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An Economic Study on Small Scale Marine Fishing in Teknaf of Cox's Bazar District of Bangladesh*

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〈Abstract〉

This study was designed to determine cost/return structures and economic efficiency of small scale marine fishing of the selected gears in Bangladesh. To achieve these objectives a total of 90 fishing units(firms) of which 30 gill net, 30 roke net and 30 set bag net fishing firms were selected. Data were collected from the boat owners and fishermen for the period of one year. The findings of the study revealed that the

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selected fishing gears were highly profitable. The annual profits of gillnet, roke net and set bag net were found to be Tk. 111,022, 75,525 and 147,241 for the selected gears. It is concluded that set bag net fishing was more profitable compared to the other two gears. Cobb-Douglas production function analysis revealed that the most of the explanatory variables included in the model were statistically significant and had positive effect in increasing revenue from fishing business.

Key Words: Marine Fishing in Bangladesh, Profitability, Fishing Gears, Gill, Roke and Set Bag Net

Ⅰ. Introduction

Bangladesh is an asian country which is located at the northern end of the Bay of Bengal between latitudes 20°34' and 26°38' north and longitudes 88°01' and 92°41' east. Bangladesh is endowed with vast marine, coastal and inland waters. The inland water area of Bangladesh is 4,337,690 ha and coastline is about 480 km long along the north and northeast part of the bay of Bengal(BBS, 1999). The nation's Exclusive Economic Zone(EEZ) extends 320km out of the sea from the coastal line. Bangladesh therefore has great fisheries potential.

The availability of sunlight, water temperature and other essential environmental components appears to be favorable for fisheries in Bangladesh. A fish that takes 3 to 5 years to reach a certain size in europe requires only one year in Bangladesh to attain the same size. Nevertheless, the annual production of fish in Bangladesh is only 162.2 thousand tons between 1998 and 1999. Per capita annual consumption of fish has slightly increased from 11.7kg between 1962-63 to 12.12kg in 1998-99. But per capita annual consumption of fish is lagging behind the required amount of 36.5kg per head per year(Islam, 2000 and Haque, 2000). Bangladesh government and other concerned organizations therefore began to pay

attention to augment the marine fish production. As a result, the country's total production of fish was increased to 2,102 thousand tons of which 1,756 thousand tones from inland sources and 346 thousand tons from marine source in 2004(FAOSTAT, 2005/06).

Fisheries sector is important from economic point of view. This sector contributes significantly to export earnings, employment generation, poverty alleviation and overall economic development of Bangladesh. The magnitude of contribution of the fisheries sector to the GDP and national income is 6% and 4.92% respectively(DOF, 2005). It generates 5.71% of total foreign exchange earnings(GOB, 2005). Export earning from frozen shrimp and fish was Tk. 2,572[1)] thousand million during 2004/05(DOF, 2005). Most of these earnings were shared by small-scale marine fisheries. Fisheries sector provides full time or part time employment to about 12 million people of the total population(GOB, 2005). About 1.4 million fisheries personnel are involved in fishing and fishing related profession in Bangladesh, out of which 55% are involved in freshwater fisheries and 36% in marine fisheries. This sector is also important from nutritional point of view. The increased demand for fish is due to the increase in population and the shortage of livestock products like milk, meat and egg. Thus, millions of people suffer from acute shortage of animal protein in their diet. Due to the shortage of livestock product, fisheries sector supply 60% of animal protein. Fish is also rich in high quality protein and essential minerals. As an important source of protein and other nutrient, inland water fisheries as well as marine fisheries can significantly contribute to fulfill the nutritional requirement of the people with its increased production.

In all respects, small scale marine fisheries is getting more importance for three reasons. Firstly, a large number of people depend on small scale marine fishing and fish industry. Secondly, as an important source of protein this sector have been significantly contributing to the nutritional

1) US$ 1 = 68.77 Taka (Bangladesh currency), dated on November 11, 2008.

requirements of the people. Thirdly, Bangladesh earns a good amount of foreign exchange every year by exporting marine fish and fishery products. Therefore, along with the development of deep-sea fisheries, prime importance should be given to improve the small scale marine fisheries where the fate of thousands of fishermen is linked. From these perspectives, the specific objectives of this study are (1) to determine cost and return of small-scale marine fishing under different types of technologies; (2) to determine economic efficiency of small-scale marine fishing; and (3) to suggest policy implications in small-scale marine fish production.

II. Marine Fishery Industry in Bangladesh

There are two sources of fisheries in Bangladesh including inland fisheries and marine fisheries. Bangladesh endowed with vast marine, coastal and inland waters have great fisheries potential. The total of marine water area is almost as large as the country. Thus marine water could be considered as the best source to increase the fish production in this country.

In Bangladesh, there are two types of marine fishing including large-scale marine fishing(industrial fisheries) and small-scale marine fishing (artisanal fisheries). In large-scale or trawler fishing, two types of trawler namely shrimp trawler and fin fish trawler are used. Small scale marine fishing is carried out mostly by traditionally mechanized/non-mechanized boats and industrial by fishing trawler. In small-scale marine fishing, four types of gears such as gill net, long line, roke net and set bag net are mainly used. Gill net is principally used for catching river shad, chinese pomfret, black pomfret, silver pomfret etc. Roke net is used for catching various types of fish such as croaker, river shad, bombay duck, Jewfish, Tiger, etc. And long line is used for catching phoka, indian salmon, etc. By using set bag net, hairtail, shrimp, faillah, etc., are mainly caught.

In the study areas, three types of gears are mainly found to be practiced by fishermen. They are gill nets, set bag nets and roke nets. Gill net is a rectangular fishing gear. The mesh size that is used for fishing depends on what size of fish to be caught. The combined action of the floats and weights maintain the vertical stretch of the net. Sufficient floats are used to overcome the weight of the lead line, which is used to maintain the stretch. Roke net is rectangular shaped net which have upper line with floats and ground line with weight. Its mesh size varies with the fish species. The net is sited vertically with the water flow. The net has two sides, one of which is fixed with the boat and another remains free. Roke net can be operated at a depth of 50 meters and more. Set bag nets are pocket typed net. Each net has large mouth and narrow tail. Mesh size becomes smaller and smaller from head to tail. Nets are kept fixed in one place in against of current for 15 days in a month by using bamboo and wooden pillars. This fishing method is restricted to water about 20 meters in depth. The main characteristics of these gears are summarized in Table 1.

〈Table 1〉 Main characteristics of gill net, roke net and set bag net

Characteristics	Gill net	Roke net	Set bag net
Capacity of boat (t)	8	6	4
Length of boat (m)	18	10	11
Breadth of boat (m)	8	6	5
Depth of boat (m)	6	4	4
Gear weight (kg)	480	200	350
Mouth of net (m)	-	-	15
Engine power (HP)	22	10	--

<Note> t = ton, m = meter, kg = kilogram, HP = horse power
<Source; Field survey, 2002>

For all types of gear, August to January is the peak period of fishing in

the study area as fishes were comparatively more abundant in this period. February to May and June to July were the lean period and off season for fishing for gill and roke nets respectively while the lean period for set bag net was identified as February to July in the area under study.

The importance of small scale marine fishing is increasing year by year with the development of the fishing technology. Moreover, the small scale marine fishing is cost effective and is capable of great improvement by modernization and innovation. It is economically profitable and provides employment for coastal people in fishing. Most of the households of coastal communities are employed in fisheries activities and relevant industries such as boat building, gear and equipment manufacturing and repairing, fish marketing and other related activities.

Ⅲ. Relevant Studies

Despite the importance of small-scale marine fishing, very few studies have been conducted on different economic aspects of the small-scale marine fish production in Bangladesh. In this section only the most common and relevant research works on marine fishing of Bangladesh are brought with their major findings. Islam(1998) observed that the income level of crew fishermen was lower compared to boat owners and owner-fishermen.

Islam and Miah(2000) studied economics of production, financing and marketing of marine fisheries in Bangladesh. The study found that marine fishing was highly profitable and net profit was positive in all selected technologies but the profitability varies significantly among the gears as indicated by benefit-cost ratio and internal rate of return.

Rashid(2000) examined the economic aspects of small scale marine fishing in Bangladesh. In this study, the financial analysis showed that fishing under long line abd set bag technologies were highly profitable.

Sofiullah(2001) determined the profitability and investment pattern of marine fishing. The study found that marine fishing was highly profitable and net return was positive in all selected technologies but the profitability varied significantly among the technologies.

All the previous studies have been conducted on the economic analysis of the small-scale marine fishing in Bangladesh, and, most of them are descriptive studies. However, the reality is that there have not been coordinated government policies to develop this sector and realize its potentials. More information is therefore required to pursue policies for its development. For these reasons, this study was designed to determine profitability of small scale marine fisheries and to analyze various factors relating the income variation under different gears of small-scale marine fishing. Furthermore, this study was conducted in Teknaf where the relevant such study has not been conducted before. The findings may generate useful information to researchers, helpful to the fishermen, policy-makers, extension specialists, fisheries economists and NGOs and it may also help mitigate the economic problems related to the small scale marine fisheries.

IV. Scope, Methodology and Data

The method of collecting data depends upon the nature, aims and objectives of the study. This study used survey method and face-to-face interview.

1. Scope of Analysis

Depending on objectives three adjacent unions namely Teknaf sadar, Subrang and Saint Martin under Teknaf Upazila of Cox's Bazar district in Bangladesh were selected because there were easy communication facilities

and a relatively homogeneous physiographic conditions. The fishing types of this region are various enough to figure out the economic feasibility for each type of fishing gear in the country. In case of small scale marine fishing in Naf River, Teknaf, three important gears such as gill net, set bag net and roke net were selected. 30 gill net, 30 set bag net and 30 roke net fishing were randomly selected from the study area to achieve the objectives of study. However, to know the fishing practices and economic returns for each gear, these gears were randomly selected from the study areas according to the availability of boat owner and fishermen. Table 2 represents the distribution of the samples in different locations.

〈Table 2〉 Sampling design and distribution of marine fishing firms

Types of gears used in fishing firms	Study areas and number of fishing firms selected			
	Teknaf sadar	Subrang	Saint Martin	Total
Gill net	10	10	10	30
Roke net	10	10	10	30
Set bag net	15	15	0	30
Total	35	35	20	90

<Source; Field survey, 2002>

For collecting data and information, a survey schedule was prepared by the logically appropriate sequence well understood questions, and contained information related to the objectives of the study. Data were collected from primary sources and the details for the operational and technical information of marine fishing were collected through direct interview from the boat owners and different categories of fishermen such as head boat driver, and laborer fishermen by using survey schedule. The collected data includes information on catch and cost of fishing activities, boats and gears characteristics, total fishing time, fishing duration, number of trip, fish catches, etc. Data were collected for the period from February 2001 to January 2002.

Data were analyzed for achieving the objectives of the study. The collected data were processed, edited, coded and transferred to different master sheets in tabular form. Analysis included classification of tables into meaningful results by using arithmetic mean, percentage and ratio, yearly frequency of fishing per boat was estimated by addressing the number of trips fished per month. The total catch per boat for the fishing period was calculated by totaling monthly production. The economic performances were classified in respect to different types of gear by using both tabular and statistical techniques. The sum, mean, gross return, total cost, net return, etc. were the simple statistical measures employed to show the gear wise performance.

2. Model Description

The Cobb-Douglas analysis was employed to identify the factors that influence the small-scale marine fishing of selected technologies. The Cobb-Douglas production function for two-inputs takes on the following form;

$$Q = AL^{\alpha}K^{\beta}e^{u} \quad \cdots\cdots (1)$$

Where,

Q = output,
L = labor,
K = capital,
A = constant term,
u = error term, and
α , β = the output elasticities of labor and capital, respectively.

These values are constants determined by each technology. Output elasticity measures the responsiveness of output to a change in levels of

either labor or capital used in production, ceteris paribus. For example if α is 0.15, a 1% increase in labor would lead to 0.15% increase in output.

Production function analysis was used to assess the contribution of variable factors involved, and, to determine the economic efficiency in small scale marine fishing by different gears. For the econometric estimation with empirical data, the marine fish production was presented by a Cobb-Douglas production function with eight inputs as explanatory variables for each selected technologies. This function was chosen as the specific functional form of the underlying relationship between the catch revenue and its explanatory variables on the basis of best-fit and significant result on output.

Cobb-Douglas production function analysis was done taking 30 gill net fishing firms, 30 roke net fishing firms, and, 30 set bag net fishing firms into account separately. The function was specified as;

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}X_7^{b7}X_8^{b8}e^{u} \quad \cdots\cdots (2)$$

The translog production function is a generalization of the Cobb-Douglas production function. To derive the elasticity Cobb-Douglas production function in equation (2) can be estimated using OLS(ordinary least squares) method, in a log linear form. The estimated equation is expressed as follows;

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + \ldots + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + u_i \quad \cdots\cdots (3)$$

Where,

Y = catch revenue (Tk.),

X_1 = experience of fishermen (years),

X_2 = capacity of boat (ton),

X_3 = maintenance and repairing cost (Tk.),

X_4 = fuel and lubricant cost (Tk.),
X_5 = ice and salt cost (Tk.),
X_6 = food cost (Tk.),
X_7 = gear weight (ton),
X_8 = mouth of net (meter),
ln = natural logarithm,
a = constant or intercept value,
b_i = coefficients to be estimated, and
u_i = disturbance term.

Now suppose that this model under the restriction of homogeneity of degree 1. This condition is equivalent to: $b_1+b_2+...+b_8=1$, the production function has constant returns to scale. That is, if each input is increased by 10%, Y increases by 10%. The explanatory variables included in the model are explained as follows;

- Experience of fishermen (X_1): The choice of fishing ground for the availability of fish and the fishing activities depend on the skill and experience of fishermen. Head boat drivers and drivers are experienced than laborer fishermen (Table 3). A positive relationship was expected to be obtained between the catch revenue and experience of fishermen.
- Capacity of boat (X_2): Capacity of boat is defined as how much amount of weight it can carry. It was hypothesized that there would have positive effect of capacity of boat on small scale marine fishing.
- Maintenance and repairing cost (X_3): Maintenance and repairing cost include the regular and preventive care costs to reduce duration of engine, gear and hull that extended. Maintenance and repairing cost is considered as an important factor in the functional analysis to explain the variation in catch revenue.

〈Table 3〉 Fishing experience of small scale marine fishermen

(unit : %)

Fishing experience(year)	Categories of fishermen		
	Head boat driver	Driver	Labor
0 to 5 years	5.50	15.94	40.00
6 to 10 years	20.50	60.06	35.00
Above 10 years	74.00	24.00	25.00
All	100.00	100.00	100.00

<Source; Field survey, 2002>

- Fuel and lubricant cost (X_4): Fuel and lubricant are generally used for lighting and powering the engines of mechanized fishing boats. Cost of fuel and lubricant was included in the functional analysis because of its significant effect on fishing income.
- Ice and salt cost (X_5): Ice and salt cost is an important cost item for small scale marine fishing. It is used for preservation of fish in order to keep them fresh. This item is expected to have significant positive effect on catch revenue of marine fishing.
- Food cost (X_6): Food is important item that can change the fishing effort of fishermen as well as the catch revenue to meet their body requirement and generate energy. Food cost was expected to contribute significantly in fishing effort and fish catch as well as income of fishermen.
- Gear weight (X_7): Gear weight is an important explanatory variable that could affect small scale marine fish production. It is expected to have positive impacts on small scale marine fishing.
- Mouth of net (X_8): Mouth of net was an important factor that influenced the catch revenue of set bag net fishing. It is assumed that the bigger mouth ensured more catch.

3. Data Description

1) Initial capital investment on fixing fishing facilities

The major assets for gillnet, roke net and set bag nets consisted of hull, engine, net(gear), pipe, refrigerator and other assets. Table 4 represents the capital investment cost of fishing assets of selected gears and percentage share of total capital investment cost. The average capital investment on assets for gill nets, roke net and set beg net fishing were Tk. 1,000,000, 400,000 and 640,000, respectively. The table reveals that average investment cost of gillnet fishing was substantially higher than those of set beg net and roke net fishing in the study area.

〈Table 4〉 Capital investment in fishing assets

Type of fishing assets	Capital investment cost (Tk.)					
	Gill net	%	Roke net	%	Set beg net	%
Hull	284,000	28.40	90,000	22.50	180,000	28.12
Engine	198,000	19.80	80,000	20.00	--	-
Net(gear)	150,000	15.00	180,000	45.00	350,000	54.68
Pipe	--	-	20,000	5.00	70,000	10.93
Ice box	100,000	10.00	-	-	--	--
Others**	268,000	26.80	30,000	7.50	40,000	6.25
Total	1,000,000	100.00	400,000	100.00	640,000	100.00

<Note> ** Other assets included rope, extra wood, float, weight etc.
<Source; Field survey, 2002>

2) Annual variable costs

The total cost of small scale marine fishing includes all costs incurred during the fishing season for one year period. In this study, the total cost consists of operating cost(fuel and lubricant, ice/salt and food cost) as variable costs and fixed cost(crew costs, maintenance and repairing costs of

boat engine, gear and boat, depreciation cost, interest on operating capital) as overhead cost. Finally, total cost per year was calculated as the sum of total operating cost and total overhead cost. All costs mentioned above are presented on Table 5 and explained as follows;

- Cost of fuel and lubricant: As the variable cost, fuel and lubricant is important cost item for gill net and roke net fishing which covers 19.42% and 10.81 % of total cost respectively. In the case of set beg net fishing, fuel and lubricant are not used.
- Cost of ice and salt: Ice and salt cost is considered as preservation cost. Ice is used only in gill net fishing. Per trip gill net fishing usually requires 2 to 6 days in the sea to catch a considerable amount of fish. The cost of ice and salt accounted for 2.61% of the total cost per year.

〈Table 5〉 Item wise cost of gill net, roke net and set bag net fishing

(unite : cost/firm/year)

Cost items	Gill net		Roke net		Set bag net	
	Cost (Tk.)	% of total	Cost (Tk.)	% of total	Cost (Tk.)	% of total
Fuel and lubricant	100,251	19.42	35,475	10.81	--	--
Ice and salt	13,489	2.61	-	-	-	--
Food	23,735	4.60	27,060	8.24	87,000	25.91
Miscellaneous cost	36,942	7.15	13,695	4.17	50,000	14.89
A. Total operating cost	174,417	33.80	76,230	23.23	137,000	40.80
Maintenance and repairing cost	141,567	27.43	74,828	22.80	47,745	14.22
Crew cost	143,021	27.71	132,132	40.26	129,760	38.64
Interest on operating capital	20,349	3.94	8,894	2.71	9,590	2.85
Deprecation cost	36,624	7.09	36,041	10.98	11,664	3.47
B. Total overhead cost	341,561	66.19	251,895	76.76	198,759	59.19
Total cost (A+B)	515,978	100.00	328,125	100.00	335,759	100.00

<Source; Field survey, 2002>

- Food cost: Food cost at sea is another important item of the operating cost depending on the number of crew and also in time of fishing. The food cost for gill, roke and set bag netters per years shared 4.60, 8.24 and 25.91 % of total cost, respectively.
- Miscellaneous cost: Fishermen must pay some charges to Bangladesh Fisheries Development Corporation(BFDC) at fish landing center, and, donate to different religion and social institutions and communities. Other small scale expenses such as kerosene for cooking, battery for lighting and other essential goods, etc. generates miscellaneous costs. Sometimes, some illegal tips that made by the fishermen were paid to police and hooligans in various stages during fishing and marketing of their catches. The contributions of miscellaneous cost in total cost of fishing were found to be 7.15, 4.17 and 14.89 percent for gill, roke and set bag net fishing firms, respectively.
- Maintenance and repairing cost: Cost of maintenance and repairing is reasonably high because fishing boat moved frequently for a long time under these selected fishing technologies. Maintenance and repairing cost for gill net, roke net and set bag net shared 27.43%, 22.80% and 14.22% of total cost, respectively.
- Cost of hired labor: In all cases, hired labor cost is the major item and includes all human labor for fishing. Crews are required for different fishing operations like catching, drying, icing, refrigerating, transporting, marketing and supporting services like cooking. The crews constitute the most important and largely used single input and share a major portion of total expenses. For gill net fishing the average cost of crew per year was 27.71% of total cost. This percentage for roke net fishing and set bag net fishing was 40.26 and 38.64, respectively.
- Interest on operating capital: Interest on operating capital is treated as a cost item and was calculated on the basis of opportunity cost of capital. The interest was surveyed at the rate of 14% per annum for the fishing period. Interest on operating capital was calculated by the following formula;

$$\frac{operating\ capital \times interest\ rate \times\ time\ considered}{2} \quad \cdots\cdots (4)$$

The period applied in this study was calculated from beginning to ending of marine fishing season, which is one year. There was no commercial bank or financial institutions for the fishermen to borrow. The average interest rate paid by fishermen in the study area to borrow from non-institutional sources like middlemen, fish merchants and relatives was considered as the cost of capital. This rate was estimated on an average at 14% per annum. Interest on operating capital for gill net, roke net and set bag net constituted 3.94%, 2.71% and 2.85% of total cost, respectively.

- Deprecation cost: General accounting method of calculating deprecation is based on the original cost of the asset, its estimated useful life, and the estimated salvage value at the end of its life. From the method, it was found that the deprecation of asset equals initial cost of the asset less salvage value divided by economic life;

$$\frac{purchased\ price \times salvage\ value}{economic\ life}. \quad \cdots\cdots (5)$$

Deprecation cost for gill net, roke net and set bag net fishing under the present study were calculated at 7.09%, 10.98% and 3.47% of the total cost respectively in the study area.

3) Return from small scale marine fishing

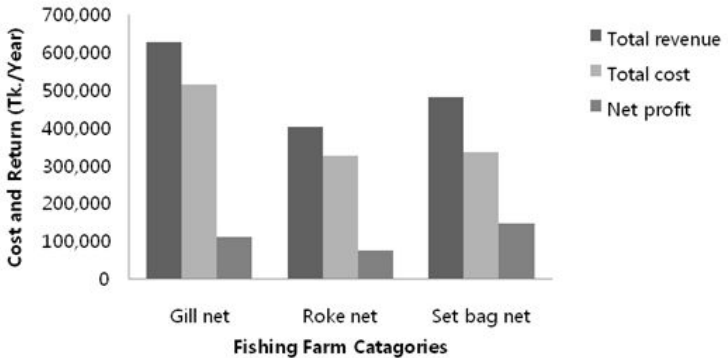
Annual total catch of fish varies significantly on fishing season which directly affects the catch of fish as well as the production. The total catch also varies with the use of different fishing technologies. Total annual catch was valued with prevailing market price to estimate total revenue from fishing. Total revenue from fishing was calculated by multiplying the total annual catch by their respective prices (Table 6).

〈Table 6〉 Economic returns of gillnet, roke net and set bag net fishing

Particulars	Gill net	Roke net	Set bag net
Catch in kg (a)	19,000	17,550	35,200
Price per kg in Tk. (b)	33	23	14
A. Total revenue in Tk. (a*b)	627,000	403,650	483,000
B. Variable cost in Tk.	174,417	76,230	137,000
C. Fixed cost in Tk.	341,561	251,895	198,759
D. Total cost in Tk. (B+C)	515,978	328,125	335,759
E. Net profit in Tk. (A-D)	111,022	75,525	147,241
F. BCR (A÷D)	1.22	1.23	1.44

<Source; Field survey, 2002>

〈Figure 1〉 Graphical presentation of total revenue, total cost and net profit of marine fishing firms



The average annual catch per boat was found to be 19,000, 17,550 and 35,200 kg/year under gill net, roke net and set bag net respectively with corresponding revenue of Tk. 627,000, 403,650 and 483,000(Table 6).

Net profit was calculated by deducting total costs from total revenue and it was positive for all gears. Annual net profit was estimated at Tk. 111,022, 75,525 and 147,241 for gill net, roke net and set bag net, respectively(Table. 6, Figure 1). It may be noted that total revenue, total cost and net profit

varied widely among the fishing gears. For roke net fishing, both the total revenue and total cost were lower which also made the net profit lower.

The undiscounted Benefit-Cost Ratio(BCR) for different gears were estimated on the basis of total cost, and, it was estimated 1.22 1.23 and 1.44 for gill net, roke net and set bag net respectively(Table. 6). This implies that the small scale marine fishing is profitable in the study area and set bag net fishing is more profitable than other gears.

Ⅴ. Results and Discussion

1. Profitability and Economic Efficiency of Small Scale Marine Fishing

The results of the estimated coefficients by gill net, roke net and set bag net, are presented in Table 7. The Table represents that the estimated production coefficient of experience of fishermen is 0.268 for gill net, 0.185 for roke net and 0.104 for set bag net, which are economically plausible and statistically significant at 1%, 5% and 10% levels. This result indicates that if 1% increase in experience of fishermen keeping other factors constant would cause of 0.268%, 0.185% and 0.104% increase catch revenue for gill net, roke net and set bag net fishing, respectively.

The estimated coefficient of capacity of boat is 0.167 for gill net, 0.352 for roke net and 0.320 for set bag net which are positive and economically plausible. This is statistically significant at 1%, 5% and 10% level, respectively. It indicates that 1% increase in capacity of boat would create 0.167%, 0.532% and 0.320% increase in catch revenue respectively, holding others inputs constant(Table 7).

The coefficient of maintenance and repairing cost for roke net and set bag net are positive and statistically significant at 1% level. The values of the coefficient for fuel and lubricant cost for gill net and roke net fishing are

positive, economically plausible and significant at 5% level. Table 7 also shows the regression coefficient for ice and salt cost is 0.433 for gill net which is positive and significant at 1%.

The values of R^2 represent the proportion of "explained" to "total" variation. The results indicate that, all the included explanatory variables in the model explained 68%, 72% and 75% variation in fish production (revenue) under gill net, roke net and set bag net fishing, respectively (Table 7). The selected production function have sufficient degrees of freedom for testing statistical significance. For each gears, eight different inputs were selected in regression equations. The input coefficients were statistically significant at different levels of probability.

〈Table 7〉 Estimated values of coefficient and related statistics of Cobb-Douglas production function

Explanatory variables	Gill net	Roke net	Set bag net
Intercept	0.244	0.199	1.230
Experience (X_1)	0.268* (0.153)	0.185** (0.073)	0.104* (0.057)
Capacity of boat (X_2)	0.167** (0.071)	0.532*** (0.184)	0.320** (0.134)
Maintenance and repairing (X_3)	0.111 (0.073)	0.674*** (0.189)	0.648*** (0.208)
Fuel and lubricant (X_4)	0.131** (0.051)	0.656** (0.323)	-
Ice and salt (X_5)	0.433*** (0.100)	--	-
Food (X_6)	0.105 (0.078)	0.229 (0.175)	-
Gear weight (X_7)	0.375* (0.131)	0.102 (0.246)	0.804** (0.391)
Net of mouth (X_8)	-	-	0.555** (0.238)
R^2	0.677	0.719	0.749
Adjusted R^2	0.574	0.645	0.696
F-value	6.589	9.797	14.291
Returns to scale	1.590	2.370	2.430

〈Note〉 1. Figures within parentheses indicate standard errors.
2. *** indicates significance level at 1 percent
3. ** indicates significance level at 5 percent
4. * indicates significance level at 10 percent

The estimated production functions for different gears in this study were also significant as evidenced by F-values. F-value of the individual equations is highly significant implying that all the included explanatory variables are important to explain the variation of marine catch under three different gears. Therefore, t-values of the individual input coefficient should also be expected to be significant.

2. Returns to Scale for Small Scale Marine Fishing

Returns to scale(RTS) reflects the degree to which a proportional increase in all inputs increase in output. Empirical analyses of production routinely investigate RTS by estimating the total elasticity of production(ε). The total elasticity of production measures the proportional change in output resulting from a unit proportional increase in all inputs. The total elasticity of production can be shown to be equal to the sum of all the partial production elasticities. In the case of two inputs this is equal to be as follows;

$$\varepsilon = E_1 + E_2 \quad \cdots\cdots (6)$$

Where, ε is total elasticity, and, Ei represents partial production elasticities. The partial production elasticities measure the proportional change in output resulting from a proportional change in the i^{th} input. The partial production elasticities is defined as;

$$Ei = \frac{\delta y}{\delta xi}\frac{xi}{y} \quad \cdots\cdots (7)$$

The returns to scale in this study are 1.59, 2.37 and 2.43 for gill net, roke net and set bag net fishing respectively, which indicates that all the production function exhibits increasing return to scale(Table 7). This means that increasing the use of included fishing inputs by 1%, fishing income would increase by 1.59%, 2.37% and 2.43% for gill net, roke net and set bag

net fishing, respectively. Results from returns to scale indicate that even with the present technology there are enough scope to increase marine fish production and income in the study area.

VI. Conclusion and Recommendations

The fisheries sector plays a vital role in nutrition, employment and foreign exchange earnings. Most of the people in Bangladesh depend on fish as main source of protein. The demand for marine fish is increasing day by day because of increasing population and acute storage of livestock products. In marine fisheries, the importance of small scale marine fishing is increasing year by year with the development of the fishing technology in Bangladesh. This study was designed to determine profitability of small scale marine fisheries and to analyze various factors responsible for the income variation under different gears of small scale marine fishing.

In this study the standard farm management techniques were applied to determine the costs, returns and profitability of fishing. On the average, total cost per year was Tk. 515,978 for gill net, Tk. 328,125 for roke net and Tk. 335,759 set bag net. Net profit was calculated by deducting all costs from the gross revenue and was found to be Tk. 111,022, 75,525 and 147,241 per year for gill net, roke net and set bag net fishing respectively. Annual total cost was estimated and was higher in gill net fishing compared to that of other selected fishing gears. Although the total revenue of gill net fishing was higher but it faced lower net profit compared to set bag net fishing.

Cobb-Douglas production function was applied to determine the economic efficiency of different fishing inputs used in the production of marine fishing. The selected variable factors are experience of fishermen, capacity of boat, maintenance and repairing cost, fuel and lubricant cost, ice and salt cost, food cost, gear weight and mouth of net. The estimated production function

with these variables fitted well for individual gears. In most of cases the signs of the coefficient were acceptable, and, variables were significant.

This study found that catch and revenue of marine fish can be increased by judicial catching. Three selected fishing gears are highly profitable, because fishermen used these gears very efficiently. Finally, depending on the net profit earned by three different gears and BCR on total cost basis, it is concluded that set bag net fishing was more profitable compared to the other two gears.

This study also identified several major problems and constraints related to fishing and overall small scale marine fishing farms. Head boat driver, boat owner and different categories of fishermen were asked to mention the problems and constraints which they had faced in the time of fishing. Lack of credit, lack of knowledge, bad weather in the monsoon and NASAKA(the team of Border security force of Myanmar) were the main problems reported by the fishermen. Moreover, although the problems and constraints were important, the government could not play appropriate role to overcome them.

On the basis of the above problems and findings of the study, the following recommendations may be advanced which are likely to be useful for policy implications;

- Financial institutions should provide enough support to build mechanized and non-mechanized boat and to buy accessories;
- Availability of fishing equipment should be ensured at proper time;
- Skill development by training of the fishermen should be arrangement by concerned authority;
- Reasonable prices of marine fish and inputs should be ensured;
- Sharing of catch revenue between fishermen and boat owner should be made rational and equitable;
- Necessary steps should be taken by the government to prevent robbery and NASAKA during the fishing time;
- Life insurance policy should be introduced for small scale marine fishermen;

- Provision should be made for social, moral and scientific education for the fisher folk as well as the fishermen;
- There should have proper rules and regulation to catch marketable size of fish rather than small size; and
- The government and concerned authority should take proper steps to develop the small scale marine fishing as well as fisheries sector in Bangladesh.

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