Resources and Environment 2018, 8(2): 21-30
DOI: 10.5923/j.re.20180802.01

Economic Viability of Using State-owned Wetlands as Water Reservoirs for Irrigation: A Case Study from Bangladesh

Santa Sarmin[1], A. K. M. Nazrul Islam[2,*]

[1]Graduate Student, Master of Economics (Environmental Economics) Programme, Dhaka School of Economics (A Constituent Institution of the University of Dhaka), Dhaka, Bangladesh
[2]Associate Professor of Environmental Economics, Dhaka School of Economics (A Constituent Institution of the University of Dhaka), Dhaka, Bangladesh

Abstract Water resource has been and will also be the most crucial asset for Bangladesh like many other countries, particularly for its agriculture sector. For the sake of maintaining sustainability, heavy dependency on groundwater is going to be a major issue of concern for the country. The groundwater level in many areas shows sharp decreasing trends. This is expected to create ecological imbalance and also increase cost of agricultural production. Against this backdrop, this paper tries to assess the feasibility of a proposed excavation project to be implemented in *Beel* Jaleshswar, one of the largest wetlands in Jessore district of Bangladesh, to reserve surface water for irrigation and other major uses. To measure economic viability of the proposed project, this paper estimates expected costs and benefits of the project. For this purpose, data have been collected from 95 households randomly selected from the study area. The findings suggest that direct economic benefit from the proposed project is estimated to be in the tune of BDT 438.32 million annually from fish and snail catch only, while the net benefits from irrigation based on three alternative scenarios are also found to be economically highly viable.

Keywords Groundwater, Surface Water, Wetlands, Excavation, Nature Based Solution, Social Cost Benefit Analysis

1. Introduction

Groundwater irrigation has been most likely the major theatrical development in Bangladesh agriculture over the last 25 years (Dey et al. 2013). Groundwater levels have declined considerably along with increased groundwater contribution in irrigation during the last decade posing serious threat to the sustainable use of water in the country (Qureshi et al. 2014). But the unavailability of required irrigation water with time is emerging as a serious concern for the country particularly due to pressure from increasing irrigation water and reduction in water supply. To make the situation even worse, India recently has set to start working on the National River Linking Project (NRLP) by linking water from the Ganga and the Brahmaputra which is expected to channel water away from the downstream country that potentially can dry out large of Bangladesh during the dry season. This may affect as many as 53 rivers of Bangladesh which have flown down from India by intensifying desertification, loss of river flows and navigability, intrusion of saline water into farm lands and most importantly making irrigation water more scare for Bangladesh during the dry season, if any political solution of rightful share of water cannot be ensured.

In addition to groundwater and rivers which serve as suppliers of water resources for Bangladesh, there is a vast area (574,356 acres) of wetlands which are the source of fisheries, aquatic vegetations and other biodiversity, irrigation and navigation services, etc. for the country. Out of 34,681 government-owned wetlands, 9,801 (28%) are leased out to private ownership for certain periods (MoL, 2017). Although the very idea behind leasing out wetlands among fishermen following the '*Jal Jar*, *Jola Tar*[1]' policy was a noble idea, in reality people who are getting access to such wetlands are 'local rich and politically influential' section who often end up employing 'real fishermen' as labors in their fisheries. Fish cultivation (culture fisheries) in wetlands like *beels*[1], *jheels*[1], canals, or other types of open waterbodies deprives access to wetland resources and services by most common stakeholders, many of whom (the local poor) are heavily dependent on wetlands for their livelihoods and nutrition. In addition, it causes the loss of wetland-based biodiversity, including indigenous local fishes, which often face serious threats from such malpractices. Further, conversion of wetlands for other

* Corresponding author:
nazrul2002@yahoo.com (A. K. M. Nazrul Islam)
Published online at http://journal.sapub.org/re

[1] Leasing out wetlands to fishermen, who are the owners of fishing nets.

purposes also reduces the possibility of using water from wetlands for irrigation and other household purposes.

There have been many studies on depleting state of groundwater table and changing patterns of irrigation and its increasing cost in Bangladesh. Different non-government organizations (NGOs) in association with relevant government departments are successfully running various community managed projects in the country, including management of wetlands. But not many studies are available on managing wetlands as water reservoirs for irrigation purpose, which perhaps is an area that needs to explore seriously by the agriculture sector in Bangladesh considering the fast depletion of underground water layers and increasing scarcity of surface water in the country.

The critical problem of groundwater depletion can be countered through sufficient recharge by surface water flow and rain water, but such possibilities are not really so high in the present context. There can be fewer substitutes for surface water in the long run for irrigation and other uses. Thus, we need to be smart enough to think both economical and environmental perspectives of water use for irrigation from now. The vast area of wetlands can also be a major source of irrigation during the dry season in the country, if they are properly managed. Water reserve capacity in the country can be enhanced tremendously by little excavation and undertaking proper maintenance mechanism. Against this backdrop, the present paper tries to assess the economic viability of using a state-owned wetland as a 'water reservoir' under community management for irrigation purposes. To undertake a benefit-cost analysis of a proposed water reservoir project at the community level for government owned wetlands: to evaluate the effect of irrigation cost on the irrigated crop production; and to assess the economic viability of a government owned wetland as water reservoir project.

2. Literature Review

Rahman et al. (2016) conducted a study to access the groundwater level fluctuation and impacts on irrigation cost of Jessore Sadar and Jhikargacha Upazillas. From the secondary data collected from BADC (Bangladesh Agricultural Development Corporation), it was found that the trends of maximum fluctuation level increased from 5.65 to 9.35m and 5.1 to 8.36m at Jessore Sadar and Jhikargacha respectively from April 2004 to April 2013. From the study it was also found that groundwater level fluctuation mostly affects the shallow tube-well (STW) irrigation. Another study by Dey et al. (2015) suggested that groundwater use was not sustainable in the Barind region and there was overexploitation of groundwater without having sufficient recharging of the aquifers. The findings also showed that the declining trend of average annual river water level is positively related with the decreasing trend of groundwater table. The combined annual flow of the surface water passing through Bangladesh is in the range of 1,200 to 1,500 billion m^3. The sediment discharge is in the range of 1.2 to 1.7 billion tonnes which originates outside the country (Ali, 2002). This huge amount of transboundary monsoon flow along with local downstream run-off causes floods in Bangladesh almost in every year. Khondoker et al. (2014) revealed that though a considerable part of *Beel* Bakar in Jessore and its floodplain is under *gher*[1] culture, still there is scope to ensure protection and to enhance livelihoods of fisher community. The study also found that excessive *gher* culture practice and possession of non-fishermen over the waterbody are the main constrains of the *beel*. The declining trend of groundwater table in Bangladesh is expected to contribute to the crisis of water availability in near future for pure drinking water, household and industrial uses and most importantly irrigation purpose. In addition, there is the uncertainty of the rightful water share of the Transboundary Rivers as a downstream country, which poses a direct threat to the surface water flow of Bangladesh. It is likely to be wiser to think about exploring the possibility of using more of surface water and rainwater sources instead of over-extracting country's underground aquifers.

3. Research Methodology

Study Area

The *Beel* Jaleshwar belongs to both Jessor Sadar Upazilla and Bagherpara Upazila. Ichali and Fatepur unions of the Jessor Sadar Upazilla; Roypur, Dorajhat union of Bagherpara Upazila cover the *beel* area (*Table 3.1*). It is adjacent to 25 villages with approximately 25,000 dependent population and 5,980 households. This *beel* is linked with 5 rivers through 18-20 *khal*.

Proposed Excavation Project

In the *Beel* Jaleshwar area, waterlogging is a serious problem for most of the months during the rainy season. On the other hand, in the dry season the crops need to be irrigated for production. Almost all of the irrigation water comes from groundwater pumping.

Table 3.1. *Beel* Jaleshwar Area

Season	Months	Time	Water Depth	Total Area (acre)	Government Owned (acre)
Rainy Season	May-November	7 months	20 feet	11,737.51	494.211
Dry Season	December – April	5 months	5 feet	1,235.53	

Source: Roypur Union Parishad, 2016

Table 3.2. Excavation Scenarios of the Proposed Project

Scenario	Excavation (feet)	Water Depth (feet)
Status quo: no excavation	0	5
Scenario 1	5	10
Scenario 2	7	12
Scenario 3	10	15

If the public-owned part of the *beel* can be excavated enough, the 2,000 acres of cultivable land in the *beel* can be irrigated with the additional amount of water without lifting groundwater. This paper proposes three possible options of excavation of the *beel*. The table 3.2 shows the three scenarios with 5, 7 and 10 feet excavation along with the 'status quo' of no excavation.

Sampling

This paper is based on a primary survey conducted by folloewng a simple random sampling technique. The sample size is estimated as 95 households using the following method of suggested by Cochran (1977):

$$n_0 = \frac{pqz^2}{e^2} \quad \text{and} \quad n = \frac{n_0}{1+\left(\frac{n_0 - 1}{N}\right)}$$

Where,
p = 0.5
q = 0.5
z = Standardized normal distribution table (95% confidence level with z value of 1.96)
e = Admissible error level (10% level of error i.e. e = 0.1)
n_0 = Rough sample size
n = Finite population correlation (FPC)
N = Total population (5,980 Households)

Methods of Data Collection

Primary data have been collected from the study area based on a questionnaire survey. Further, focus group discussions (FGDs) and key informant interviews (KIIs) are also conducted on direct users of the wetlands and other important stakeholders or experts to get supplementary information on the proposed excavation project. Secondary data have been accumulated from related organizations like BBS (Bangladesh Bureau of Statistics) and BADC (Bangladesh Agricultural Development Corporation) through literature review.

Methods of Data Analysis

Descriptive Analytical Tool

The demographic features of the respondents, groundwater table and irrigation costs have been analyzed using measures of central tendency and measures of dispersion along with graphical presentations.

Statistical Model

To show the past trend of groundwater table and forecast future condition, this study has used Microsoft Excel for time series data analysis. To evaluate the weight of groundwater irrigation cost on crop profitability, the following multivariate linear regression model is used:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + e$$

Where,
Y = Profit per acre (BDT);
X_5 = Fertilizer cost (BDT);
β_0 = Intercept term;
X_6 = Pesticide cost (BDT);
X_1 = Land size (acre);
X_7 = Output (Maund);
X_2 = Labor cost (BDT);
X_8 = Byproduct (BDT);
X_3 = Seed cost (BDT);
e = Stochastic error term.
X_4 = Irrigation cost (BDT);

All explanatory variables, except for farm size are divided by land size to place them on per acre basis. The multivariate linear regression model using a log-log functional form is then reconstructed and analyzed by using a ordinary least square (OLS) method with the help of STATA 12.0. The simple linear regression model reconstructed is as follows:

$$\ln Y = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5\ln X_5 + \beta_6\ln X_6 + \beta_7\ln X_7 + \beta_8\ln X_8 + e$$

Indicators

Farmer's Benefit-Cost Ratio (BCR): In addition, an indicator of farmers benefit cost ratio can be calculated here based on the following equation. This indicator is used in World Bank (2000) as agricultural performance indicator:

$$\text{Farmer's Benefit-Cost Ratio (BCR)} = \frac{\text{Gross return from produced crop}}{\text{Total cost of production}}$$

Cost-Benefit Analysis

The economic viability of the proposed project has been scrutinized by employing a Social Cost Benefit Analysis (SCBA). The possible direct economic benefits and costs of the wetland excavation and surface water irrigation project are calculated as below. There are two tools that have been used in this research paper to reach the conclusion.

Benefit (B) = Value of reserved water for irrigation

Cost (C) = Excavation cost of wetland+ Re-excavation cost + Irrigation infrastructure + Maintenance cost

Net Benefit: Net Benefit = Benefit (B) – Cost (C); If (B-C) is positive, the project is economically viable.

Net Present Value (NPV): Net present values of the different scenarios (table 3.2) of the project are calculated to get the discounted value of the benefit of the proposed project.

$$\text{Net Present Value (NPV)} = -C_0 + \sum_{i=1}^{n} \frac{B_i - C_i}{(1+r)^i}$$

Here,

C_0 = Initial cash outflow (Excavation cost of wetland and Irrigation infrastructure)

B_i = Benefit in year i (Value of reserved water for irrigation)

C_i = Cost in year i (Maintenance cost and Re-excavation cost)

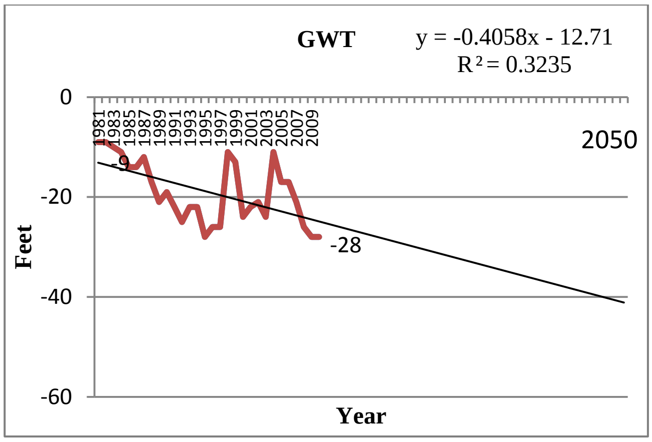
r = Social discount rate = 10%

Rationale for Social Discount Rate: For a private investment project, the rate of discount in NPV calculation is influenced by the rate of interest that could be obtained on the investment. However, in the case of public-owned projects, it is more appropriate to use a social rate of discount (WRC, 2010). By employing a Monte Carlo Simulation, Jalil (2010) concluded that 9-11% should be used as optimal social discount rate for various long term projects in Bangladesh. The discount rate is similar to the ones used by Government of Pakistan, India and China. Besides, a discount rate of 12 percent is assumed in "Economic Modeling of Climate Change Adaptation: Needs for Physical Infrastructures in Bangladesh" (MoEF, 2008). As per 2016, a social discount rate of 10 percent is assumed to calculate NPV of the *Beel* Jaleshwar excavation and surface water irrigation project.

4. Results and Discussion

Groundwater and Its Uses in Jessore

Figure 4.1 shows the average groundwater trend in *Beel* Jaleshwar area and its adjacent 4 unions of Bagherpara and Jessore Sadar Upazila from 1881 to 2010. The unions are Roypur, Dorajhat, Ichali and Fatepur. The groundwater level in area of *Beel* Jaleshwar was 9 feet in 1981 which decreased to 28 feet in 2010. Though fluctuating, the overall groundwater level is showing a decreasing pattern.



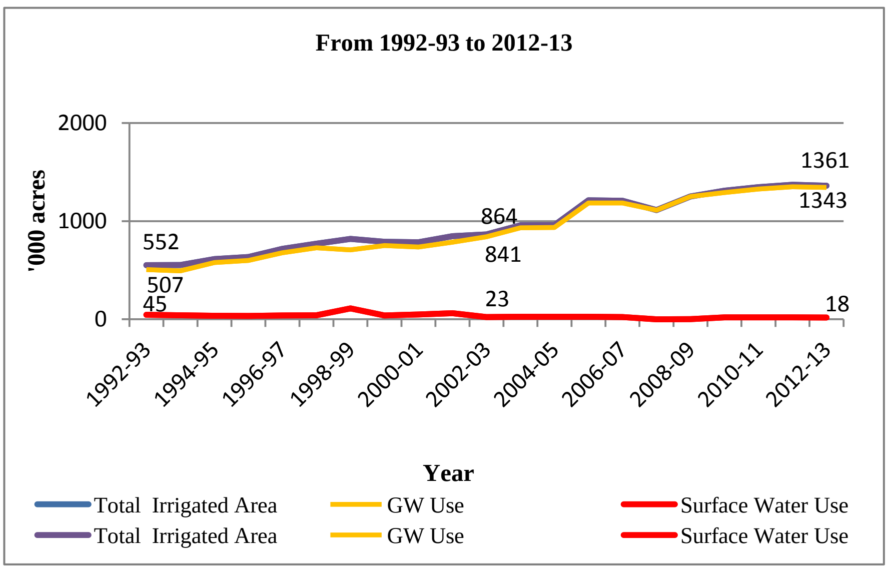
Source: BBS, 2012

Figure 4.1. Groundwater Level in *Beel* Jaleshwar Area

A linear trend line is added to simply forecast the future trend in groundwater level in *Beel* Jaleshwar area. It can be observed that with current falling trend, the groundwater level is forecasted to be below 40 feet in year 2050.

Figure 4.2 shows groundwater and surface water irrigation along with the total irrigated area. It can be easily noted from the figure that groundwater irrigation covers the most portion of the total irrigated area. It increases over the years along with the total irrigation. On the other hand, the surface water irrigation shows a deceasing trend over the 20 years.

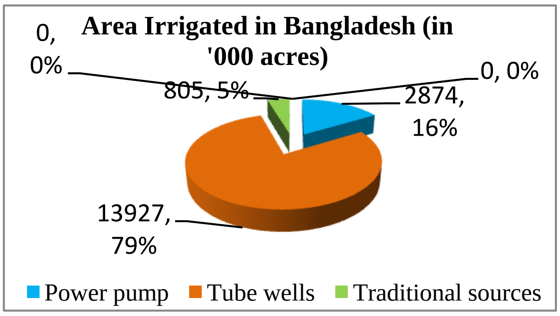
From 45,000 acres in 1992-93, the surface water irrigated area fell to 18,000 acres in 2012-13. In 1992-93, 507 out of 552 thousand acres were irrigated by groundwater, while in 2012-13, 1343 out of 1361 thousand acres were irrigated by groundwater lifting.



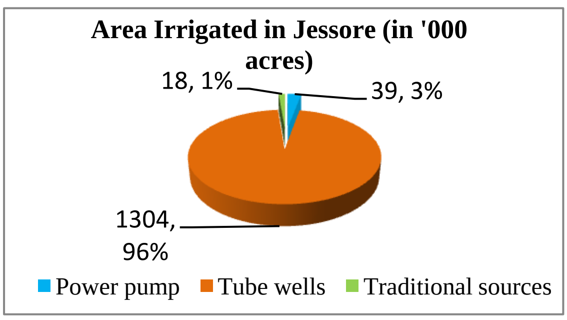
Source: BBS, 2014

Figure 4.2. Irrigated Area under Groundwater and Surface Water in Jessore (in '000 acres)

The two parts of *figure 4.3* represent the total irrigated area by power pump, tube-wells and traditional sources in the 2012-13. The traditional sources in the figure include *doons*[1], sewing baskets & others. The irrigated area by tube-wells out of the total 13,927 thousand acres is 79 percent of the total. In Jessore, 96 percent of the irrigated areas were under tube-wells. Power pump irrigates 16 percent in whole country and 3 percent of total irrigated area in Jessore. To irrigate 5 percent in total country and 1 percent area in Jessore out of the total irrigated area, traditional methods of irrigation are used.



(a)



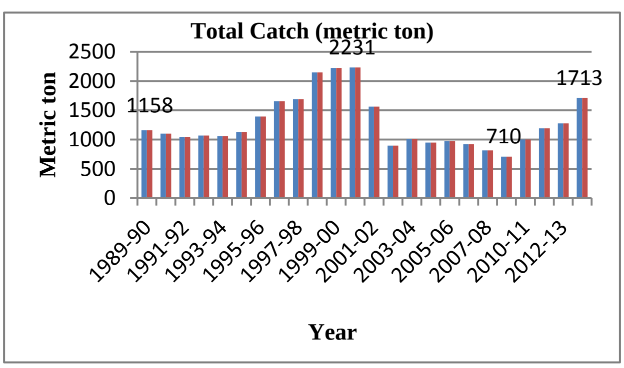
(b)

Source: BBS, 2014

Figure 4.3. Irrigation under Different Means in 2012-13

Beel Fisheries in Jessore

Figure 4.4 shows the annual production of *beel* fisheries in Jessore from fiscal year 1989-90 to 2013-14. The figure represents an increasing trend at first from 1991-92, then it decreased again. In recent years the fish production in Jessore *beels* is showing an increasing trend again.



Source: BBS, 2016

Figure 4.4. Annual Fish Production from Beel Fisheries in Jessore

The highest production belonged to year 2000-01 as 2231 metric tons of fish in these 24 years and lowest one is 710 metric tons in 2007-08. In fiscal year 2013-14, the total fish production in the *beels* of Jessore was 1713 metric tons, which was the highest after year 2000-01.

Patters of Water Uses in Beel Jaleshwar Area

Table 4.5 shows the water use patterns of the respondent households in the area. There is a firm indication that the households are mostly dependent on groundwater for most uses.

Table 4.5. Water Use of the Households

Purpose	Drinking water	Household uses	Jute retting	Irrigation
River	0%	0%	0%	0%
Canal	0%	0%	3.16%	0%
Pond	0%	0%	96.84%	0%
Groundwater	100%	100%	0%	100%
Wetland	0%	0%	0%	0%
Rain	0%	0%	0%	0%

Source: Calculation based on field survey, 2016

It was understood that 100 percent of the surveyed households extract groundwater for drinking, household uses and irrigation purposes. Canals and ponds are used for jute retting. About 88 percent households have their own tube well for household uses and drinking purpose. Rest of the households uses neighbor's tube well for drinking and other uses.

Table 4.6 shows the use of *Beel* Jaleshwar by the adjacent households. There is no use of this *beel* for drinking water, household uses, irrigation and jute retting purpose. About 93.7 percent households catch fish from the *beel*. 92.6 percent collects snail for market sell and fodder collection for duck.

Table 4.6. Wetland Uses

Purpose of Use	Frequency	Percentage
Drinking water	0	0
Household uses	0	0
Fishing	89	93.7
Snail collection	88	92.6
Irrigation	0	0
Jute retting	0	0
Transport	67	70.5
Recreation	36	37.9

Source: Calculation based on field survey, 2016

70.5 percent of households use the *beel* for transportation to another village beside the *beel*. And 37.9 percent households use the *beel* for recreational purpose mostly boat riding.

Crop Profitability Analysis

Table 4.7 shows profit distribution between the damaged farms and others. 13.68 percent of farms have damaged crops. The average profit of households without damage (86.32 percent) is estimated to be BDT 7,713 per acre.

Table 4.7. Profit (per acre)

Measures	Not Damaged	Damaged	Total
Frequency	82	13	95
Percentage	86.32	13.68	100
Mean (BDT)	7,713.26	-41,417.79	990.07
Minimum (BDT)	121.21	-53,974.14	-53,974.14
Maximum (BDT)	27,703.46	-19,575.76	27.703.46

Source: Calculation based on field survey, 2016

The households with damaged crops have BDT 41,417 of negative profit (loss) per acre. This amount of profit loss turns down the total profit per acre to BDT 990. It can be added that, all the 13 farms with crop damage face negative profit for *boro*[1] cultivation. The overall maximum and minimum profits per acre are BDT 27.703 and BDT -53,974, respectively which depicts a high deviation in profit distribution.

Table 4.8. Two Sample t-test with Equal Variance

Group	Observation	Mean	Std. Err.	Std. Dev.
Not Damaged (0)	82	7713.265	867.7829	7858.108
Damaged (1)	13	-41417.79	2282.153	8228.421
Combined	95	990.0686	1919.438	2439.135
Difference		49131.05	2360.41	18708.36

diff = mean(0) - mean(1) t = 20.8146
Ho: diff = 0 degrees of freedom = 93
Ha: diff < 0 Ha: diff = 0 Ha: diff > 0
Pr (T < t) = 0.0000 Pr (|T| > |t|) = 0.0000 Pr (T > t)= 1.000
Source: Calculation based on field survey data, 2016.

The *table 4.8* shows the results of two sample t-tests of the profit levels of the farms with and without damaged crops. The results prove that there is a significant difference between the profit levels of households with and without crop damage. The difference is BDT 49,131 which is significant at 1 percent level.

Table 4.9 represents the results of the simple linear regression. Profitability of farms is measured by linear regression model using a log-log functional form which is analyzed by ordinary least squares (OLS) method. From this model the regression result can be found as *table 4.9*.

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + e \quad (i)$$

The regression model constructed is as follows from the result,

$$\ln Y = 32.221 + 0.791 \ln X_1 - 1.134 \ln X_2 - 0.117 \ln X_3 - 1.888 \ln X_4 - 1.989 \ln X_5 - 0.244 \ln X_6 + 4.542 \ln X_7 + 0.540 \ln X_8 + e \quad (ii)$$

The R^2 value is found to be 0.6981, which means that the explanatory variables have the power to explain about 69 percent variations in the dependent variable. Thus, this model fits the data around 69%. The coefficient of land size (X_1) is 0.791; which means that there is positive relationship between land size and profit of farms per acre. If other things remain same, 1% increase in land size (acre) leads to 0.79% increase in profit of farms on an average which is statistically significant at 10 percent level of significance. The coefficients of labor cost (X_2), seed cost (X_3), irrigation cost (X_4) and pesticide cost (X_6) are -1.134, -0.117, -1.888 and -0.244 respectively which means that, average profit per acre is negatively related with these variables. There is no strong statistical evidence for these coefficients. If other things remain same, 1% increases in irrigation cost leads to 1.8% decrease in profit of farms on an average which is not statistically significant.

Table 4.9. Linear Regression Result for Model (*i*)

Dependent Variable	Explanatory Variables	Coefficients	Standard Error	t	P > t
lnY (Profit)	$\ln X_1$ (Land size)	0.791*	0.315	2.51	0.014
	$\ln X_2$ (Labor cost)	-1.134	1.049	-1.08	0.283
	$\ln X_3$ (Seed cost)	-0.117	1.166	-0.10	0.920
	$\ln X_4$ (Irrigation cost)	-1.888	1.856	-1.02	0.312
	$\ln X_5$ (Fertilizer cost)	-1.989*	0.768	-2.59	0.012
	$\ln X_6$ (Pesticide cost)	-0.244	0. 124	-1.96	0.054
	$\ln X_7$ (Output)	4.542***	1.130	4.01	0.000
	$\ln X_8$ (By-product)	0.540**	0.163	3.31	0.001
	Cons	32.221	21.860	1.47	0.145
Regression statistics: Number of observation = 82 Prob> F = 0.0000 R-squared = 0.6981 Adj R-squared = 0.6651					

*** implies significant at 1% level, ** implies significant at 5% level and * implies significant at 10% level
Source: Calculation based on field survey data, 2016.

The coefficient of fertilizer cost (X_5) is -1.989 which means that, there is negative relationship between fertilizer cost and average profit per acre. If other things remain same, 1% increase in fertilizer cost would result in decreased profit per acre by 1.9% on an average which is statistically significant at 10 percent level. The coefficient of output (X_7) is 4.542 which depicts that there is positive relationship between output and profit per acre of farms. If other things remain same, 1% increases in output leads to 4.542% increase in profit of farms on an average which is statistically significant at 1 percent level. The coefficient of by-product (X_8) is 0.540 which depicts that there is positive relationship between output and profit per acre of farms. If other things remain same, 1% increases in output leads to 0.540% increase in profit of farms on an average which is statistically significant at 5 percent level.

Farmer's Benefit Cost Ratio (BCR)

In addition, an indicator of farmers benefit cost ratio can be calculated here based on the following equation. The farmer's BCR is 1.02 which is little more than 1. Thus, the benefit-cost ratio of the farmers is satisfactory.

Farmer's Benefit Cost Ratio (BCR) =

$$\frac{\text{Gross return from produced crop}}{\text{Total cost of production}} = \frac{60327}{59337} = 1.02$$

Direct Economic Benefits from Beel Jaleshwar

The duration for fishing and snail catch in a year is 7 months including rainy season namely June to December. On an average a household collects 278.9 kg of fish and 1,466.32 kg of snail per year which leads to a total benefit of BDT 52,638. Benefit from fish catch (BDT 39,790) is greater than that of snail catch (BDT 12,848). From this information, total benefit from the *beel* of its dependent people can be calculated as BDT 314.77 million. This benefit is shared between 75.6 percent from fish catch and 24.4 percent from snail collection. The fish cultivation is mostly occurred in the government-owned lands in the *beel* along with the private lands. This type of farming is done by digging large ponds into the deep areas. On average one acre of land provides BDT 2.5 lakh or BDT 0.25 million of net benefit.

Table 4.10. Total Direct Annual Benefits

Benefit	Duration (annually)	Annual Benefit (million BDT)	Total Annual Benefit (million BDT)
Fish Catch	7 months	0.03979 per household	237.94
Snail Catch	7 months	0.012848 per household	76.83
Subtotal			314.77
Fish Cultivation	4-5 months	0.25 per acre	123.55
Total			438.32

Source: Calculation based on field survey, 2016

Thus, only from the government owned 494.211 acres the total annual benefit is calculated as BDT 123.55 million. *Table 4.10* depicts the total view of the direct benefits. The direct benefit from the *beel* of its dependent people can be calculated as BDT 438.32 million annually.

Economic Benefits and Costs of the Proposed Excavation Project

Possible Benefits from Water Use

Table 4.11 shows the water availability in the dry season and its possible economic benefit. In the dry season the total water available in the *beel* is estimated to be 76,20,000 m^3 which can irrigate 1771.43 acres of land in thr *boro* rice season. In the government-owned area (494.211 acres) of the *beel*, 30,48,000 m^3 of water is available which is sufficient to irrigate 708.57 acres of *boro* rice cultivating land.

Table 4.11. Water Availability in the Dry Season

Beel	Area (acre)	Water Depth	Volume of Water (m^3)	Irrigated area for boro (acre)
Total area	1,235.53	5 feet	7620000	1771.43
Government owned	494.211	5 feet	3048000	708.57
Percentage of total (%)	40	-	40	40

Source: Calculation based on secondary data, 2016

The irrigation water requirement is calculated by following Hossain et al. (2013). This study revealed that the average water requirement for *boro* rice is 4301.6 m^3 per acre per season. In dry season 40 percent of total area under is government-owned.

Economic Benefit from the Proposed Excavation Project

Table 4.12 shows a view of total excavation schemes and regarding benefits in the government-owned *beel* area (494.211 acres) only. The column number 1 is representing the different schemes. Three different scenarios have been developed based on the three proposed excavation schemes: 5, 7 or 10 feet excavation along with the 'status quo' option. Column 3 in the table shows the total expected water depth after the proposed excavation is done. The total volume of water in the government-owned area is presented in column 4 which is reasonably increasing with the depth of water. These amounts of water can be used to irrigate *boro* rice fields in the dry season. Column 5 in the table 4.12 shows that around 708 acres of land can be irrigated using the existing water in the dry season, which depicts a benefit of BDT 6.3 million annually. This amount of benefit is calculated as per the average cost of irrigation water for 1 acre *boro* land. The average cost of irrigation is considered to be BDT 8,893 per acre per season, which is depicted as the price of irrigation water.

As per the first scenario, 5 feet more are to be excavated to the existing 5 feet water depth which can contain irrigation water for 1417.15 acres of *boro* land in total. Scenario 1 can generate an economic benefit of BDT 6.3 million annually. Thus excavation of 5 feet in the *beel* raises the economic benefit by BDT 6.3 million annually. Similarly, a 7 feet excavation as per the scenario 2 makes the water level 12 feet deep which can contain 7315200 m^3 of water. This amount of water is sufficient to irrigate 1700.58 acres of *boro* land annually with a total benefit of BDT 15.1 million. Thus scenario 2 brings the additional benefit of BDT 8.8 million compared to the status quo. Similarly, scenario 3 with 10 feet excavation project causes the opportunity to irrigate 2125.72 acres of *boro* land annually which in turn can generate a total economic benefit of BDT 18.9 million. Thus the extra benefit that can be generated as per the scenario 3 is calculated to be BDT 12.6 million per year.

Column 8 and 9 shows the total economic benefits of the proposed excavation project against a time period of 10 and 20 years, respectively. Without excavation the *beel* water of the government-owned area can provide a total benefit of BDT 63 million in 10 years and BDT 126 million in 20 year period, respectively. Against the scenario 1 with 5 feet proposed excavation the proposed economic benefit for a 10 year time period is estimated to be in the tune of BDT 126 million, while the benefit can be enlarged to BDT 252 million for 20 years. For the scenario 2 the expected economic benefit for a 10 year time period is found to be BDT 151 million and BDT 302 million for 20 years. As per the scenario 3, the benefit is BDT 189 million for a 10 years and BDT 378 million for 20 years time period.

Economic Cost of the Proposed Excavation Project

Table 4.13 shows the distribution of the expected costs of the proposed excavation project, which includes costs of excavation and setting up required irrigation infrastructure. The costs of the excavation under different scenario are calculated as the cost of local digging practice inside the *beel* for fisheries purpose. The excavation cost for a 1 feet depth is considered to be BDT 5,000 per acre, including the machinery and labor costs based on local standards. For a 5 feet excavation, the total government-owned *beel* area requires an estimated cost of BDT 12.3 million under scenario 1, while scenario 2 requires 17.2 million, and scenario 3 BDT 24.7 million.

Continuous water flow in the *Beel* Jaleshwar causes siltation problem at the bottom of the *beel*. Any excavation project requires a regular re-excavation to maintain the water level. It is understood from the key informant interviews (KII) that for 3 feet excavation is required per 5 years to hold the water depth. In column 4 of the table 4.13 the re-excavation cost is estimated based on this understanding and estimated to be BDT 0.015 million per 5 years for the total government-owned 494.211 acres of the *beel*.

Table 4.12. Excavation Scenario in Government-owned *Beel* Area and Its Economic Benefit

Scenario	Excavation (feet)	Water Depth (feet)	Volume of Water (m^3)	Area to be Irrigated for *Boro* (acre)	Possible Benefit in terms of Irrigation Water per Year (BDT million)	Additional Benefit (BDT million)	Benefits in 10 years (BDT million)	Benefits in 20 years (BDT million)
1	2	3	4	5	6	7	8	9
Status quo: no excavation	0	5	3048000	708.57	6.3	-	63	126
Scenario 1	5	10	6096000	1417.15	12.6	6.3	126	252
Scenario 2	7	12	7315200	1700.58	15.1	8.8	151	302
Scenario 3	10	15	9144000	2125.72	18.9	12.6	189	378

Source: Calculation based on primary data, 2016

Table 4.13. Cost of the Proposed Excavation and Irrigation Infrastructure

<table>
<tr><th>Scenario</th><th>Excavation (feet)</th><th>Cost of Excavation (BDT million)</th><th>Cost of Re-Excavation per 5 Years (BDT million)</th><th>Cost of Irrigation Infrastructure for 2000 acres of Land (BDT million)</th><th>Annual Maintenance Cost of Infrastructure (BDT million)</th></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>Status quo: no excavation</td><td>0</td><td>-</td><td>-</td><td rowspan="4">14.32</td><td rowspan="4">0.019107</td></tr>
<tr><td>Scenario 1</td><td>5</td><td>12.3</td><td rowspan="3">0.015</td></tr>
<tr><td>Scenario 2</td><td>7</td><td>17.2</td></tr>
<tr><td>Scenario 3</td><td>10</td><td>24.7</td></tr>
</table>

Source: Calculation based on primary data, 2016

Table 4.14. Net Benefit from Excavation Project

Scenario	Excavation (feet)	Benefits (10 years) (BDT million)	Benefits (20 years) (BDT million)	Total Cost (10 years) (BDT million)	Total Cost (20 years) (BDT million)	Net Benefit (10 years) (BDT million)	Net Benefit (20 years) (BDT million)
1	2	3	4	5	6	7	8
Status quo: no excavation	0	63	126	14.51	14.70	48.49	111.3
Scenario 1	5	126	252	26.84	27.06	99.16	224.94
Scenario 2	7	151	302	31.74	31.96	119.26	270.04
Scenario 3	10	189	378	39.24	39.46	149.76	338.54

Source: Calculation based on primary data, 2016

The cost of irrigation infrastructure is estimated (column 5) on the basis of a Bangladesh Agricultural Development Corporation (BADC) project[2] which was completed in 2007. For 115,125 acres of cultivable land, the total cost of surface water irrigation (river, *haor* and *beel*) was estimated to be BDT 824.08 million per year where per acre cost was found to be BDT 0.00716 million. For the 2000 acres of cultivable land in *Beel* Jaleshwar, an estimated amount of BDT 14.32 million is required for infrastructure development.

In column 6 of the *table 4.13*, the maintenance cost of the surface water irrigation project is calculated on the basis of another project of BADC. Under the Innovative Use of Surface Water Irrigation Project (IUSWP), activities are distributed over 4 districts under 6 zones of BADC (Deb, 2011). Kendri *Haor* Irrigation Scheme (KHIS) in Jaintapur of Sylhet is one of these. This 5 cusec LLP scheme uses Kendri *Haor* as the water source with the objective of irrigating 60 ha or 14,826.3 acres. The annual maintenance cost of this scheme is BDT 141645. On this manner, annual maintenance cost of irrigation infrastructure is calculated as BDT 0.019107 million for 2000 acres cultivable land in *Beel* Jaleshwar.

Net Economic Benefit of the Proposed Excavation Project

The *table 4.14* above shows the net economic benefit from the proposed excavation project in *Beel* Jaleshwar. Column 5 and 6 depicts the total cost of the project covering 10 and 20 years time period, respectively. Without excavation, the total cost of surface water irrigation is estimated to be BDT 14.51 million annually which includes the cost of infrastructure set up and maintenance for a time period of 10 years with a net benefit of BDT 48.49 million. For a 20 year proposed time period, this cost is found to be BDT 14.70 million, while the net benefit is estimated to be BDT 111.3 million.

[2] The project was run by the Implementation Monitoring and Evaluation Division (IMED) of the Government of Bangladesh and sponsored by the Ministry of Agriculture covering 22 districts of the country i.e. Manikgonj, Munshigonj, Narayangonj, Norsingdi, Lakshmipur, Comilla, Chandpur, Brahmanbaria, Hobigonj, Sunamgonj, Chittagong, Cox's Bazar, Kishoregonj, Netrokona, Mymensingh, Jamalpur, Barisal, Bhola, Patuakhali, Madaripur, Gopalgonj & Shariatpur. The main objective of the project was to irrigate land through surface water by utilization of 5-cusec pumps and floating pumps through double lifting.

For the *scenario 1* with 5 feet excavation, the total cost is estimated to be BDT 26.84 million for a time period of 10 years that includes estimated costs of excavation, re-excavation, irrigation infrastructure set up and maintenance. The net benefit for 10 year period is calculated to be BDT 99.16 million. Thus the total cost of scenario 1 for 20 year period is BDT 27.06 million where the net benefit is BDT 224.94 million.

For the *scenario 2* with the proposed 7 feet excavation, the total cost is set out to be BDT 31.74 million for 10 year time period, which includes costs of excavation, re-excavation, irrigation infrastructure set up and maintenance. The net benefit for 10 year period is found to be BDT 119.26 million. The total cost of scenario 2 for 20 year period is BDT 31.96 million where the net benefit is BDT 270.04 million.

Similarly, for the *scenario 3* with 10 feet excavation, total cost is expected to be BDT 39.46 million for 10 years including cost of excavation, re-excavation, irrigation infrastructure set up and maintenance. The net benefit for the 10 year period is BDT 149.76 million. The total cost of scenario 3 for 20 year period is BDT 39.46 million where the net benefit is BDT 338.54 million.

Net Present Value (NPV) from the Proposed Excavation Project

Table 4.15. NPV of the Excavation Project

Scenario	Excavation (feet)	NPV (10 years) (BDT million)	NPV (20 years) (BDT million)
1	2	3	4
Scenario 1	5	50.67	80.47
Scenario 2	7	61.13	96.85
Scenario 3	10	76.98	121.7

Source: Calculation based on primary data, 2016

The *table 4.15* shows the net present value from the proposed excavation project for a time period of 10 and 20 years, respectively. For *scenario 1*, the NPV for the 10 years time period is BDT 50.67 million, while for 20 years it is estimated to be BDT 80.47 million. Against the proposed *scenario 2*, the NPV is BDT 61.13 million and BDT 96.85 million for 10 and 20 year time period, respectively. Similarly, as per the *scenario 3*, the NPV is estimated to be

BDT 76.98 million and BDT 121.7 million for 10 and 20 years time period respectively. It can thus be concluded from the *table 4.15* by analyzing all three scenarios, a 20 year time period is found to be more preferable. Among the three scenarios, *scenario 3* is thus preferable than *scenario 1* and *2* for both 10 and 20 years time periods.

5. Conclusions

Bangladesh is gifted with as many as 26,275 wetlands which have a total area of 574,356 acres. If the government-owned wetlands can be excavated enough to store rainwater in the monsoon and use the stored water to irrigate cultivable lands in the dry season, it may solve both the problems of overflow in the rainy season and scarcity of water in the dry season of a year. In addition, this practice is expected to lessen the pressure on the over-use of groundwater for the irrigation purpose. This study proves that long term excavation projects on government-owned wetlands are more profitable than short term projects and thus can maximize social benefits. From the environmental context, this is more sustainable than to maintain waterbodies with their natural flows beyond economic gains.

This paper recommends a proposed excavation project to be implemented in the government-owned area of Beel Jaleshwar with an objective to provide irrigation water in the adjacent areas during the dry season. It can also be suggested that the maintenance of the beel should be unto the dependent community for better management.

REFERENCES

[1] Ali, L. 2002, An Integrated Approach for the Improvement of Flood Control and Drainage Schemes in the Coastal Belt of Bangladesh. A. A. Balkem Publishers, the Netherlands.

[2] BBS, 2012, *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics, Dhaka, Bangladesh.

[3] BBS, 2014, *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics, Ministry of Planning, Government of People’s Republic of Bangladesh, Dhaka.

[4] BBS, 2016, Bangladesh Bureau of Statistics, Ministry of Planning, Government of People’s Republic of Bangladesh, Dhaka.

[5] Cochran, W.G., 1977, *Sampling Techniques*, 3rd ed., John Wiley & Sons, Canada.

[6] Deb, P. K., 2011, Performance Evaluation of Selected Surface Water Irrigation Schemes of BADC, Department of Water Resources Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka.

[7] Dey, Nepal Chandra, Bala, Sujit Kumar, Islam, A K M Saiful and Rashid, Md. Abdur, 2013, Sustainability of Groundwater Use for Irrigation in Northwest Bangladesh, BRAC Research and Evaluation Division, Dhaka.

[8] Dey, Nepal Chandra, Bala, Sujit Kumar, Islam. A K M Saiful, Saha, R., Shopan, A. A. and Rashid, Md. Abdur, 2015, Environmental and Economic Sustainability of Groundwater for Irrigation, BRAC Research and Evaluation Division, Dhaka.

[9] Hossain, I., Siwar, C., Mokhtar. M. B., Dey, M. M., Jaafar, A. H. and Alam, M., 2013, Water Productivity for *Boro* Rice Production: Study on Floodplain *Beels* in Rajshahi, Bangladesh. Journal of Bio-sciences, 21: 123-136.

[10] IMED, 2011, Impact Evaluation Study of Expansion of Irrigation through Utilization of Surface Water by Double Lifting, Implementation Monitoring and Evaluation Division (IMED), Ministry of Planning, Government of the People’s Republic of Bangladesh.

[11] Jalil, M. M., 2010, Approaches to Measuring Social Discount Rate: A Bangladesh Perspective. *SSRN Electronic Journal*, Available at: https://ssrn.com/abstract=1921987.

[12] Khondoker, S., Hossain, M. L. and Moni, K. A. H., 2014, Wetland management in Bangladesh: A Study on *Beel* Bakar. Forestry and Fisheries, 3(4): 320-328.

[13] MoEF, 2008, Economic Modeling of Climate Change Adaptation Needs for Physical Infrastructures in Bangladesh, Department of Environment, Ministry of Environment and Forests, Comprehensive Disaster Management Programme, Ministry of Food and Disaster Management, Government of the People's Republic of Bangladesh, Dhaka.

[14] MoL, 2017, Ministry of Land, Government of Bangladesh, Dhaka, Bangladesh.

[15] Qureshi, A.S., Ahmed, Z., Krupnik, T.J., 2014, Groundwater Management in Bangladesh: An Analysis of Problems and Opportunities. Cereal Systems Initiative for South Asia Mechanization and Irrigation (CSISA-MI) Project, Research Report No. 2, Dhaka, Bangladesh: CIMMYT.

[16] Roypur Union Parishad, 2016, Roypur, Bagherpara, Jessore.

[17] Rahman, G. M. A., Dutta, C. B., Faruque, M. J., Sohel, M. H. and Sayed, A., 2016, Ground Water Level Fluctuation and Its Impact on Irrigation Costing at Jessore Sadar of Bangladesh. Agriculture, Forestry and Fisheries, 5(3): 37-42.

[18] WB, 2000, Performance Indicators: Agriculture, Annex 5 - Project Performance Indicators for the Irrigation and Drainage Sub-Sector, World Bank.

[19] WRC, 2010, Wetland Ecosystem Services and Their Valuation: A Review of Current Understanding and Practice, Water Research Commission (WRC), Wetland Health and Importance Research Programme, 1(9).