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Socioeconomic factors affecting profitability of seaweed culture in Saint Martin Island of Bangladesh

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Abstract

Seaweed culture provides financial benefits and creates employment opportunity for coastal inhabitants of Bangladesh. This study was conducted to assess profitability and to determine the socioeconomic factors that affect the profitability of seaweed culture in the coastal region. Primary data were collected from 33 seaweed farmers for the study. The data were collected during the period of March 15 to March 31, 2018 through direct interviews and observation using a semi structured questionnaire and a check list. Both tabular and functional analyses were used to achieve the objectives of the study. It is evident from the study that seaweed culture is a profitable business. The total per square-meter cost of seaweed production was Tk. 1520 with a gross return of Tk. 2801.4 and net return was estimated at Tk. 1281.4 with a Benefit-Cost Ratio (BCR) 1.82. To estimate the contribution of different inputs on seaweed production through Cobb-Douglas production function, the explanatory variables considered were: bamboo cost, rope cost, human labour cost, repairing cost, age, experience, training, education and number of family members. Among these variables, labour and training were found positively significant at 1 percent level of significance with the regression coefficient of 0.209 and 0.556, respectively. This indicates that seaweed culture might be brought economic benefits of the community if they received more training and employ more labour. Therefore, policy should be focused on creating appropriate training arrangement and skilled labour to the coastal community for getting higher benefit. Seaweed farmers think that seaweed culture can be adopted as an alternative livelihood option if the government and other stakeholders help them with necessary supports for seaweed culture.

Key words: Seaweed culture, livelihood, profitability, Bangladesh

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Introduction

Seaweeds, popularly known as marine algae, are a group of photosynthetic non-flowering plant-like organisms that can be found throughout the world's oceans and seas. Based on their dominant pigmentation they are generally classified into three major groups, i.e. mainly available in three colors, i.e. red (Rhodophyta), brown (Phaeophyta) and green (Chlorophyta). Seaweeds are enriched with protein, carbohydrates, beta-carotene, minerals, vitamins, and essential amino acids. Due to the excellent nutritional profile, seaweeds are now considered to be the food supplement for the 21st century. Meanwhile, seaweeds are also regarded as a high profile commercial marine biota for its magnitude of uses, like raw materials of bio-chemicals (agar, agarose, algin, carrageenan), dyes, feed, enzymes and drugs (Athithan, 2014). Seaweed has been cultured traditionally for decades and probably for centuries in several Asian nations such as

China, Korea and Japan. Until about 1980, most of the seaweed production from other nations in the region has been from the harvest of wild stocks although limited culture took place in nations such as the Philippines and Indonesia (Trono, 1990). As early as the 1970s, it was recognized that demand for seaweed and seaweed products was outstripping supply and cultivation was viewed as the best means to increase production (Naylor, 1976). According to the statistics of FAO (2016), the total world seaweed production in 2016 was about 28.85 million tons while it was 14.65 million tons in 2007 which indicates that within the time frame the production increased around 97%. So, total seaweed production became double within 10 years.

The world market size of seaweed had also tremendous increase with its production. In 2007, the total market size of seaweed was $ 6.08 billion in 2007 and it became $ 11.45 billion in 2016. Though the overall global production and market size of seaweed have increased significantly over the years, Bangladesh has not made significant contribution yet. According to the country status reports at FAO (1990), it was reported that approximately 15 metric tons of seaweeds (all varieties) were produced in Bangladesh in 1989 where culture methods were yet to be introduced. Surprisingly, recent data regarding seaweed production in Bangladesh are not that much available in any authentic primary and secondary sources. Bangladesh is naturally bestowed with 193 seaweed species including 19 commercially important species. Despite having such natural abundance of seaweed species, favorable climatic condition and 480 km long coastline with 25,000 km^2 of coastal area, Bangladesh is still lagging behind in terms of seaweed production. Recently, researchers of different institutions and organizations have focused on seaweed cultivation as a vital exploration for Bangladesh economy.

Bangladesh Fisheries Research Forum (BFRF) conducted experiments on two commercially important seaweed species; *Hypnea sp.* and *Caulerpa racemosa* and recorded water quality parameters, growth rate of seaweed species and costs associated with line, net and suspended rope methods in 2008. Sarkar *et al.* (2016) conducted a study on manufactured, value added seaweed products and analyzed their acceptance to consumers. Four value added seaweed food products; namely, seaweed jelly, soup, ice-cream, curd; two functional food products, namely, seaweed singara, samucha/samosa, and two cosmetic products, namely, seaweed face pack, shampoo were prepared at Fish Processing Laboratory, Bangladesh Agricultural University (BAU), Mymensingh. *Hypnea* sp. seaweed powder was used in manufacture of all the products. For seaweed jelly, soup, ice-cream and curd consumer acceptance was 66.67%, 50%, 41.67% and 83.34%, respectively. For seaweed singara and samucha/samosa, 100% acceptance was found. Seaweed face pack and shampoo got 100% and 66.67% consumer's acceptance, respectively. Thus, all these products have potential to be produced commercially. Siddique *et al.* (2013) conducted a proximate analysis of chemical composition and amino acid profile of *Gelidium pusillum* to understand the nutritional status. The result from this study suggested that *Gelidium pusillum* could be utilized as a healthy food item for human consumption. Sarkar *et al*. (2016) conducted a survey and identified 193 naturally occurred seaweed species in Bangladesh. This study has also highlighted the conventional utilization of seaweed in Bangladesh and revealed that the Mog and Rakhaine and other tribal communities of Saint Martin Island had been consuming seaweed as salad and sauce traditionally. Seaweed farming is frequently promoted as a lucrative alternative occupation for artisanal fishers in Southeast Asia (Hill *et al.*, 2011) by improving communication pattern of seaweed farmers and extension services to enhance agricultural-aquaculture developments (Ekasari *et al*., 2013)

Espaldon et al., (2010) conducted a study that aimed to assess the contribution of seaweed farming in Calatagan, Batangas, Philippines based on the sustainable livelihood framework. In that study, it was revealed that seaweed farming had positive impacts on the livelihood of the seaweed farmers in terms of natural capital, physical capital, social capital, human capital and financial capital. The results of the cost and returns analysis in this study showed that income from a unit (2000 sq m area) of seaweed farming would be sufficient to meet the household expenses of the seaweed farmers. Msuya (2011) studied the impact of seaweed farming on the socioeconomic status of coastal communities in Zanzibar, Tanzania and revealed that the Kidoti women group had significantly increased profits from TZs1.5 million ($652.14) to TZs 2.7 million ($1173.85) in 2006 and 2009.

BRAC, the largest NGO of the world, reported that children living in the coastal regions of Bangladesh are 1.5 time more likely to be stunted in 2018. World Bank (2016) revealed that nearly 12 million people were leading their lives in poverty and it is possible to eradicate poverty and malnutrition in the coastal regions of Bangladesh through seaweed farming. It is quite evident that seaweed farming has been considered as an income generating activity in the Philippines, Tanzania and many other coastal communities. In Bangladesh, the profitability of seaweed farming in the coastal region and the socioeconomic factors affecting the seaweed production is yet to be determined analytically. Hence, understanding the importance of nutritionally enriched seaweed as food and seaweed farming as a profitable venture for the coastal farmers, this study was conducted to identify the socioeconomic factors that influence the profitability of seaweed farming in the Saint Martin Island of Bangladesh.

Materials and Methods

Study area and Sampling: The study was conducted in the Saint Martin Island which is a union of Teknaf Upazila of Cox's Bazar district (Figure 1). It is a small island of 36 sq. km. in the north eastern part of the Bay of Bengal, about 9 km south of the tip of the Cox's Bazar-Teknaf peninsula, and forming the southernmost part of Bangladesh. The inhabitants primarily live from fishing including seaweed culture. The other staple crops are rice and coconut. Being very common on the island, algae are collected, dried, and exported to Myanmar (Wikipedia, 2020). There are approximately 3700 people lives in Saint Martin Island (Wikipedia, 2020). Out of them, a few are engaged in seaweed culture. The total number of population (who cultured seaweed) was not found from anywhere. Therefore, snowball sampling technique was used for collecting primary data. Data were collected from March 15 to March 31, 2018 in order to assess the costs and returns associated with seaweed farming. A total of 33 farmers were selected for face to face interviews as well as for focus group discussions using an open ended semi-structured questionnaire.

Figure 1. Saint Martin Island in Bangladesh.

***Analytical techniques*:** Collected data were analyzed in accordance with the objectives of the study. Mainly two techniques of analysis were used in this study, tabular and functional techniques. Before assessing the influence of socioeconomic factors on the profitability of seaweed farming, it is needed to calculate profitability. In Saint Martin Island, farmers practice seaweed in net culture method. In this method, a bamboo made square frame of 1m x 1m size fabricated with rope (obtained from coconut husk) was normally chosen as a support since it had loose braids to hold the seaweed seedlings. Rope with 16 mm diameter was used and the mesh size of the rope made nets on the culture frame was maintained as 20 cm. Four medium size empty plastic bottles were tied with rope in each corners of the frame. To sink the entire frame partially under seawater, four stones were also tied to each corners of the frame. 1-2 inch long *hypnea spp*. of seaweed seedlings were then tied with soft ropes (Nylon) in the net. The farmers were found to cultivate seaweed in the government demesne land and therefore, no land rent was calculated for this study. Meanwhile, the seedlings required for seaweed farming were naturally abundant in Saint Martin Island. Therefore, no fixed cost was involved in per square-meter seaweed cultivation. Variable costs including float cost, bamboo cost, rope cost, stone cost, hired labor cost, family labor cost, repairing cost were considered for one square-meter seaweed cultivation in net culture method for one season (October-April). Simple tabular technique was used to calculate the costs and revenues. The following profit (π) equation was used to assess the profitability:

$$\pi = P_y Y - \sum_{i=1}^{n}(P_{xi}X_i) - TFC$$

Where,

π = Net return of from seaweed (Tk./Square-meter)
P_y = Per unit price of seaweed (Tk./kg)
Y= Quantity of seaweed per square meter (kg)
P_{xi} = Per unit price of ith inputs (Tk.)
Xi = Quantity of the ith inputs per square meter (Kg)
TFC = Total fixed cost (Tk.), and
i = 1, 2, 3, ...n (number of inputs)

There was no fixed cost item used in seaweed cultivation. So, fixed cost for seaweed cultivation was considered as zero.

***Gross return*:** Gross return was calculated by multiplying the total volume of output of an enterprise by the average price in the harvesting period. It consisted of sum of the volume of seaweed production. The following equation was used to estimate GR:

$$GR = \sum_{r=1}^{n} Q_s P_s$$

Where,

GR= Gross Return from seaweed (TK./ square meter)
Q_s = Quantity of the rth product of seaweed (kg/square meter)
P_s = Average Price of the rth product of seaweed (kg/square meter).

r =1, 2, 3, … , n and
f =1, 2, 3, … , n.

Benefit cost ratio (BCR) is a relative measure, which is used to compare benefits per unit of cost. The BCR estimated as a ratio of gross return and total cost. The formula of calculating BCR (undiscounted) is shown below.

Benefit Cost Ratio = Gross Return / Total Cost

Many factors might affect gross return of seaweed production but it is quite difficult to include all the variables in a model due to theoretical and economic considerations. Considering the effects of explanatory variables on return from seaweed, nine explanatory variables were considered namely bamboo cost (X_1), rope cost (X_2), human labour cost (X_3), repairing cost (X_4), age (X_5), experience (X_6), training (X_7), education (X_8) and number of family members (X_9). All these variables have been estimated with data arranged on per square-meter basis. Linear regression function was chosen to determine the effects of key variables on seaweed production. The log form of the linear regression model proved to be a superior alternative on theoretical and economic grounds. According to the Cobb-Douglas type production function, the relationship between gross return and the inputs and the socioeconomic variables takes the following form:

$$Y_i = aX_{1i}^{b1}\ X_{2i}^{b2}\ X_{3i}^{b3}\ X_{4i}^{b4}\ X_{5i}^{b5}\ X_{6i}^{b6}\ X_{7i}^{b7}\ X_{8i}^{b8}\ X_{9i}^{b9}\ {}_{ui}$$

By taking log in both sides for the costs of inputs used (X_1 to X_4), the linear regression function was transformed into the following logarithmic form because it could be solved by the ordinary least squares (OLS) method.

$$\ln Y_i = \ln a + b_1 \ln X_{1i} + b_2 \ln X_{2i} + b_3 \ln X_{3i} + b_4 \ln X_{4i} + b_5 \ln X_{5i} + b_6 X_{6i} + b_7 X_{7i} + b_8 X_{8i} + b_9 X_{9i} + u_i$$

Where, Y = Gross return (Tk./square meter); X_1 = Cost of bamboo (Tk./square meter); Cost of floats (Tk./square meter); X_2 =Cost of rope (Tk./square meter); X_3 =Cost of labor (Tk./square meter); X_4 = Cost of repairing (Tk./square meter); X_5 = Age of the seaweed farmers, X_6 = Experience of the farmers, X_7 = Training received or not (dummy, 1= if farmers receive training, 0= otherwise), X_8 = Year of schooling of the farmers, X_9 = Household size or number of family members in the household; In a = Constant or intercept of the function, b_1, b_2, …, b_9 = Coefficients of respective variables; i = 1, 2, 3, ..., n; and u_i = Error term.

Results and Discussion

***Cost of seaweed cultivation*:** The land where the inhabitants of the Saint Martin Island culture seaweed in the coastal belt is under the common resource pool. Therefore, the cost of seaweed culture is mainly variable cost which may affect the profitability of seaweed culture. Table 1 shows the total cost of seaweed culture in the study area. One of the most important inputs of seaweed production was human labour. It was required for different operations like site preparation, transplanting, weeding, drying, grading, marketing, etc. In this study, human labour was measured in terms of man-days, which usually consisted 8 hours of work by an adult man. In the study area, the average wage rate was Tk.140 per man-day during the study period which is very low compared with main land area. To convert the physical data into financial terms, the total man-days of human labour were multiplied by average wage rate of Tk.140. The cost of family labour was calculated according to the wage rate at which the farmers could have hired labour. Hired labour was required sometimes for making the frame and sewing the net for seaweed farming. Family labours provide the service of tying seaweed seedlings, harvesting and drying. In seaweed culture, per square meter cost of hired labor and family labour for one season were calculated as Tk. 280 and Tk.840 consecutively which comprised 55.46 percent of the total cost (Table 1).

Table 1. Per square-meter total cost of seaweed production for one season.

Cost Items	Unit	Quantity	Price (Tk.)	Total Cost (Tk.)	Percent of Total
Float cost	Piece	4	5	20	1.32
Bamboo cost	Piece	1	120	120	7.89
Rope cost	Bundle	7	25	175	11.51
Stone cost	Piece	4	-	-	-
Hired labour cost	Man-days	2	140	280	18.43
Family labour cost	Man-days	6	140	840	55.46
Repair/Maintenance	Tk.	-	-	85	5.59
Total cost	Tk.	-	-	1520	100

Source: Field survey, 2018

Rope is an essential thing required in net culture method for seaweed cultivation. Seven bundles of coir and nylon rope were used for sewing net, tying seaweed seedlings in the net, tying empty plastic

bottles and stones in each corner of the bamboo frame. The cost of each bundle of rope was Tk. 20 and the total cost of rope was Tk. 140 (Table 1).

Farmers used medium size empty plastic bottles as floats. Usually, four floats were needed to tie with each corner of the frame. Considering, Tk. 5/empty plastic bottles, the total cost of floats was Tk. 20 (Table 1).

To cultivate seaweed in net culture system, the first and foremost thing is to make a 1m x 1m size frame by bamboo. On an average, this task was completed by using one piece of bamboo and its cost was Tk. 120 which was 7.89 percent of the total cost (Table 1).

During the time of tidal surge and harvesting, sometimes the bamboo frame of the net culture system gets damaged or broken and the net becomes torn. The average repairing costs of this damage were valued at Tk. 85 which was 5.59 percent of the total cost (Table 1).

The total cost of seaweed culture is estimated around Tk. 1520 per square metre for a season. This is also variable cost as there is no fixed cost item in the seaweed culture.

***Gross and net returns from seaweed culture*:** Gross return from seaweed production was calculated by multiplying the total amounts of sea weed by average market price. Total gross return from per square meter seaweed production was Tk. 2801.4 (total harvested volume of seaweed was 48.3 kg which is multiplied by Tk. 58/kg). The net return was obtained by deducting all costs (variable and fixed) from gross return. Per square net returns from production of seaweed was Tk. 1281.4. The benefit cost ratio (undiscounted) was calculated by dividing the gross return by the total cost. Here, benefit cost ratio (undiscounted) was used to derive the profitability of production. The BCR of seaweed was 1.84 which is higher than the unity indicating that if farmer invest one Take they receives Taka 1.84.

***Socioeconomic factors affecting the profitability of seaweed farming*:** Nine variables were included in the model where two of them were statistically significant. The regression coefficient of human labour was 0.209 (Table 2) which is positive and significant at 1 percent level of significance. It indicates that 1 percent increase in the cost of human labour, keeping other factors constant, would increase the gross return of seaweed production by 0.209 percent. The result indicates that if more labour would be employed and training would be provided to the seaweed cultivated households, they will be financially benefited. This is relevant because seaweed culture is dependent on labour as household culture seaweed in the coastline. It is evident from Table 2 that the value of the coefficient of multiple determination (R^2) is 0.982, which indicates that about 98.2 percent of variation in gross return has been explained by the factors included in the model. The value of adjusted R^2 was 0.951 which indicates that about 95.1 percent of variation of the gross return is explained by the explanatory variables included in the model. The F value 70.485 of the estimated production function was significant at one percent level of significance (Table 2), which implies very good fit of the model for the seaweed production.

The magnitude of the regression coefficient of training was 0.556 with positive sign implies that keeping other factors remaining the same, an one percent increase in training to the farmers lead to an increase in the gross return by 0.556 percent. This coefficient was statistically significant at 1 percent level of significance. Training was found to be the most influencing factor for higher seaweed production and gross return. The summation of all the regression coefficients or production elasticities of the estimated model gives information about the return to scale, that is, in response of output to a proportionate change in all inputs. The sum of all the production coefficients of the equations for seaweed farming was 0.903 (Table 2), indicate that the production function exhibited decreasing return to scale for the selected farming.

Table 2. Estimated values of co-efficient and related statistics of linear regression function.

Explanatory variables	Estimated coefficients	T-values	Level of significance
Intercept	709.515	2.760	0.010
Bamboo cost (X_1)	0.011	0.252	0.803 ns
Rope cost (X_2)	-0.069	-1.421	0.169 ns
Human Labour Cost (X_3)	0.209	2.848	0.009*
Repairing cost (X_4)	-0.079	-1.499	0.147 ns
Age (X_5)	0.024	0.289	0.775 ns
Experience(X_6)	0.085	1.084	0.290 ns
Training (X_7)	0.556	6.697	0.000*
Education (X_8)	0.069	1.535	0.138 ns
Household Size (X_9)	0.097	1.521	0.142 ns
R		0.982	
R^2		0.965	
Adjusted R^2		0.951	
F-Value		70.485	
Returns to scale Σb_i		0.903	

Here, ns=non-significant sign, * =Significant at 1% level; Source: Own estimation, 2018

Conclusion and policy recommendation

It may be concluded that seaweed farming is highly profitable. If proper training program and production technology can be made available to the farmers in time, yield and production of seaweed may be increased which can help the farmers to increase income and improve livelihood conditions. Seaweed farming can help in improving the nutritional status of the coastal people. Therefore, the coastal farmers can profitably produce seaweed along with their main occupational activities. Further, proper training on seaweed farming and adoption of new production technology may help to increase income and employment opportunities of the coastal farmers. The domestic and foreign consumption of seaweed will certainly increase in future. The present and future potential market and demand for seaweed should be determined through a comprehensive study in order to take up a well-planned production programme at national level.

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