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Fish Biodiversity and Economic Performance of Fish Catching in *Dekhar Haor:* A Case Study of Sunamganj District, Bangladesh

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Abstract: *The study was intended to analyze the fish biodiversity and economic performance of fishing in Dekhar haor of Sunamganj district, Bangladesh. During the study period, 84 species of fish fauna under 30 families were recorded. Overall, value of Shannon-Wiener diversity (H), Simpson's diversity (D) and Simpson's Reciprocal index (1/D) were found 2.041, 6.290 and 6.369 respectively indicating a greater diversified area. The results of the cost and return indicated that the fishermen spent almost half (48.56%) of their total cost for purchasing fishing gear which was accounted Tk. 93056.06 per season. It appeared from the profitability analysis that, per season gross return and net profit from all species were Tk. 74779.25 and Tk. 55616.25, respectively for small-scale haor fishing. BCR was 3.90 for fishing which indicated that the haor fishing was profitable and expected to continue. Fishermen were faced with several constraints among which flash food was marked as a serious problem in this study area.*
Keywords*: Fish biodiversity, Haor area, Profitability.*

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I. Introduction

The *haor* areas of Bangladesh are blessed with huge potential of fisheries resource with aquatic biodiversity. It has considerable economic and aesthetic value which greatly influencing the ultimate environment quality in a diversified way. *Haors* are the combination of floodplains and beels which go under water in monsoon and in the dry season the beels are isolated from the floodplains [1]. In Bangladesh, there are 96 *haors* covering an area of 1, 92,367 hectares located here and there, mostly lie in the district of Kishoregonj, Netrakona, Kushtia, Habigonj, Sunamganj, Moulvibazar and Sylhet district of Bangladesh [2]. In greater Sylhet, most prominent *haors* are Saneer *haor*, Hail *haor*, Hakaluki *haor*, Dekhar *haor*, Maker *haor*, Chayer *haor*, Tanguar *haor* and Kawadighi *haor* [3]. Dekhar *haor* has a remarkable importance on fish production, retaining fish biodiversity, meeting local and national demand for fish protein and serve as a good source of fish seed supply for other adjacent water bodies. These qualities are responsible for high yield and considerable increase in fish production. It is noteworthy that, total fish production in Bangladesh surges from 35.48 to 37.03 lakh metric ton between the year 2014 and 2015, respectively [4]. Moreover, Bangladesh is the third ranking country in Asia after China and India regarding fish production [5]. About 1.2 million people directly and another 12 million people are indirectly earned their livelihood from fisheries sector [6]. Notably, fishing community who are living hand to mouth are considered as the poorest of the poor [7]. Being an isolated community, these people are deprived from many amenities of life [8]. Additionally, *haor* is gradually silted up due to flash flood and other man-made causes and overfishing is one of the common phenomena in this area [9]. Considering all the circumstances, research related to biodiversity and fish catching is essential for proper fisheries resource management. Therefore, the present study was carried out to achieve the following objectives:

1) To know the current fish biodiversity and relative change of fish biodiversity in Dekhar *haor;*
2) To determine the costs and returns in open water fishing in the study area; and
3) To identify the problems faced by fishermen and make some policy recommendation for better fisheries resource management.

II. Materials And Methods

2.1 Selection of the study area

Dakshin Sunamganj upazila under Sunamganj district was selected purposively. The study areas included the three villages namely *Noapara*, *Jolklols* and *Kaikker* par for collecting the necessary information which lies between latitude 24°34´N to 25°12´N and longitude 90°56´E to 91°49´E. The total area of the Dekhar *haor* is about 11514.6 hectares and is made up of 36 small, medium and large interconnecting beels, canals, rivers, and croplands [10]. For the investigation, simple random sampling technique was applied for profitability analysis and following purposive sampling technique was initiated for getting the information related fish biodiversity through direct interview. Thus, a total 80 sample fishermen were included in this study.

2.2 Data Source and Acquisition Method

A questionnaire survey, Focus Group Discussion (FGD) and Key Informant Interview (KII) were performed for collecting the primary data. Secondary data sources like reports, publications, handouts, etc. relevant to this study were also checked.

2.3 Analytical Technique

Species Diversity Index (H)

The measures of species diversity, the Shannon index [11], H were calculated.

$$H = -\sum_{i=1}^{S} P_i \ LnP_i$$

Where, P_i is the proportional abundance of its species such that P_i = n/N, n is the number of the individuals in the species and N is the total number of the individuals of all species in the community i.e. P_i is the fraction of the entire population made up of species, i. Here, H = The Shannon diversity index, S = Numbers of species encountered, **Σ** = Sum from species i to species S.

Simpson's Diversity Indices

Simpson's Diversity Index is another measure of diversity. In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the abundance of each species [12]. Simpson's Index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). There are two versions of the formula for calculating D, either is acceptable, but be consistent. The value of D ranges between 0 and 1.

$$D = \sum \left(\frac{n}{N}\right)^2$$

$$D \frac{\sum n\,(n-1)}{N(N-1)}$$

Where,

n= Total number of organism of a particular species

N= Total number of organism of all species

2.4 Profitability Analysis)

Gross Return (GR)

Gross return was calculated by multiplying the total volume of output of an enterprise by the average price of that enterprise during harvesting period [13].

$$GR_i = \sum_{i=1}^{n} Q_i P_i$$

Where, GR_i = Gross return of i-th product in Tk.;
P_i = Selling price of i-th product in Tk.; and
Q_i = Quantity of i-th product per Kg.
i =1, 2, 3…………………….…. n

Net Profit (NR)

Net profit was calculated by deducting all costs (Variable cost and fixed cost) from the gross return. To estimate the relative profitability of different agricultural enterprise profit equation of the following algebraic form was used:

$$\pi = \sum_{i=1}^{n} (P_i\,.Y_i) - \sum_{i=1}^{n} (P_{X_i}.X_i) - TFC$$

Where,

π = Profit
Y_i= Quantity of the i-th produces;
X_i= Quantity of i-th input;
i =1, 2, 3……. n (number of times)
P_{Y_i}= Price per unit of the i-th produces;
P_{X_i}=Price per unit of the i-th input;
TFC=Total fixed cost; and

Benefit Cost Ratio (BCR)

The benefit cost ratio is relative measure which was used to compare benefit per unit of cost. BCR was estimated as a ratio of gross return and gross costs. The formula of calculating BCR (Undiscounted) is shown below:

$$BCR = \frac{GR}{TC}$$

Where,

GR= Gross return; TC=Total cost.

2.5 Constraint Facing Index

Constraints faced by fishermen in the study areas were measured by using structured questionnaire. The fishermen were asked to give their opinion on 8 selected constraints which were identified during data collection period. A four point rating scale was used for computing the constraint score of a respondent. For each constraint score of 3, 2, 1 and 0 was assigned to indicate the extent of constraint as high, medium, low and not at all, respectively. The total constraint scores were computed for each respondent by adding his scores for all the constraints.

The Constraint Facing Index (CFI) was computed using the following formula [14].

$$CFI = (C_h \times 3) + (C_m \times 2) + (C_l \times 1) + (C_n \times 0)$$

Where,

CFI = Constraints Facing Index;

C_h = Number of respondents having high constraints;

C_m = Number of respondents having medium constraints;

C_l = Number of respondents having low constraints; and

C_n= Number of respondents having no constraints.

III. Result and Discussion

3.1 Present fish biodiversity of Dekhar *haor*

During the study period, 84 species of fish fauna under 30 families were recorded. Among them, 12 species of carps, 24 species of catfishes, 11 species of barbs and minnows, 3 species of clupeids, 2 species of snakeheads, 5 species of eels, 13 species of perches, 2 species of feather backs, 3 species of loaches, and other miscellaneous 3 species including shrimp mainly *Macrobrachium rossenbergii* and *Macrobrachium malconsonii* and *Macrobrachium sp.* were recorded.

Table 3.1: Computation of Shannon and Simpson's Diversity Indices

Group	Number of individual species	P_i	P_i^2	$Ln\ P_i$	$P_i \ln P_i$
Cat fish	24	0.286	0.082	-1.251	-0.358
Perches	13	0.155	0.024	-1.864	-0.289
Carp	12	0.143	0.020	-1.944	-0.278
Barbs and Minnows	11	0.131	0.017	-2.032	-0.266
Snakehead	5	0.059	0.003	-2.830	-0.167
Eels	5	0.059	0.003	-2.830	-0.167
Clupeids	3	0.036	0.001	-3.324	-0.119
Loaches	3	0.036	0.001	-3.324	-0.119
Feathers back	2	0.024	0.0005	-3.730	-0.090
Miscellaneous	6	0.071	0.005	-2.645	-0.188
Total	84	1.000	0.157	-25.774	-2.041

Indices	Computed Value
Shannon Diversity Index (H)	2.041
Simpson's Indices $D = \sum \left(\frac{n}{N}\right)^2$	0.157
Simpson's Index of Diversity (1 – D)	0.843
Simpson's Reciprocal Index (1 / D)	6.369

Shannon Diversity Index

The Shannon diversity index (*H*) is another index that is commonly used to characterize species diversity in a community. Like Simpson's index, Shannon's index accounts for both abundance and evenness of the species present. The proportion of species *i* relative to the total number of species (p_i) is calculated, and then multiplied by the natural logarithm of this proportion (ln p_i). The resulting product is summed across species, and multiplied by -1 [15].

$$H= -\{-0.358+(-0.289)+(-0.278)+(-0.266)+(-0.167)+(- 0.167)+(- 0.119)+(- 0.119)+(- 0.090)+(- 0.188)\}=2.041$$

The Shannon diversity index (H) is 2.041. Converting the Shannon diversity index to effective number of species or true diversity gives exp (2.041) = 7.698 effective species. As the community is not perfectly even (i.e., different probability frequencies of each species), there exist dominance. The greater the dominance, the greater the diversity When there is a degree of dominance, the Simpson effective number of species (6.369) will be less than the Shannon effective number of species (7.698).

Simpson's Diversity Indices (D)

The term 'Simpson's Diversity Index' can actually refer to any one of 3 closely related indices. Simpson's Index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). There are two versions of the formula for calculating D, either is acceptable, but be consistent.

$$D= (0.082+0.024+0.020+0.017+0.003+0.003+0.001+0.001+0.0005+0.005) =0.157$$

With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity. Table 3.1 shows that, D = 0.157 which is very near to 0 representing a bigger diversity in that community.

Simpson's Index of Diversity (1 – **D)**

The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. This makes more sense. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different species. Here, the Simpson's Index of Diversity (1 – D) is 0.843 which nearly approaches to the unity confirming a greater diversity on that area.

Simpson's Reciprocal Index (1 / **D)**

The value of this index starts with 1 as the lowest possible figure. This figure would represent a community containing only one species. That is, the higher the value, the greater the diversity. The maximum value is the number of species (or other category being used) in the sample. Our calculation gives a numerical value of 6.369 which again establishes the substantiality of diversification.

3.2 Cost Associated with *Haor* Fishing

Generally, in *haor* area, fishermen catch fish six months in a year. But for simplicity's sake here total production means the amount of fish catch in six months. Fishing costs are distinguished as fixed and variable cost. The capital investment pattern of *haor* fishing presented in table 3.2.

Food cost

Food cost was considered as variable cost and it is important in small-scale *haor* fishing. Food cost means that cost which was spent in the fishing time to survive the fishermen. The per season average food costs were Tk. 2795.70 which accounted 14.59% of total cost.

Table 3.2: Item wise cost incurred by fisherman/Season

Item wise cost	Taka/Season	% of total
Variable cost		
Food cost	2795.70	14.59
Fishing gear	9305.06	48.56
Bait cost	410.13	2.14
Maintenance and miscellaneous cost	2313.0	12.07
Total Variable Cost (TVC)	14823.89	77.36
Fixed cost		
Boat cost (Depreciation)	1894.39	9.89
Lease value	2000.0	10.44
Interest on operating cost	444.72	2.32
Total Fixed Cost (TFC)	4339.11	22.64
Total Cost (TVC+TFC)	19163.0	100.0

Fishing gear

The survey result showed that about 70% fishermen used current net, 7.5% was used cast net, 6.25% was used push net (*thela jal*) 3.75% was used lift net *(chatka jal)* and only 7.5% used hook and lime for fishing and 100% fisherman use boat during fishing (Table 3.3)

Table 3.3: Fishing assets of the fishermen in the study area

Type of gear	No. of respondent	Percentage
Current net	56.0	70.0
Lift net	3.0	3.75
Cast net	6.0	7.50
Push net	5.0	6.25
Hook and lime	6.0	7.50
Fishing trap	4.0	5.0
Total	80.0	100.0

Most of the fishermen invested their large portion of capital in purchasing fishing gears. The average amount of investment in purchasing fishing gear were calculated at Tk. 9305.06 per season and it accounted for highest cost for fishermen which is almost half of their total investment which was 48.56% of total cost (Table 3.2).

Cost of bait

Bait is used in hooks as a feed to catch fish. Bait is an important item for *haor* fishing. Small shrimps and *Kecho* (Earth warm lubricous terrestris) were generally used as bait in fishing. Average bait cost of fishermen who used hook and lime for fishing were calculated Tk.410.13 per season and which constituted 2.14% of the total cost for fishing.

Maintenance and miscellaneous cost

Maintenance and miscellaneous cost involved regular and preventive care to reduce deterioration of boat, net its economic life. These two items were grouped together because in practice, it is difficult to separate them. Maintenance and miscellaneous cost was exceptionally higher for fishing and accounted for 12.07% of the total cost and accounted for Tk. 2313 per season.

Boat cost

In calculating boat cost (depreciated), the straight-line method was used. According to straight line method, depreciation equals the difference between the purchase price and the salvage value of boat, divided by their economic life. The average estimated cost of depreciation was Tk. 1894.39 per season for fishing which constituted 9.89% of the respective total costs.

Lease value of *jolmohol*

There are two fishing societies in the study area for *Ashamelachunni beel* and *Gojamoni beel* and number of member of these beel were 36 and 26 respectively. The fishermen leased in a specific area of those beel for a period in condition to pay a fixed portion of money from the government by fishermen society. Lease value of *Ashamelachunni bee*l was Tk. 530700 for 5 years and Tk. 35000 for *Gojamoni beel* for 1 year. Most of the fishermen were engaged in fishing in mid-January to mid-April and their cost for lease value is calculated Tk. 2000 per fishermen (Table 3.2).

Interest on operating cost

Interest on operating cost was computed at the rate of 12 percent for a year. It was assumed that if the owner of a farm borrowed money from micro credit institutions, it would have paid interest at the above mentioned rate.
Interest on operating capital formula can be written as follows:
Interest on operating capital (IOC) = AI × i × t

Where,

AI = Total Investment/2;
i = Interest rate which was assumed at 12 percent; and
t = Length of the period of fishing (6 months).

The period of fishing was considered six months in a year. The interest means the average operating costs over the period as all the costs were not incurred at the same time; rather these were used throughout the fishing period from beginning to the end. Table 3.2 shows that the estimated costs were Tk. 444.72 for each fishermen which contributes 2.32% of total cost.

Total Cost

The average total cost accounted Tk. 19163.0 per season under small-scale fishing in *Dekhar haor* of Sunamganj district.

3.3 Total Catch per Boat per Month

The catch varies with the types of gear (net) used. These variations also depend on the nature of the gear itself and how it is used and the number of hours spent at *haor*. Table 3.4 shows that per month species-wise fish catch was maximum in Puti followed by Taki which was 22.44 kg/month and 17.56 kg/month, respectively. The lowest amount of fish catches by the fishermen was Baim which accounted for 3.64 kg/month and it was because due to reduction of mud in *haor* area.

Table 3.4: Species wise average amount of fish catch by fisherman /Month

Sl. No.	Name of the fish species	Quantity (Kg)	Price (Tk./kg)	Total Return (Tk.)
1.	Veda *(Nundus nundus)*	13.13	217.5	2855.78
2.	Puti *(Putius ticto)*	22.44	64.0	1436.16
3.	Tengra *(Mystus vittatus)*	13.76	216.08	2973.26
4.	Taki *(Channa punctate)*	17.56	54.37	954.74
5.	Baim *(Macrognathus aral)*	3.64	280.13	1019.67
6.	Escha *(Macrobrachium indella)*	10.85	223.25	2422.26
7.	Chela *(Chela bacaila)*	5.11	156.88	801.66
All Species/Month		86.49	144.10	12463.53
All Species/Season		518.94	144.10	74779.25

Gross Revenue

Total return consisting of revenue from fishing was calculated by multiplying the total catch by their respective prices. Table 3.4 presents the costs and returns of *haor* fishing under different technologies. The average per month and per season gross return from all species was found Tk. 12463.53 and Tk. 74779.25, respectively.

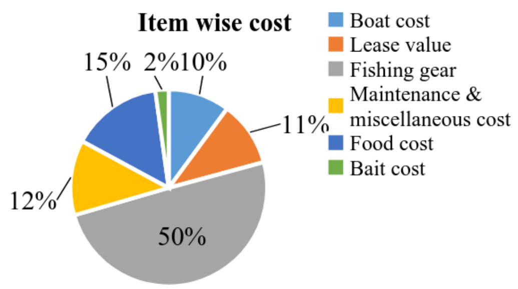

Figure 3.3: Item wise cost incurred by fisherman/season

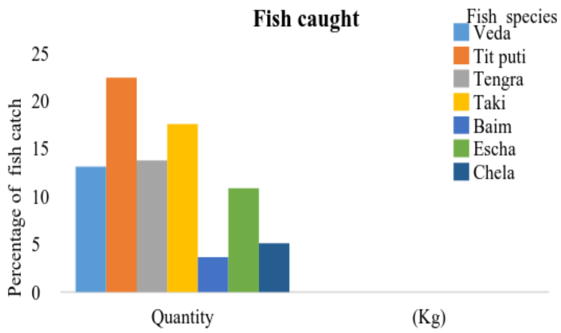

Figure 3.4: Species wise average amount of fish catch by fisherman/month

Net Profit

Net profit was calculated by deducting all costs from total returns. Net profit earned by fishermen was Tk. 55616.25 under different fishing gears. It may be noted here that gross revenue, net profit and rate of return on operating investment (RROI) were found 4.33 returns on operating investment (BCR) were found 3.90 and it means the fishermen earned four times than their investment.

Table 3.5: Cost and return of *haor* fishing per season

Cost and return	Taka/Season
Gross return/revenue	74779.25
Total cost	19163.0
Net profit	55616.25
Rate of return on operating investment (RROI)	4.33
Rate of return on capital investment (RRCI)	39.47
Benefit Cost Ratio (BCR)	3.90

$$\text{Rate of return on operating investment } (RROI) = \frac{Gross\ \ revenue}{Operating\ \ capital}$$

$$\text{Rate of return on capital investment } (RRCI) = \frac{Gross\ \ revenue}{Depreciation}$$

Operating capital = Total Cost-Depreciation

=Tk. (19163.0-1894.39)

=Tk. 17268.61

3.5 Constraints Faced by the Fishermen

The problems related to fishing were poor communication and transportation facilities, flash flood, lack of marketing facilities, lack of scientific knowledge and technology, low price of fish, lack of capital, high price of fishing gear and lack of institutional credits. These problems are structured through the Constraint Facing Index (CFI) below:

Table 3.6: Constraints faced by the fishermen in Sunamganj

Constraints	Extent of constraints faced by the fishermen				CFI	Rank
	High (3)	Medium (2)	Low (1)	Not at all (0)		
Inadequate capital	41	17	15	7	172	3
High price of fishing gears	9	38	20	13	123	6
Flash flood problem	55	16	6	3	203	1
Lack of marketing facilities	10	30	20	20	110	7
Lack of transportation and communication facilities	47	25	5	3	196	2
Lack of scientific and technological knowledge	20	29	22	9	140	5
Low price of fishes	31	23	19	7	158	4
Lack of institutional credits	20	21	5	4	107	8

Majority of the fishermen opined that the flash flood problem suffered them badly ranked by 1st major problem with CFI score 203. Lack of transportation and communication facilities was another foremost problem faced by the *haor* fishermen. The CFI for this problem was calculated at 196 which ranked as 2nd problem. Inadequate capital seemed one more problem with CFI score 172 (3rd rank) for the fishermen followed by 4th rank problem low price of fishes (CFI score 158). Other problems like lack of scientific and technological knowledge, high price of fishing gear, lack of marketing facilities and lack of institutional credits were ranked as 5th (CFI score 140), 6th (CFI score 123), 7th (CFI score 110) and 8th (CFI score 107), respectively.

IV. Concluding Remarks

This study confirms that fish production in the study area is economically rewarding (four times) and profitable. It might create employment, augmenting income and improving the standard of living of *haor* fishermen. Moreover, this study area is highly diversified with some effective species. Despite these norms, some initiatives i.e., use of illegal fishing gear like current net, fishing by complete dewatering, and use of pesticides in agricultural production must be banned for increasing the richness of fish biodiversity. Otherwise, the declining biodiversity might negatively affect the probability of fishing. Construction of a permanent embankment might help the fishermen to overcome the flash flood problem to enhance the sustainable livelihood based on *haor* fishing.

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