends on agriculture. The natural catastrophe like floods, droughts etc. hinder the agricultural development. Flood and drainage congestion generally destroy the Boro crop at the ripening stage. The dominant food crop of Bangladesh is rice which accounts for about 75 percent of agricultural land use (and 28 percent of GDP). Rice production increased every year since 1980s (through 1987) except Fiscal Year (FY) 1981, but the annual increases have generally been modest, barely keeping pace with the population. Rice production exceeded 15 million tons for the first time in FY 1986-87. In the mid-1980s, Bangladesh was the fourth largest rice producer in the world, but its productivity was low compared with other Asian countries, such as Malaysia and Indonesia (Mandal 2006). High yielding varieties of seed, application of fertilizer and irrigation have increased yields, although these inputs also raise the cost of production and chiefly benefit the richer farmers.

The cultivation of rice in Bangladesh varies according to seasonal changes in the water supply. With the increasing use of irrigation, there has been a growing focus on another rice-growing season extending during the dry season from October to March. The production of this *Boro* rice, including high yielding varieties, expanded rapidly until the mid-1980s, when production leveled off at just below 4 million tons. Where irrigation is feasible, it is normal for fields throughout Bangladesh to produce rice for two harvests annually. Between rice-growing seasons, farmers do everything possible to prevent the land from lying fallow and grow vegetables, peanuts, pulses or oilseeds if water and fertilizer are available.

Groundwater irrigation plays a crucial role in agriculture of Bangladesh and thus in the national economy. Given its dense population and level of rural poverty, Bangladesh is very much in need of enhanced crop production. As far as the crop production is concerned, groundwater irrigation has contributed significantly to the cereal production, mainly *Boro* rice and wheat, by supplementing soil moisture in the dry months of November/December to April/May. Thus cropping pattern is being moved towards HYV rice. Almost all of its 9.1 million hectares of net cultivable area, however, is already in use and any additional crop output can only come from increasing yield and/or cropping intensity. Methods that are available to achieve these ends depend he mainly on irrigation – particularly minor irrigation technologies comprising low lift pumps (LLPs), deep tubewells (DTWs), shallow tubewells (STWs) and manually operated pumps (MOPs), which together are responsible for 85% of irrigation coverage in the country (Mandal 2006, Economic Review 2006). Thus groundwater irrigation is of vital importance as an input to the agricultural economy and for food security. Therefore, it is attempted in this paper to examine present agricultural development and assess the irrigated crop economy in the lower Gangetic plain as a case study.

Materials and Methods

Study Site: The study area was selected considering the poor agricultural activities and crop production, vulnerable soil fertility and less development of groundwater use compared to other floodplain areas of the country. Five consecutive villages, namely, Naktikandi, Kharakandi, Natunkandi (Latif Matbarerkandi), Purankandi and South Bakharerkandi (Sikderkandi) under Shibchar thana were selected as these villages have more involvement in groundwater irrigation, though these are surrounded by many river branches. The location of the study villages is shown in Fig. 1. The area is characterized by the erosion and accretion game of the Ganges which give rise to emergence of medium to large size shoals/sand bars (locally known as *char*). Study shows that the development of groundwater irrigation in this part of the country is not as old as the evolution of these villages (Islam *et al.* 2007).

In the study area, crop year is mainly divided into two seasons- Rabi and Kharif; again Kharif season has been subdivided into Kharif-I and Kharif-II. Rabi season starts from mid-October and ends in mid-March, while Kharif-I season spreads from mid-March to mid-July and Kharif-II within the span of mid-July to mid-October. Crop production is greatly influenced by the seasons. Farmers select their crops based on the land type, availability of irrigation water and on the local market demand. Rice, wheat, mustard, jute, lentil, spices, vegetables, sugarcane are the major crops cultivated in the area. The dominant irrigated crop in the study area is HYV Boro rice. With the increasing demand for municipal and rural supplies, agricultural, industrial and other uses, and understanding the natural distribution for long-term sustainability of groundwater irrigation is very important.

Sample Collection: The study area covered five adjacent villages of Naktikandi, Kharakandi, Natunkandi, Purankandi and Sikderkandi under Matbarer Char Union of Shibchar Upazila, Madaripur district of southwest Bangladesh. The area was selected considering the low agricultural growth and groundwater development. This study was based on the field survey data collected during the survey period (January-March 2007) through direct interviews of 83 respondents using structured questionnaires. The respondents were selected randomly covering all the study villages. Among the respondents, there were 49 water buyers (WBs) and 34 water sellers (WSs) which have been given in Table 1. The study also covered as many as 44 wells out of which 3 were of electric centrifugal pump and the rests were of diesel centrifugal pump.

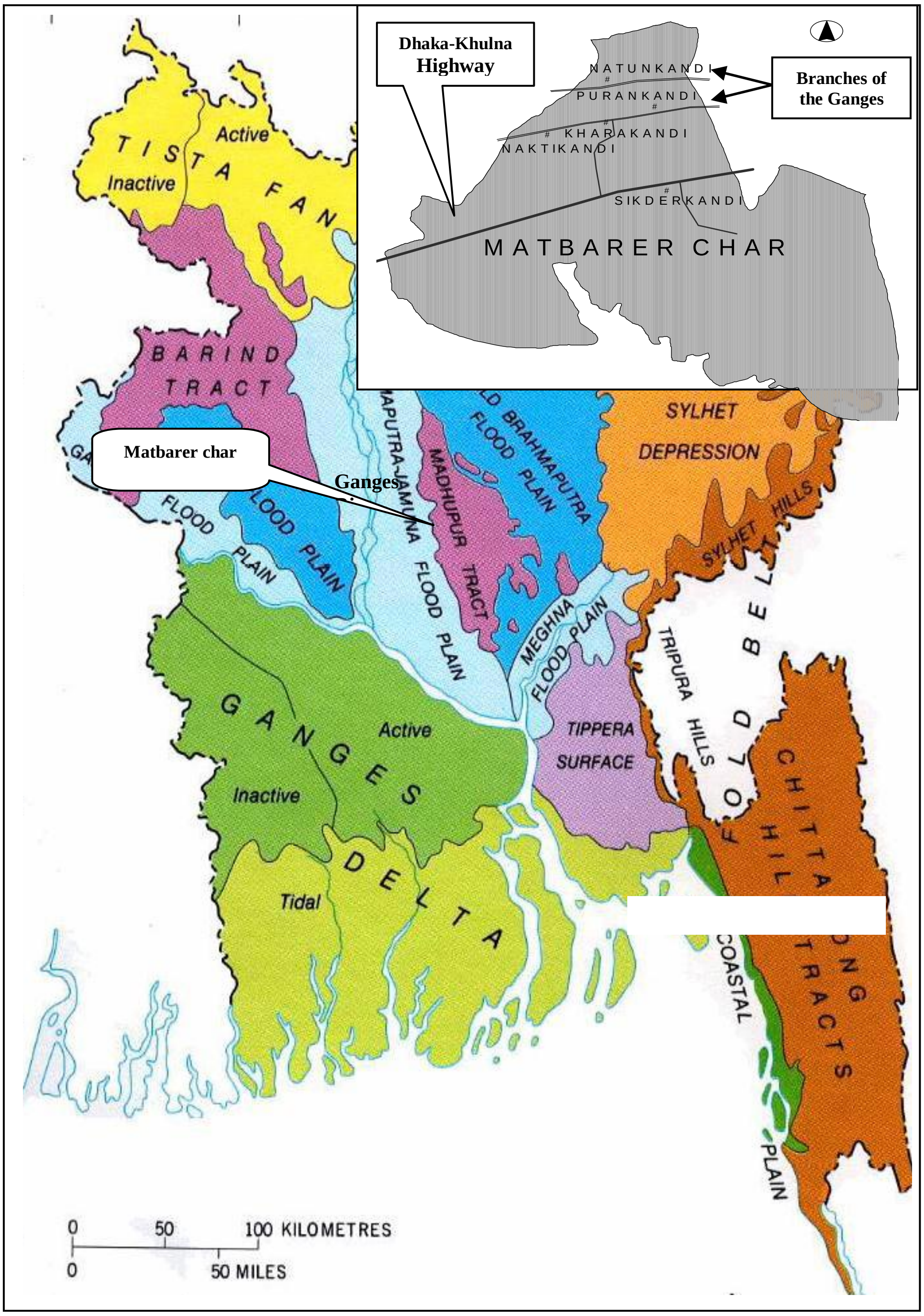

Fig. 1. Location of study villages under Matbarer char Union, Shibchar, Madaripur (modified after Alam *et al.* 1990).

Table 1. Summary of the respondents' count.

Water Transaction Code	Villages with number of respondents					Total
	Naktikandi	Kharakandi	Purankandi	Natunkandi	Sikderkandi	
WB	9	12	10	15	3	49
WS	5	4	8	11	6	34
Total	14	16	18	26	9	83

Results and Discussion

***Economics of Groundwater Extraction* :** details of economics of groundwater extraction presented in Table 2 show that capital costs of well installation per well including pumps are approximately Tk 1,000 for Diesel Centrifugal (DC) and 900 for Electric Centrifugal (EC) power motive. Costs have been indexed at current prices using wholesale price indices. Repair and maintenance cost of running the well/season in 2005-06 is estimated to be about Tk 1,380 and Tk 300 for DC and EC power motive, respectively. The average supervision, diesel and lubricant cost per well per season is about Tk 11,364, Tk 34,976 and Tk 1,351, respectively while the supervision and electricity cost for EC motive power is Tk 8,000 and Tk 15,000, respectively. The study shows that the total cost for a STW run by DC motive power is almost twice that for EC motive power. This is why the farmers in the study villages are strongly in favor of EC motive power.

Table 2. Comparative economic analysis for DC and EC motive power.

Item	DC Cost (Tk)	EC Cost (Tk)
Well construction cost	1,00	900
Distribution line cost	566	566
Repair and maintenance cost	1,380	300
Supervision cost	11,36	8,00
Diesel/electricity cost	34,97	15,00
Lubricant (Mobil) cost	1,351	-
Total cost per STW	50,63	24,76

***Cropping Pattern, Cropping Intensity and Yield of Major Crops* :** Cropping pattern for each village under present situation is furnished in Table 3. A wide range of cropping patterns was found in the study area, but the major patterns are rice based. Pulses, oilseeds, vegetables, jute, wheat, sugarcane are the major non-rice crops. With the availability of ensured irrigation water, farmers shifted towards growing more productive Boro-Fallow-Aman pattern. Previously the cropping pattern in the study area was Aus-Jute-Fallow. Rice is the most dominant crop being grown almost everywhere in the study villages throughout the year in each of the Kharif-I, Kharif-II and Rabi seasons. The cropping pattern was covered by 79.22% with rice and mustard, and the remaining 20.78% by jute, sugarcane, onion, pulses, oilseeds and vegetables etc.

Table 3. Present cropping patterns in the study area.

Village Name	Cropping Patterns
Naktikandi	Rabi Crops-Boro Rice-Fallow/ Sugarcane
Kharakandi	Rabi Crops-Boro Rice-Fallow/ Wheat-Jute/Mesta-Fallow
Purankandi	Boro Rice-Fallow-T Aman/ Wheat-Jute-Fallow
Natunkandi	Boro Rice-Fallow-T Aman/ Rabi Crops-T Aman-Fallow
Sikderkandi	Rabi Crops-Boro Rice-Fallow

The cropping intensity is determined as the ratio of total cropped area to net cultivated area, which is expressed in terms of percentage. Farmers grow one or two crops and left their lands fallow during the rest of the time. The highest cropping intensity was found to be 173% in Purankandi village while the lowest was 124% in Sikderkandi village. The average cropping intensity in the study area was 146%. The country has achieved an average cropping intensity of about 185% (NWMP 2001).

The yield of different crops in the study area presented in Table 4 shows that the survey result produced mixed evidence about the change in yields of different crops. For irrigated Boro rice, only about a quarter of the respondent farmers reported an increase, whereas 65% reported decreases and the remainder had no change in yield in the year 2006 compared to 5 years ago. For other crops there were mixed responses as well. Main causes of yield decline/stagnation of HYV Boro rice as per farmers' opinions were intensive cropping, unbalanced fertilizer application with more use of nitrogenous fertilizer and/or no fertilizer use over mining soil nutrients compared to crop removal etc.

Table 4. Yield of major crops in the study area.

Crop Name	Average Yield (Kg per acre)
HYV Boro	1945 (for Water Buyer) 2086 (for Water Seller)
T. Aman	371
Wheat	720
Mustard	148
Sugarcane	12160
Onion	2304
Jute	640

Groundwater Productivity on Boro Rice : The rice variety widely adopted in the study area is BR-29. This variety has grown in duration of 140 to 150 days. The preferred planting method is transplanting of seedling using wet bed technique. After land is prepared, 35-40 days old seedlings are transplanted to the field and then the irrigation water supply period commences. The 3-day rotation method is practiced for water distribution in the study area. The water sellers maintain the rotational system. On an average, water is applied 35-40 times in the field during rice crop season. Due to seasonal river flood in the area, deposition of new finer sediments allows more percolation of irrigated water causing absorption of more water. It was observed that continuous shallow ponding is needed to obtain a good rice yield. Most of the farmers are familiar with the rotational irrigation schedule and have accepted it as an equitable program for water sharing. The applied groundwater productivity and applied irrigation rate for water sellers and buyers are presented in Table 5. The survey result shows that water sellers applied more water than the water buyers.

Table 5. Groundwater productivity and applied irrigation rate for Boro rice in the study area.

Village Name	Water Productivity		Applied Irrigation Rate (m^3 per acre)	
	Water Seller	Water Buyer	Water Seller	Water Buyer
Naktikandi	0.27	0.36	7720	5340
Kharakandi	0.57	0.58	3643	3357
Purankandi	0.31	0.35	6665	5554
Natunkandi	0.42	0.46	4895	4200
Sikderkandi	0.35	0.41	8053	2739
Average	0.38	0.43	6195	4238

There is a common understanding among the farmers that the more the water depth in the field within limits, the better the yield of irrigated rice. In fact, this is not true. Even under irrigated conditions, occasional drainage is necessary for aeration. A series of water management studies conducted by BRRI indicated that a range of water depths ranging from soil saturation only to 10 cm standing water gave statistically insignificant differences in rice yields, provided other management practices were uniform and equal (Islam 1986, 1987). It was observed that the average groundwater productivities were 0.38 and 0.43 kg m^{-3} for water sellers and water buyers, respectively. National Water Management Plan (NWMP 2001) recommended total required water depth for HYV Boro rice is between 1200 and 1500 mm per season, depending on soil condition. Considering the maximum value the average water used by farmers was 34 % more than the recommended limit, which has no contribution to the growth of crops (Islam 1989, 1991).

Crop Economy and Cost of Boro Rice Cultivation : Crop production inputs such as human labor, draft power and most seeds are generally supplied by farmers in Bangladesh. However, with the shift to HYV technologies, there great importance of purchased inputs such as chemical fertilizer, pesticides, irrigation and power tiller services etc., which are marketed through private-sector traders.

The input use and cost of Boro rice cultivation at present situation are presented in Table 6. The cultivation costs were Tk 1,4335, Tk 1,3875 and Tk 1,1271 per acre for the water buyer, water seller with diesel pump and water seller with electric pump respectively.

Water buyers’ cultivation cost was slightly higher than that of the water sellers. This is mainly due to the difference in irrigation cost (Table 6).

Table 6. Cost of cultivation of Boro rice in the study area.

Line Items	Qty. (Kg)/No	Rate (Tk kg^{-1} or Tk Day^{-1})	Total Tk per acre
Seed	20	30	600
Seed bed preparation	2 (man-day)	125	250
Seed bed Management	2 (man-day)	125	250
Land Preparation (Power Tiller)	8	125	1,000
Transplanting, Weeding and Harvesting	35 (man-day)	125	4,375
Pesticide	2		300
Fertilizer			1,400
Irrigation (Water Buyer)			6,160
Irrigation (Water Seller with DC motive power)			5,700
Irrigation (Water Seller with EC motive power)			3,096
Total cost for water buyer			14,335
Total cost for water seller with DC motive power			13,875
Total cost for water seller with EC motive power			11,271

The gross income analysis from major crops both for water sellers and water buyers is presented in Table 7. Two major crops were considered for income analysis in the study area. The gross income for water buyers was estimated from crop yield per acre multiplied by its unit price. The income from water selling makes the difference between water buyers’ and water sellers’ gross income per year. Gross income of water sellers is about 32% higher than that of water buyers.

Table 7. Gross income analysis from major crops for water buyers and water sellers.

Income	WBs (Tk per acre)	WSs (Tk per acre)
Boro rice	21,250	22,789
Mustard	2,812	2,812
Water selling	-	6,160
Gross income	24,062	31,761

Impact of Groundwater Irrigation and Other Inputs on Crop Economy: Besides irrigation, crop production needs various agricultural practices- land preparation, seedling or plantation, application of fertilizers, intercultural operations, plant protection etc. for a good harvest as those have impacts on crop economy. A timely cultural operation increases the yield, but in the study area cultural practices are not upto the mark. As a result, yield obtained for different crops are not satisfactory. Human labor and animal power are required in various stages of crop production. Peak period for human labor is during transplantation and harvesting while animal labor in land preparation. There is a high demand for labor during the *Boro* rice transplantation and harvest. Power tiller is used for land preparation in the study area. Farmers started using power tillers to meet up the shortage of draft power. Field survey shows that the average labor requirement of Boro rice production is 35 person-days/acre. Vegetable production is more labor-intensive than rice crops, requiring an average of 70 person-days.

Chemical fertilizers are important inputs for HYV rice production. In the study area, all farmers apply chemical fertilizers and only a few are reported to use organic manures. Nitrogen is the most common and widely used nutrient and urea is the major source of nitrogen. Phosphate is next only to nitrogen in total volume of use as fertilizer. The most widely used phosphate fertilizer is TSP. Potash is the third most widely used nutrient, and MP is the only source of potash. In some areas the farmers have reported zinc and sulpher deficiency and they used gypsum or zinc sulphate to overcome that deficiency. In the area, farmers use Urea, TSP and MP at the rate of 110-150, 60-90 and 20-30 kg/acre respectively. The fertilizer application by the farmers is not balanced and is well below the recommended doses. N, P_2O_5, K_2O ratio used by the farmers was 7:3:1 against the appropriate ratio of 5:4:3 for HYV Boro rice (NWMP 2001). Previously, organic manure was applied but now-a-days cow dung is mostly used as fuel. Though the application of organic manure as cow dung would enrich the soil structure and increase the water holding capacity of soil but it is used mostly for household fuel consumption instead of field application.

Agricultural Constraints **:** Over the recent years, because of land and technological constraints, growth of crop agriculture has been less than expected. Bangladesh has a very little scope to increase agricultural production through expansion of land, as the cultivated land has remained constant and even decreased in many cases. The introduction of modern varieties of rice, wheat, oil seeds, potato and other crops has shortened the production cycles and increased cropping intensities and yield. With the expansion of boro cultivation, diesel for operating pumps is becoming a major agricultural input, and cost on this account will increase due to the high price of petroleum fuels in the world market. The higher cost of engines, pumps and installation cost of the tube well along with higher operation cost will make it less economical. The allocation for subsidies has been kept at a minimum level for allowing Government intervention at times of scarcity, which has been taken as an advantage by the private sectors to make undue profits. Lack of electric supply and/or diesel outlet is big problems being faced by the farmers in the study area. Due to very small size of holdings and large number of individual holdings, the financial position of individual farmers to own individual tube wells is very difficult and of uneconomical proposition. Only cooperatives, association or share of farmers can have the full benefits from the shallow tube wells if they are suitably supported and encouraged by the concerned authority.

In the study area, the water sellers install their wells or pumps in their own plots or on other farmers' plot to irrigate their own plots and sell excess water to other farmers under varied contractual arrangements. There are very few water sellers who do not have any land in their tubewell command areas and run their pumps absolutely with business interests. Small farmers dominated the ownership of STWs. Entry or exit of pump owners in the irrigation business depends on profits or losses, pump capacity, size of the command area, operating capital, managerial efficiency, condition of machine, reputation, social relationship etc. The labor engaged in agriculture has also been declining. Apart from the rural to urban migration of households, there has also been a movement from farm to non-farm occupations within the rural areas supported by the opportunities of employment created in the rural trade and transport sectors with the expansion of rural roads, the increased marketed surplus of agricultural product, improvement of literacy rates, migration to foreign countries etc. However, there is huge potentiality of agricultural expansion applying and increasing suitable technology and enhancing knowledge and efficiency of local farmers. Moreover, the provision of electricity for irrigation pumps should be given top priority, as the cost of irrigation by electric pumps is about 50% lower than that for diesel run pumps. There should have diesel supply at subsidized rate until and unless the electricity reaches the irrigation pump motors in the study area.

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