Valuation of Inland Wetlands: A Study on Some Selected Wetlands for the Burdwan District of West Bengal

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Abstract: *This paper deals with the economic valuation of some selected wetlands in the Burdwan district of West Bengal. In this study, we have considered wetlands under different Primary Fishermen's Co-operative Societies of the district. We have estimated indirect use values of wetland resources in terms of the environmental and ecological services it provides to support current production and consumption of fisheries. The study shows that with the reduction of wetland area caused by siltation or by eutrophication leads to a loss of consumer's surplus and producer's surplus. It also determines the reduction in the total value of selected wetlands as a result of 2% reduction in its area. The several factors underlying these results are analysed in the study.*

Key Words: Wetlands, Primary Fishermen's Co-operative Societies, Indirect use values, Indirect Valuation, Supply Function, Demand Functions, Consumer's Surplus, Producer's Surplus.

JEL Classification: Q20, Q22, Q26

1. Introduction

Wetlands are the interface between land and water and are the perpetuators of the global hydrological cycles. An estimated 6% of the land surface of the world is wetland (Bazilevich, Rodin, Rozov, 1971). The Ramsar Convention at the fourth conference of the Contracting Parties in 1990 at Montreux adopted a simple classification system of wetland types. This system recognizes thirty-five types grouped under three major categories, marine and coastal wetlands, inland wetlands and man made wetlands.

The coastal ecosystem has four major components i.e., the salt, marshes in the temperate zone, mangroves in the tropical zone; coral reefs and sea grass. Of these components the mangroves ecosystem has assumed particular significance in view of its pivotal role both from the ecological and economic points of view[3].

Mangroves now-a-days are under severe threats because of its increasing economic importance. Human and mangroves interaction is evident from the studies undertaken in various mangroves rich countries. On the other hand, most of the inland wetlands in India are directly or indirectly associated with river systems like Ganges, Brahamaputra Narmada, Tapti, Godavari, Krishna, and Cauveri.The largest inland wetlands ecosystem in India is the Gangetic Flood Plain. This is the reason that we have chosen most of the wetlands in our present study that are the parts of this Gangetic Flood Plain.

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The present paper is a part of the doctoral work of Ms. Chameli Pandit which is in progress at the University of Burdwan, West Bengal, India. The authors are indebted to Dr. Rajarshi Majumder, Dept. of Economics, University of Burdwan, for providing valuable suggestions on the use of computer packages to get the econometric results. The remaining errors, however, are the sole responsibility of the authors.

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[3] Their major environmental services include storm protection, share stabilization and control of erosion and flooding. They are also a biomass expansion and a nursery ground for marine life. On the ecological side, mangroves serve as the breeding and rearing area for wild shrimp stocks that are commercially important.

The functions of wetlands are very extensive and range from nutrient recycling, groundwater recharge, prevention of erosion, salinity control to anthropocentric functions such as providing livelihood and life support such as food, water, fish, fuel, recreation, etc. However the tragedy is that these valuable resources are threatened. Over the last fifty years, the world population has increased in developing countries. The exploitation of lands, water bodies and forests as a result of development has increased dramatically. Changes in the natural landscape occurring due to resource extraction, introduction of new and more intensive types of agricultural practices, urbanization have all influenced the conditions of wetlands. As most of the wetlands in our study are in the Gangetic Flood Plain and they are subject to heavy flooding. It has caused inflow of silt and has resulted in heavy sedimentation. This sedimentation is one of the cause of macrophytic growth and shrinkage of water area. The wetlands are a complex and fragile ecosystem. Hence, they do not have a 'self cleaning' ability and therefore they readily accumulate pollutants. The indiscriminate and heavy use of fertilizers and pesticides in the watershed areas are leading wetlands to be eutrophic. The increase in, levels of nutrients and heavy sedimentation have led to the prolific growth of aquatic plants. All these have led to shrinkage of the wetland area, a decline in biodiversity and resource base and consequently their potential to meet the needs of the people dependent of the resources. Mainly these threats to wetlands arise out of failure resulting from information, delay in implementation of policies and timely Governmental interventions.

The present study attempts to present an economic analysis, using techniques of economic valuation, to assess the loss of wetland area. Economic valuation methodology involves the monetary measure of a change in an individual's well being due to a change in environmental quality[4]. This measure is referred to as Total Economic Value (TEV, hereafter)[5]. This TEV is split into use value and non-use value[6]. Use value consists of two parts-direct use value and indirect use value. Indirect use value is determined by the contribution of resources in terms of their environmental and ecological services to support current production and consumption. This study attempts to calculate this indirect use value of wetlands, which supports fisheries[7].

The present study is based on the co-operative owned wetlands of the Burdwan district of West Bengal. Burdwan district maintains a significant balance between agriculture and industry. It is enriched with rivers like Ganges, Ajoy, Damodar and many others small rivulets. Moreover various tanks and water bodies are scattered throughout this district. These have resulted from high underground water table of the district, which may be their outcome of frequent floods that occur. The main rivers of the district are Bhagirathi[8] in the east, Ajoy and its tributaries in the north and Dwarakeshwar, Damodar and its branches in the southwest. Besides there are innumerable old beds of rivers all over the districts. These water-bodies are generally being brought under pisciculture by forming new Primary Fishermen's Co-operative Societies (PFCS, hereafter). The PFCS we have chosen for our study is a representative sample of the co-operatives in this district. Moreover, the records are well maintained in all these PFCS.

The plan of the paper is as follows. Section 2 deals with the features of the selected wetlands and the database. Section 3 considers the methodology adopted for evaluating consumer's and producer's surplus. The section also includes the results of the study followed by a brief analysis. Finally, the concluding remarks are made in Section 4.

2. Features of selected wetlands and database

There are fifty PFCS in the Burdwan district. Out of these ,fifty percent are based on tank, beels or ponds and the remaining fifty percent are based on rivers. Among the twenty five co-operatives based on these tank, beels or

[4] The change in environmental quality is the loss of wetland area in our study.

[5] For details of TEV one can refer to any standard text on Environmental Economics.

[6] Non-use value implies those benefits or losses to individuals that arise from environmental changes independently of any direct or indirect use of the environment.

[7] Wetlands in general are used mainly to promote fisheries and also to some extent for expansion of irrigational activities. For simplicity in the present paper we focus mainly on fisheries to determine the valuation of wetlands.

[8] Bhagirathi is mainly the distributary of river Ganges.

ponds, most of the co-operatives are defunct. Again some are newly formed. Due to non availability of data we are not considering these co-operatives for the present study. Seven co-operatives out of these twenty five are found to be suitable for an analysis. These seven PFCS can also be considered as a representative sample of PFCS. So the present paper deals with these seven co-operatives which are situated in the different parts of the Burdwan district of West Bengal. These seven PFCS are Nachan Matsajibi Samabay Samity, Natu Mohanpur Matsajibi Samabay Samity, Barabani Matsajibi Samabay Samity, Naliapur Matsajibi Samabay Samity, Sudpur Matsajibi Samabay Samity, Kobla Matsajibi Samabay Samity and Sri Sri Ramkrishna Matsajibi Samabay Samity.

The wetlands under various co-operatives in our study more or less suffer from the same problem. These resources are mostly affected either by siltation or by eutrophication, or from both. Mostly the wetlands that are in the Gangetic Flood Plain suffer from heavy siltation that are the resultant of frequent flood. Moreover due to poor infrastructure facility and lack of proper embankment, fish from the water bodies move out with the flow of water. This scenario is found not only in the heavy flood season but also at the time of moderate rainfall. Also this prolific growth of aquatic plant is so highly deep rooted that it cannot be cleared by netting. It creates bushes and shrubs at the middle of some wetlands in our study. All these factors lead to a reduction of wetland area. Moreover these bushes and shrubs, which appear at the middle of wetlands, create difficulties at the time of fish catch. This results in heavy fall of fish catch. The present study attempts to evaluate these losses and measures the reduction of both consumer and producers surplus.

In this study we want to estimate the supply and the demand functions for fish and hence to estimate the gain or loss in producer's and consumer's surplus due to a change in wetland area. The purpose is to determine indirect valuation of wetlands on the basis of change in producer's and consumer's surplus. The data set for estimating the supply function has been obtained directly from the records of the co-operatives. However the data for estimating the demand function has been obtained from the fish market. These data have been obtained from the year 1990 to 2003.

3. Methodology and the results

The theoretical model is based on the work of Sathirathai (1998) and Barbier and Sathirathai (2001). They have estimated the changes in consumer's and producer's surplus associated with increase in the areas of mangroves. Increase in the areas of mangroves implies increase in the area of coastal wetlands. However the present paper attempts to focus on the valuation of inland wetlands instead of coastal wetlands. For this we have estimated the consumer's and producer's surplus as a result of decrease in wetland areas[9]. As our study is based on co-operatives we assume that the property right is defined for each of the PFCS. Each PFCS can be considered as a firm in a perfectly competitive market.

The main objective of the price-taking firm is

$$\text{Max} \quad p\, f(E, M) - c\, E \tag{1}$$

where p=price, E=human effort defined as the number of labours used for catching fish in a year (mandays\year), M=wetland area (acre), which is taken as exogenous in our study. c is the unit cost of effort (Rs.)

We assume a Cobb Douglas production function and it is written as

$$Y = f(E, M) = m\, E^a M^b \tag{2}$$

where Y is the amount of fish catch (kg./year).

The duality of profit maximization is the minimization of cost of effort. So we minimize c E subject to $Y = m\, E^a M^b$ and for this we set up the Lagrangean expression as follows:

[9] From the survey, it is found that wetland areas have been reduced either due to siltation of for eutrophication. So we have considered reduction in wetland area (instead of its increase) in our study.

$$L=cE+ \lambda (Y-mE^aM^b) \quad (3)$$

where λ is the Lagrangean multiplier.

Differentiating the Lagrangean expression with respect to the effort variable and the Lagrangean multiplier we get:

$$(\delta L/ \delta E) = c- \lambda maE^{a-1}M^b = 0 \quad (4)$$

$$(\delta L/ \delta \lambda)= Y-m E^a M^b = 0 \quad (5)$$

From equation (5), we get $E = [Y/m M^b]^{(1/a)}$

which yields the cost function: $C (c, Y, M) = c\, m^{(-1/a)} Y^{(1/a)} M^{(-b/a)}$ (6)

Since we have considered each co-operative as a price taking firm, we can equate P with marginal Cost i.e., P= MC. This can be considered as the (measure of) supply function of the firm[10].

Thus, $P = MC= (\delta C/ \delta Y) = (c/a)\, m^{(-1/a)} M^{(-b/a)} Y^{\{(1-a)/a\}}$ (7)

Since the co-operatives in our study has some distinct features, we have used fixed effect model of Panel data analysis for estimating the supply function. On the basis of the regression results related to the fixed effect model we can estimate the individual effect of the co-operative, which is fixed, but unknown. It has been mentioned earlier that there are some common problems facing most of the wetlands under various co-operatives. Apart from that, there may be some problem, which is specific to the individual co-operative. These problems may arise from mismanagement of the co-operatives, poor infrastructure, lack of capital, inefficiencies, etc. To capture all these effects, we have considered fixed effect model of Panel data analysis. Under panel analysis equation (7) can be written as

$$\ln MC_{it} = \ln [(c/a)\, m^{(-1/a)}]_i +[(1-a)/a]\ln Y_{it}+(-b/a)\ln M_{it}$$

$$i=1,2,\text{-------}7 \;\&\; t=1,2,\text{----------}32 \quad (8)$$

Here the individual effect is captured by the constant term i.e.,

$\ln[(c/a)\, m^{(-1/a)}]_i$ which is taken to be constant over time 't' and specific to the individual cross-section unit[11].

For calculating equilibrium price and output, we require the demand function[12]. In our study, we have considered an iso elastic demand function of the form $Y=\alpha P^{-\beta}$. The corresponding inverse demand function is

$$P = \alpha^{(1/\beta)} Y^{-(1/\beta)} \quad (9)$$

The regression demand equation is

$$\ln P_t = \ln (\alpha^{1/\beta}) +(-1/\beta) \ln Y_t \quad (10)$$

For evaluating equilibrium output, we have equated equations (8) and (10)

i.e., $\ln (\alpha^{1/\beta}) +(-1/\beta) \ln Y_t = \ln A_i +[(1-a)/a]\ln Y_{it}+(-b/a)\ln M_{it}$ (11)

where $A_i = (c/a)\, m^{(-1/a)}$

[10] In perfect competitive market we know that for estimating supply function we equate price with marginal cost, which is a function of output. So we actually get P = MC (Y) or P = f (Y).It implies inverse of supply function.

[11] Our time period is from the year 1990 to 2003 for the individual co-operatives. This implies that under panel data analysis, we have all total 98 observations. However the negative values of marginal cost are ignored. The reason is that equation (8) is in terms of natural logarithm. Thus after ignoring negative values of marginal cost we have all total thirty-two observations.

[12] Here we are neglecting the problem of simultaneity for estimating demand and supply functions. Although the time period is same but due to negative values of MC some of the time point is dropped. So we are not getting the same time point for estimating the simultaneity problem.

The equilibrium output evaluated from equation (11) is the initial value of equilibrium output. Once we know equilibrium output we can determine equilibrium price from equation (7) or equation (10). Similarly the changed supply function caused by reduction in wetland area can be estimated. Let the regression equation for the changed supply function is

$$\ln MC'_{it} = \ln [(c/a)\, m^{(-1/a)}]'_i + [(1-a)/a] \ln Y'_{it} + (-b/a) \ln M'_{it} \qquad (12)$$

Equation (12) is estimated by changing [13] the value of wetland areas, other values of the variables remain the same.

Therefore the final values of equlibrium price and output can be estimated by equating equations (10) and (12).

The regression results of the supply functions in both the situations i.e., before and after the change in wetland area are given respectively in Tables 1 and 2.

Table1: Regression Results before the change in wetland area.

Independent Variables		R^2	F-statistics
lnY	lnwa		
0.504 (1.760289)	-0.622 (-0.970148)	0.77	78.03
Fixed Effects			
Nachan	4.817		
Natu	7.485		
Barabani	6.798		
Naliapur	5.588		
Sudpur	6.028		
Kobla	9.492		
Ramkrishna	7.669		

Note: Dependent variable ln MC. Figures in parentheses are the values of t-statistics.
wa is the wetland area. ln represents natural log.

From the regression results we see that the amount of fish catch is positively related with the marginal cost and is significant at 5% level of significance. However the case is opposite in case of wetland area. The wetland area is negatively related to marginal cost and is insignificant at a high level of significance. The result implies that if we want to increase fish catch from a given wetland area, we have to increase cost. Unless and until we put more input to a given wetland area volume of fish catch cannot increase. This requires increase in costs. Moreover from the results it also follows that when wetland area decreases marginal cost increases in order to increase fish catch. When wetland area decreases it requires more attention for proper maintenance of the resources. To get the same volume of fish catch the co-operatives have to expend more.

Here also we get the same results. That is fish catch is positively related with the MC and is significant at 5% level of significance. However wetland area is negatively related with the MC and is insignificant even at a high level of significance.

From the numerical figures of fixed effects of both the Tables we find that there is not much difference between the two situations. Hence in our study we are ignoring these differences between the two situations. Therefore the supply functions in both the situation starts from the same point as relevant from the figure1.

Table2:Regression results after reduction in wetland area

Independent Variables		R^2	F-statistics
lnY	lnwa		

[13] Here we have considered 2% reduction of wetland area.

0.513 (1.823)	-0.610 (-0.968)	0.779	81.208
Fixed Effects			
Nachan	4.711		
Natu	7.346		
Barabani	6.770		
Naliapur	5.501		
Sudpur	5.927		
Kobla	9.344		
Ramkrishna	7.536		

Note: Dependent variable ln MC. Figures in parentheses are the values of t-statistics.
wa is the wetland area. ln represents natural log.

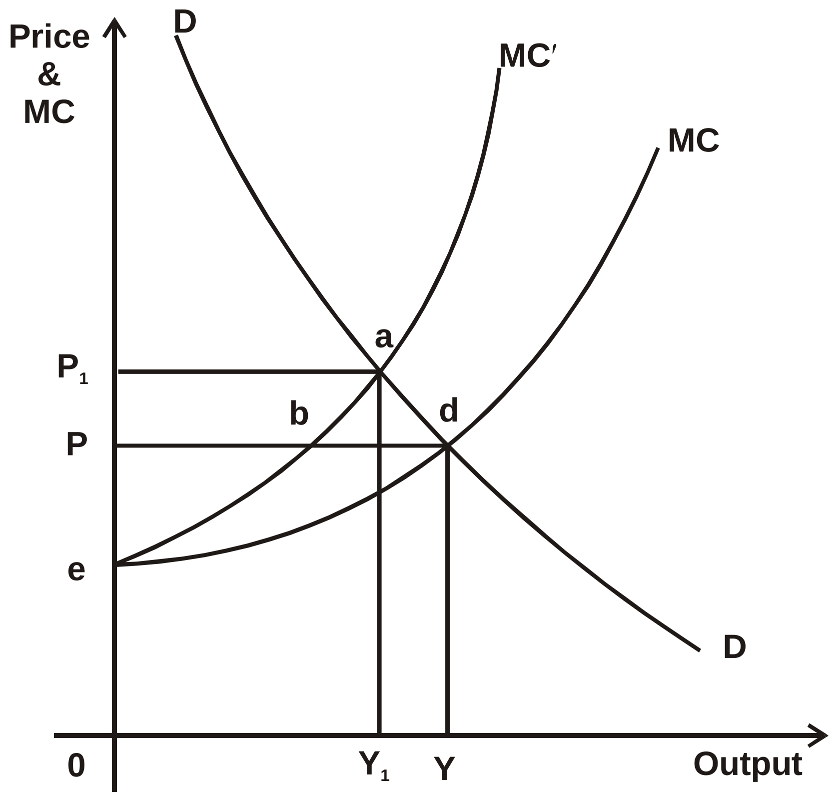

Fig. 1

The estimated demand function[14] is shown in Table 3.

Table3: Estimated results of the demand function

Independent Variables	Values of the coefficient	Standard error	Values of the t-statistics	R^2
Constant	3.243	.066	49.399	.765

[14] The estimated demand function is common for all the PFCS as the demand for fish comes from the consumers side which is independent of the wetland area. Demand function is estimated by using the SPSS software.

LnY	-.06891	.011	6.249	

Dependent variable is ln P.

From the regression result of the demand function, we see that both the independent variables are significant at 1% level of significance. Amount of output is negatively related with the price of fish catch in the market.

In figure1, net loss of consumer's and producer's surplus are given respectively by the area abd and ebd.

The calculated values of consumer's and producer's surplus are given in Table 4.

Table 4: Values of changes in consumer's surplus(CS) and producer's surplus(PS) for different co-operatives.

Name of the Co-operatives	Values of change in CS (Rs.)	Values of change in PS (Rs.)	Total values (Rs.)
Nachan	-.04	-6.08	-6.12
Natu	-0.0007	-0.035	-0.0357
Barabani	-0.000014	-0.0092	-0.009214
Naliapur	-0.0045	-1.12	-1.1245
Sudpur	-0.0072	-0.68	-0.6872
Kobla	-0.000015	-0.00039	-0.000405
Ramkrishna	-0.00065	-0.024	-0.02465

From Table 4, we see that all the changes of consumer's and producer's surplus are negative. The last column of Table 4 implies the value that one may attach to a reduction in 2% wetland area. For example a 2% reduction in wetland area under Nachan PFCS leads to a reduction in its value by Rs.6.12. This implies that with the reduction of wetland area both the producers and consumers are losing their surplus values. It is true that with the reduction of wetland area the environmental carrying capacity of fish stock decreases. Moreover the bushes and shrubs of aquatic plant also reduce the total volume of fish catch. Apart from this, poor infrastructural facilities hamper the growth of fish stock. All these factors lead to a total reduction of fish catch. This reduction of fish catches lead to a total loss of consumer's as well as producer's surplus.

4. Concluding remarks

From the above analysis, it can be said that wetlands are treated as the medium of fish production. From the regression results, we see that the impact of wetland area is insignificant for fish production. The fishermen are not utilizing these resources effectively. Lack of proper infrastructure, insufficient capital, lack of initiative ness, improper management, etc. are the several factors behind this insignificant result. These resources should be managed properly before utilizing these resources as an input for fish production. This requires participatory development involving local people and other stakeholders related to these wetlands. Unless and until the stakeholders realize the importance and various functions of the wetlands, it is impossible to manage these resources. Desilting of pond and proper embankment are the immediate action needed for effective utilization of these resources. Renovation of the water bodies should be done at a certain time interval. Agriculturists who cultivate their land in the surrounded water bodies should minimize the use of chemical fertilizers and pesticides. This can only control the growth of weeds.

With the adoption of Tenth Five Year Plan Government has drawn attention towards these resources. With the implementation of '*Sampoorna Grameen Rozgar Yojana*' many wetlands in Haryana are under the process of renovation. If this is applied in West Bengal, then through proper management, the problems related to poor infrastructure for fishing activities can be solved.

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