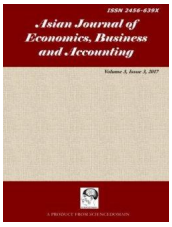

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An Economic Analysis of Agar-Wood Production in North-Eastern Bangladesh

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Authors' contributions

The work was carried out in collaboration between all authors. Author PD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MH managed the literature searches and assisted in the analyses. Authors SAS and MSP managed the analyses and controlled the overall study. All authors read and approved the final manuscript.

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ABSTRACT

The present study was carried out to examine the economics of agar-wood production and assess the financial viability of agar plantations in north-eastern Bangladesh (Barlekha Upazila, Moulvibazar District). Primary data were collected through structured questionnaire administered on 30 agar farmers using purposive sampling technique during the months of September, 2017. The total cost of agar-wood production was found BDT 1450571.20 per acre and BDT 1611.73 per agar tree. The net return was found BDT 1892928.80 per acre and BDT 2103.27 per agar tree, and undiscounted BCR considering total cost was 2.30. Financial viability of 1 acre of agar-wood plantations for the period of 12 years was found feasible with respect to net present value (NPV) BDT 552326.54, discounted benefit cost ratio (BCR) 2.07, internal rate of return (IRR) 23.7 per cent. Sensitivity analysis also suggested the viability of agar-wood production in different situations. The study revealed that agar-wood production is a highly feasible enterprise from which the farmers can enjoy economic benefits.

Keywords: Benefit cost ratio; net present value; internal rate of return; sensitivity analysis; agar-wood.

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1. INTRODUCTION

The agar tree (*Aquilaria malaccensis*) is one of 15 tree species in the Indo-Malaysian genus Aquilaria of the Thymelaeaceae family [1]. It is a large evergreen tree, growing over 15-40 meters tall and 0.6-2.5 meters in diameter, and has white flowers [2]. Agar trees are widely grown in south and south-east Asia including Bangladesh, Bhutan, India, Indonesia, Iran, Malaysia, Myanmar, the Philippines, Singapore and Thailand [3]. This tree contains dark resinous heartwood called agarwood, eaglewood, oud, gaharu or aloeswood [4], and offers a primary source of essential oil called oleoresin. This wood has high demand for medicine, incense and perfumes across Asia, Middle East and Europe [5].

The main value of agar trees lies in its naturally occurring brown to black oleoresin deposits (agar oil) found in patches and streaks in the heartwood. Agar-wood has been used for diverse purposes throughout the world for thousands of years. Its use has been reported in Ayurvedic, Tibetan and traditional east-Asian medical practice, including *Shahih Muslim* and *Susruta Samhita* [2,6]. Agarwood incense has been burned to produce a pleasant aroma for centuries, on important religious ceremonies, by Buddhists, Hindus and Muslims [7].

In Bangladesh, the production of agar-wood started about 400 years ago in the Suzanagar union under Barlekha Upazila of Moulvibazar District in Sylhet [5]. About 25,000-30,000 workers were engaged in cultivation, collection, processing and marketing of agar and agar-based products in the country [8]. However, little is known about the economic feasibility of agar production in Bangladesh. Reliable information on the financial performance of agar plantations is also lacking [9-13]. Therefore, the present study was undertaken to examine the economics of agar-wood production and assess the financial viability of agar plantations in north-eastern Bangladesh. It is expected that this study will have important implications for agar producers, extension workers, policy makers, researchers, NGO officials to develop the agar-wood sector of the country.

2. METHODOLOGY

The study was conducted at Barlekha upazila of Moulvibazar district, because the majority of agar garden of the country are located in this area. Data required for the present study were collected from both primary and secondary sources. For primary data, a sample of 30 agar farmers was selected by using purposive sampling technique. A structured questionnaire was administered to collect primary data through direct personal interview from the respondents during the months of September, 2017. The questionnaire was divided into four core segment to obtain the necessary information from the respondents. First segment contains some general information about agar farmers like name, district, upazila, village and cell number. Second segment was related to the socio-economic variables of the respondent which include age, family size, education and length of experience. The third segment was related to the cost and return of the agar-wood production. The last segment was related to the problems of agar-wood production and their probable solutions. The collected raw data was carefully checked to detect errors and omissions and to avoid irrelevant information. Secondary data were collected from National and International journals, published and unpublished documents and from different websites.

The total cost of production was calculated by adding total variable cost and total fixed cost. Total variable cost included material cost (agar seedling, fertilizer, nailing, insecticide and irrigation cost) and labor cost (collection of seedling, land preparation, hole preparation, planting, thinning and gap filling, fertilizer application and weeding, insecticide application and pruning, and nail setting cost). Likewise, total fixed cost included land use cost. All the cost items were calculated in Bangladeshi Taka (BDT).

Gross return was calculated as:

> Gross return (BDT) = Yield (quantity) × Sales price (BDT)

Net return was calculated as:

> Net return (BDT) = Gross return (BDT) – Total cost (BDT)

Where,

> Total cost (BDT) = Total fixed cost (BDT) + Total variable cost (BDT)

Benefit cost ratio was calculated as:

Benefit cost ratio (BCR) = $\frac{Gross\ return(BDT)}{Total\ cost\ (BDT)}$

To assess the financial viability for 1 acre (1acre = 100 decimal = 0.405 hectare) of agar plantations net present value (NPV), discounted benefit cost ratio (BCR) and internal rate of return (IRR) were calculated for a period of 12 years. In general, any investment is considered viable if net present value is positive, benefit cost ratio is greater than one and internal rate of return is greater than required rate of return or opportunity cost of capital. For calculating present value of benefit and cost the discount rate of 10 % was considered as it was the interest rate given by the local branch office of Bangladesh Krishi Bank.

Net present value was calculated as:

$$NPV= \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^2}$$

Where,

B_t = Incremental benefit in the t^{th} year
C_t = Incremental cost in the t^{th} year
n = Project expected life period
i = Discount rate

Discounted benefit cost ratio is the ratio of present value of gross benefit to present value of gross cost. It was calculated using following formula:

$$BCR= \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

Where,

B_t = Incremental benefit in the t^{th} year
C_t = Incremental cost in the t^{th} year
n = Project expected life period
i = Discount rate

IRR may be defined as that which equates initial investment with the future value of resulting cash flows [14]. It was calculated using following formula:

$$IRR= LDR + (HDR - LDR) \times \frac{NPV \text{ at } LDR}{Difference \text{ between } NPV \text{ at } LDR \text{ \& } HDR}$$

Where,

LDR = Lower discount rate
HDR = Higher discount rates
NPV = Net present value

3. RESULTS AND DISCUSSION

3.1 Basic Information of Agar Plantation in Barlekha

Some basic information regarding agar plantation practices in Barlekha upazila of Moulvibazar district are mentioned in Table 1.

3.2 Socio-economic Profile of Agar Farmers

An examination of socio-economic characteristics of the agar farmers revealed that 53.4 percent farmers were within the age group of 25-40 years, 23.3 percent were within the age group of 41-50 years and 23.3 percent were above 50 years. With regard to education level of farmers, 16.7 percent were illiterate, 43.3 percent completed primary education, 36.7 percent completed secondary education and 3.3 percent completed higher secondary and above level of education. Category of family size shows that small, medium and large family accounted for 13.3 percent, 46.7 percent, and 40 percent of total number of selected family in the study area. About 46.67 percent farmers had 5-10 years of experience, 40 percent had 11-20 years of experience and 13.33 percent had above 20 years of experience on agar farming (Table 2). It was revealed that the young and middle aged people with low-level of education and long experience engaged in agar producing activities.

Table 1. Basic information of agar plantation in Barlekha

Particulars	Information
Season of seed sowing	March - April
Season of seedling planting	June - September
Maturity period of agar plant harvested in natural method	25 - 30 years
Maturity period of agar plant harvested in nail method	12 - 15 years
Time of pruning	3 - 5 years
Time of nail setting	6 - 7 years
Average height of mature tree	10 - 15 meter
Season of harvesting	October - March

Source: Field survey (2017)

Table 2. Socio-economic characteristics of agar farmers

Items		Percent of total
Age group	25-40 years	53.4
	41-50 years	23.3
	Above 50 years	23.3
Education Level	Illiterate	16.7
	Primary	43.3
	Secondary (up to S.S.C level)	36.7
	H.S.C and above	3.3
Household size	Small (3-4 persons)	13.3
	Medium (5-6 persons)	46.7
	Large (7 & above)	40
Experience	5-10 years	46.67
	11-20 years	40
	Above 20 years	13.33

Source: Field survey (2017)

3.3 Economics of Agar-wood Production

3.3.1 Cost of agar-wood production

Total cost of production involves all cost items incurred by the farmers in cultivating of agar plant during a period of 12 years. The total cost was derived by adding variable cost and fixed cost, and total variable cost comprises material cost labour cost for agar production. The variable cost of per acre of agar plantation was calculated as BDT 1330571.20 and per agar tree was BDT 1478.40, which was 91.73 percent of the total cost. Total fixed cost was BDT 120000.00 per acre and BDT 133.33 per agar tree, which was 8.27 percent of the total cost. Under variable cost, material cost was calculated as BDT 797991.19 per acre and BDT 886.65 per agar tree which was 55.00 percent of the total cost and labour cost was BDT 33615.81 per acre and BDT 37.35 per agar tree, which was 2.33 percent of the total cost. Among different cost items, purchasing of nail for nailing on mature agar plant (6-7 years) occupied highest share (52.93%) of total cost (Table 3).

3.3.2 Gross return, net return and benefit cost ratio

It was estimated that 900 agar tree can be obtained from 1 acre of land due to damage of some seedlings at initial stage of production (assumed 75 percent survival rate). The farmers sold their agar plant to the processors and the price was fixed through the bargaining. The average price of agar plant was BDT 3,715 per tree. The gross return of agar farmers was BDT 3343500.00 per acre (Table 3). The net return was estimated at BDT 1892928.80 per acre and BDT 2103.27 per agar tree. Benefit cost ratio (undiscounted) of agar farmers was estimated at 2.30, that means the farmers are getting BDT 230 by investing BDT 100 (Table 3). This indicates that, agar-wood production is a profitable business.

3.4 Financial Viability of Agar-wood Production

Thus financial viability for agar-wood production was determined for a farm of 1 acre of land for a period of twelve years. Cash inflow, cash outflow and incremental net benefit (INB) with their present values for a duration of 12 years are shown in (Table 4). Most of the cost items of agar production incurred in the first year of operation. Because of nailing cost gross cost was highest in seventh year. The net present value calculated at 10% discount rate was BDT 552326.54 (Table 5). Similarly, discounted benefit cost ratio was 2.07 which means that BDT 100 of initial investment yields a net benefit of BDT 207. The internal rate of return was 23.70% which was very high as compared to required rate of return i.e. 10%. Since, IRR was greater than the required rate of return representing the opportunity cost of capital, investment on agar production was financially viable.

3.5 Sensitivity Analysis

"Reworking an analysis to see what happens under these changed circumstances is called sensitivity analysis" [15]. Sensitivity analysis shows how the profitability of the projects changes with changes in the value of any variable/variables in the discounted cash flow analysis.

Table 3. Cost and return of agar-wood production in the study area

(Per acre= 900 tree)

Sl. no.	Items of cost			Unit	No./ quantity	Price (BDT/unit)	Total Value (BDT/ acre)	Value (BDT/ tree)	% of total cost
	Variable Cost								
	I	Material Cost		BDT	-	-	797991.19	886.65	55.00
	1.	Agar seedling		Piece	1200	19.20	23048.33	25.61	1.59
			Urea	Kg	127.17	17.12	2177.15	2.41	0.15
			TSP	Kg	57.23	23.44	1341.36	1.49	0.09
A.	2.	Fertilizer	MoP	Kg	11.56	16.25	187.86	0.21	0.01
			Compost	Kg	117.34	13.73	1611.09	1.79	0.11
	3.	Cow dung		Kg	90.17	2.00	180.35	0.20	0.01
	4.	Cost of nail		Kg	13237	58.00	767746	853.05	52.93
	5.	Insecticide		Kg	1.79	435.22	779.05	0.87	0.05
	6.	Irrigation		BDT	-	-	920.00	1.02	0.06
	II	Labour Cost		BDT	-	423	33615.81	37.35	2.33
	1.	Collection of seedling		Man-days	6.59	423	2787.57	3.09	0.19
	2.	Preparation of land		Man-days	13.41	423	5672.43	6.30	0.39
	3.	Hole preparation		Man-days	12.66	423	5355.18	5.96	0.37
	4.	Planting, thinning and gap filling		Man-days	9.48	423	4010.04	4.46	0.28
	5.	Fertilizer application and weeding		Man-days	8.38	423	3544.74	3.94	0.25
	6.	Insecticide application and pruning		Man-days	5.78	423	2444.94	2.71	0.17
	7.	Nail setting on mature plant		Man-days	23.17	423	9800.91	10.89	0.68
	III	Interest on operating capital		BDT	-	-	498964.20	554.40	34.40
	Total variable cost				-	-	1330571.20	1478.40	91.73
	Fixed Cost								
B.	1.	Land use cost		BDT	-	-	120000.00	133.33	8.27
	Total fixed cost				-	-	120000.00	133.33	8.27
C.	**Total Cost (A+B)**			BDT	-	-	1450571.20	1611.73	-
D.	**Gross return**			BDT			**-**		-
	1.	Agar plant		Piece	900	3715	3343500.00	3715	-
E.	**Net return (D−C)**			BDT	-	-	1892928.80	2103.27	-
F.	**BCR**			-	-	-	2.30		-

Source: Authors estimation based on field survey (2017); Note: 1acre = 100 decimal = 0.405 hectare

Table 4. Cash flows in agar-wood production for 1 acre of land in the study area

Year	Gross cost (GC)	Gross benefit (GB)	Incremental net benefit (INB)	Dis. factor @ 10%	Present value of GC	Present value of GB	Present value of INB
0	50836.10	0	-50836.10	1	50836.10	0	-50836.10
1	10000	0	-10000	0.91	9100	0	-9100
2	10000	0	-10000	0.83	8300	0	-8300
3	11612	0	-11612	0.75	8709	0	-8709
4	10000	0	-10000	0.68	6800	0	-6800
5	11612	0	-11612	0.62	7199.44	0	-7199.44
6	10000	0	-10000	0.56	5600	0	-5600
7	787546.91	0	-787546.91	0.51	401648.92	0	-401648.92
8	10000	0	-10000	0.46	4600	0	-4600
9	10000	0	-10000	0.42	4200	0	-4200
10	10000	0	-10000	0.39	3900	0	-3900
11	10000	0	-10000	0.35	3500	0	-3500
12	10000	3343500	3333500	0.32	3200	1069920	1066720

Source: Authors estimation based on field survey (2017)

Table 5. Financial viability of agar-wood production for 1 acre of land in the study area

Sl. no.	Particulars	Value
1.	Net present value (BDT)	552326.54
2.	Benefit cost ratio	2.07
3.	Internal rate of return	23.70

Source: Authors estimation based on field survey (2017)

Table 6. Sensitivity analysis of agar production

Sl. no.	Situation	NPV (BDT)	BCR	IRR
1.	10 per cent increase in the cost of nails	513171.50	1.92	22.40
2.	10 per cent increase in labour cost	550189.54	2.05	23.56
3.	10 per cent increase in gross cost	500567.19	1.88	21.67
4.	10 per cent decrease in agar tree price	445334.54	1.86	21.42

Source: Authors estimation based on field survey (2017)

From financial analysis which was stated earlier it was proved that agar-wood production is a source of great profit. At first, sensitivity analysis was conducted on the assumption that, what would happen if only cost of nails increased by 10 percent while all other costs of the project would remain the same. In second case, it was assumed that labour cost increased by 10 percent while all other costs remain the same and in third case, gross cost increased by 10 percent. In last case, it was assumed that, if agar tree price decreased by 10 percent than what would happen to project NPV, BCR and IRR. The (Table 5) showed results of sensitivity analysis for agar-wood production units. The benefit cost ratio was more than 1.88 even with 10 per cent increases in the cost of nails, cost of labour and gross cost. Also, even if the agar tree price falls by 10 per cent, the benefit cost ratio would still be above 1.86.

3.6 Problems Encountered by Agar Farmers

3.6.1 Scarcity of high quality seedlings

The growth and quality of agar plant largely depends on seedlings. Low quality seedlings can easily affected by different insects and diseases. For this their survival rate is low. In the study area, good quality seedlings were scarce and price of seedlings were high. Previous research [9] also mentioned this problem in his study on agar plantations.

3.6.2 Lack of training

Training on agar cultivation and management is essential for better production. But in the study area, training facilities on agar cultivation and management was very lacking. About 60 percent sample farmers mentioned that they did not get any kind of training regarding agar cultivation and management.

3.6.3 Lack of credit

Agar-wood production cost is very high and all the farmers in the study area were not economically solvent. They need money for running their farming operations, but credit was available only at a very high interest rate. Previous research [9] also revealed that, lack of credit facilities was a major problem in agar processing.

3.6.4 Labour scarcity

Without efficient labour, work is not possible in any sector. In the rainy season shortage of human labour prevail in the study area and cost of labour was very high. About one in every three respondent farmers in the study area reported this problem.

4. CONCLUSION

Agar is probably one of the most valuable tree species in the world, yielding various non-timber forest products (NTFP). The hill agro-ecosystems of north-eastern Bangladesh is ideally suited to grow agar and could be an excellent producer of cultivated agar. This high valued tree would benefit rural people and contribute greatly to the economy of the region. The findings suggested that production of agar-wood is a profitable enterprise with better net return BDT 1892928.80 per acre and BDT 2103.27 per agar tree and benefit cost ratio (undiscounted) 2.30. From the financial viability study of agar-wood production for a farm of 1 acre of land and for a period of 12 years it was estimated that NPV was BDT 552326.54 at 10% discount rate, discounted benefit cost ratio was 2.07 and IRR was 23.70 % which was very high as compared to required

rate of return. Thus it can be concluded that agar-wood production is a feasible enterprise. However, agar farmers faced some problems regarding the management and cultivation of agar plant. Government and non-governmental financial organizations should provide financial support to agar farmers by delivering easy loan at lower interest rate. The Forest Department and NGOs (Non-Government Organizations) should strengthen training programs for agar farmers on agar cultivation and management. Government should provide favourable environment to encourage more people to engage in agar production.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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