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COMMERCIAL PRODUCTION PRACTICES, RETURNS AND RISK-BEARING ABILITY IN THE SMALL-SCALE GARDENING OF AGAR PLANTS IN SELECTED AREAS OF BANGLADESH

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ABSTRACT

Commercial gardening of Agar Plant (AP) is an emerging part of agribusiness enterprises in Bangladesh which is existence in some cases at a small scale of limit, demanding the proper strategies for prompting AP commercial production. Therefore, the objectives of the study were to identify the commercial production practices, producers' returns and the risk-bearing ability in small-scale gardening of agar plants. Bharlekha upazila in Moulvibazar district of Bangladesh was selected as the study area. Data were collected from randomly selected eighty AP producers of that area during the year 2017.The average life of the plants is around 16 years, and the production activities are the seed and sapling collection and growing; land selection and preparation and sapling planting; intercultural operation; nail setting on agar plants; and harvesting and selling which are mainly done by the AP producers. There is a strong backward and forward linkages have been identified. Results showed that the AP plant production enterprise is highly profitable only in the long-term period of 16 years time, which is not possible in short-run. Also, the break-even analysis of AP production resists a large drop of yield and price before incurring a loss, which gives the farmers a comfortable margin of safety and a risk bearing ability. The study recommended that the government and non-government organizations should come forward to provide directions and supports for promoting and sustaining agar plant production on commercial basis throughout the country.

Keywords: agar plant, commercial production, small-scale gardening, risk-bearing ability

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INTRODUCTION

There are various species of aromatic plants in the world and of them, agar plant (*Aquilaria malaccensis* species) is one and only the variety is found in Bangladesh, but at present, natural existence of agar plant is almost absent. *Aquilaria malaccensis* (agar plant) is widely distributed in South and Southeast Asia. There are differing accounts of the countries in which it occurs. *Aquilaria malaccensises* found in 10 countries viz. Bangladesh, Bhutan, India, Indonesia, Iran, Malaysia, Myanmar, Philippines, Singapore and Thailand. At the end of 2004, all Aquilaria species were listed as a threatened species. *Aquilaria malaccensis* (agar plant), the primary source of agar has also been listed as a threatened species by the 'Convention on International Trade in Endangered Species of Wild Fauna and Flora' (CITES, 200; Chowdhury, M. *et. al.* 2018). Agar is one of the most promising Non-Timber Forest Products (NTFPs) of Bangladesh. Despite the huge demand in local and international markets, no major extension program has so far conducted by governments or other agencies in Bangladesh. The Forest Department (FD) recently raised some agar plantations in denuded and encroached forest areas of the Chittagong and Sylhet districts. In the homestead, farmers have planted agar tree in different micro sites e.g., home yard, back yard, front yard, boundary and marginal land. Media, including television and radio are playing major roles for promotion of agar plant sector. There are also some privately-owned agar plantations in the north-east, particularly in Moulvibazar district where many families have been engaged in production and marketing of agar and agar-based secondary products for several decades (Aktar, N. 2016). In an addition, several reports have been come up with small scale and personal agar wood plantations in Sylhet, Habiganj and Chittagong Hill Tracks. Bangladesh is favourable for agar tree production commercially. But very little information is available on cultivation practices, processing and its problem and profitability. Now, there is a need to study the process as ample scope of a boost up its production, particularly in south-east hilly regions in the country (Aktar, N. 2016). Rigorous research is needed for development of agar enterprise and increase systems productivity with intercropping of other plants or crops (Ali, S. and Kashem, M. A. 2019). In view of this situation the present study was attempted to analyze cultivation practices, market linkages and the cost and returns of agar plant production in Bangladesh. It was expected that present study would be very effective and informative for national research development and policy formulation.

In Bangladesh the heritage of agar plant and industry is about one-thousand-year-old, which was established basing on agar plants produced in Barlekha upazila of Maulavibazar district

(Boxes *et al.*, 2009). In some areas of Moulvibazar, Sylet, Chittagong Hilltracts and Cox's Bazar districts, APs are commercially cultivated in private land, homestead garden, government leased land and forest. Besides, it is scatteredly cultivated in limited scale in other portions of Bangladesh. In country, majority of the farmers as well as agro-entrepreneurs are still now almost totally unaware about the profitability of AP production. Few producers in Bangladesh are now growing APs with their own initiatives. No prescribed methods for cultivation, harvesting, transformation, handling, processing and storage of APs are practiced by the producers. The AP producers perform all these activities in their own indiscriminate ways and methods. On the other hand, appropriate and scientific methods for performing the mentioned activities are still not prescribed by any government organizations (GOs) or non-government organizations (NGOs). To establish potential, widespread and sustainable production of APs in the country should be completed through standard and scientific ways and methods. Under this backdrop, the present study makes an effort to identify the indiscriminate ways and methods used by the AP producers and provide suitable suggestions to develop standard and scientific ways and methods for the activities of the AP production sector. Overall, it is worthy mentioned that all activities of AP production enterprise are dealt with own initiatives and experiences of the producers. Organizational promotion activity and policy support are mainly absent for the AP production. Therefore, in aspect of agribusiness a complete study on commercial production of APs needs to be assessed the present status of this sector. Although several studies were carried out in previous time but they show far difference from the present study in terms of information, methods and results. By addressing the research gap, considering the present hindrance settings, the study has been undertaken to identify the functions of AP producers, their backward and forward linkages to AP production enterprise, the profitability of the enterprise, and the risk bearing ability by means of AP production in the study locations. Key research questions of the present study are: (i) what are the functions of AP producers in the study area? (ii) by what means the backward and forward linkages to AP production enterprise? (iii) how much it actually costs to produce AS and makes return? and (iv) are AP production farmers have risk bearing ability at different risks of price, yield and costs. However, the specific objectives of the study are: (i) to identify functions of agar plant (AP) producers in the study area;(ii) to analyze backward and forward linkages to AP production enterprise;(iii) to estimate the profitability of AP enterprise, and (iv) to evaluate the risk bearing ability to AP production at different risks of price, yield and costs. We believe that the findings of the study will be helpful for producers, researchers and policy makers to take

information on production decision, future research work formulation and policy decision regarding the AP sector of Bangladesh.

METHODOLOGY

Study area

The history of agar plants (APs) in Bangladesh is very ancient and it was naturally growing in Sythet, Chittagong, Cox's Bazar and Chittagong hill tracts from time immemorial but at present natural grown of agar tree is very hard to find in country (Ali, S. and Kashem, M. A. 2019). Among those, the Baralekha upazila under Moulvibazar district is famous for AP production and processing, thus this upazila has been selected for the study area (fig-1). Baralekha upazila is situated between 24° 33' and 24° 50' north latitude and between 92° 20' and 92° 18' east longitude. The upazila is bounded on the north by Bianibazar (Sylhet), on the east by India, on the south by Kulaura, on the west by Golapganj and Shrimongal upazilas (sylhet).

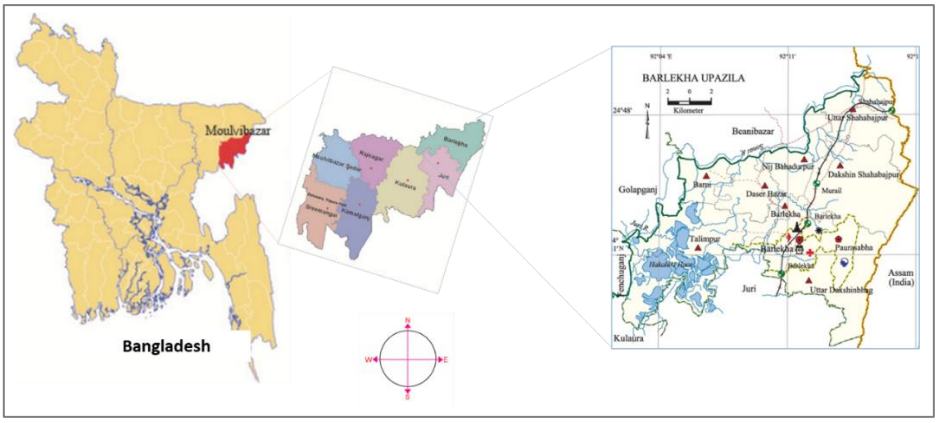

Figure-1: Location of Bharlekha upazila of Moulvibazar district in Bangladesh

The largest commercially cultivated cluster of APs in Bangladesh like 6 unions out of 10 in Bharlekha upazila of Moulvibazar district was selected for collection of the primary data. The six unions of investigation were Dakhinbag Dakhin, Dakkhinbag Uttar, Sujanagar, Nizbahadur (including Pourosova), Sahbagpur Dakkhin and Sahbagpur Uttar. As the unions are closely situated, they were considered as a single cluster for commercial AP production. Before selecting the study area properly, field visits were performed by the researchers in several AP produced areas in country.

Sampling design: About 550 farmers in the study upazila are gardening of APs in their farm land commercially. Therefore, the study is considered the population size (N) at 550. The study also assumes 15% of precision (e), 95% of confidence level (Z=1.96) and 74% of variance in population (σ). The formula for required sample size is,

$$n = \frac{Z^2 * \sigma^2 * N}{(N-1)e^2 + Z^2 * \sigma^2}$$

Result founds sample to be n =80.035 for this study. Therefore, for better representation of the population the total sample size is taken as 80 farmers.

Methods of data collection

The study was analysed mainly on the primary data collected from AP producers through face-to-face interview survey by using a pre-tested questionnaire. Based on the basic information collected through FGDs and field visits, and field experience, a questionnaire was developed and then finalized by an effective field test. Thus, the collected information and data were properly processed and finally the processed data were analyzed by different statistical techniques. The respondents provide information from their memory as they normally don't keep record. Secondary data was also used in this study, which was gathered from a variety of journals, reports, websites, books, and handouts.

Period of data collection

The survey has been conducted with a household questionnaire from 15th July to the 15th December of 2017.

Data analysis

The data were analyzed using descriptive, mathematical and statistical technique. For data analysis, Microsoft Office Excel was used. The objective based analytical technique is discussed below:

Objective-i: Identification of functions of agar plant (AP) producers

The main functions of agar plant (AP) producers are qualitative information which have been identified by tabular analysis. For quantitative estimation, the basic statistical techniques like mean, sum, minimum, maximum or percentages have been used.

Objective-ii: Analyzing backward and forward linkages to AP production enterprise

In the analysis of backward and forward linkages to AP production enterprises, the supply chain mapping techniques has been used.

Objective-iii: Estimation of profitability

The profitability of AP production was measured in terms of gross return, gross margin, net return and benefit cost ratio.The gross return (GR) of *AP* was calculated by multiplying the total output at the farm gate price. The formula is-

$$GR_i = \sum_{i=1}^{n} p_i * y_i$$

where,y_i = Quantity of the main product; and P_i = Per unit price.

Gross margin (GM) was estimated where variable cost (TVC_i) is deducted from total return, then net margin (NM) was estimated by deducting fixed costs (TFC_i) from GM. For this purpose, the following equation proposed by Dillon and Hardaker (1993) was used.

$GM_i = GR_i - TVC_i$

$NM_i = GM_i - TFC_i$

where, total cost (TC) includes all types of variable and fixed cost items involved in the production process. The total cost was estimated as follows:

$$TC_i = \sum_{j=1}^{n} P_{x_{ij}} x_{ij} + TFC_i$$

where, $\sum_{i=1}^{n} P_{x_{ij}} x_{ij}$ = TVC_i = Total variable cost; x_{ij} = Quantity of the j[th] variable; $P_{x_{ij}}$= Per unit price of the j[th] variable input; and TFC_i = Total fixed cost.

Then the study analysed benefit-cost ratio (BCR). Here, BCR was measured in the undiscounted level, the formula of BCR is:

$$BCR_i = \frac{GR_i}{TC_i}$$

The decision rule is that; a high ratio more than one indicates high net possibility to profits.

Objective-iv: Evaluation of risk bearing ability at different risks of price and yield

The study applied break-even point and margin of safety percentage methods to evaluate the farmers' risk bearing ability to AP production at different risks of price, yield and costs.

Breakeven equations were formed by arithmetic manipulation of the profit equation and solving for the item of interest. In breakeven point $NM_i = 0$, thus $p_i y_i - VC_i - FC_i = 0$. Therefore, the breakeven points can be written as:

The break-even points for output, $y_{be} = \frac{VC_i + FC_i}{p_i}$;

The break-even points for output price, $p_{be} = \frac{VC_i + FC_i}{y_i}$;

Finally, the study resulted the economic safety margin by estimating the margin of safety percentage (MSP) using the following formula:

$$MSP_i = \frac{Y_i - y_{bei}}{Y_i} \times 100$$

where, Y_i = actual value; and y_{bei} = breakeven value.

The study derived margin of safety percentage for yield and price for AP. No doubt, a greater margin of safety indicates the soundness of the business. The unsatisfactory margin of safety

can be rectified by lowering variable or fixed cost, by increasing selling price or by substituting unprofitable product by profitable product.

RESULTS AND DISCUSSION

In the study area, APs commercially cultivated in both homestead gardens and in the field areas. APs are the major crops and the sources of livelihood, and based on the plants, several agribusiness enterprises have been developed. Therefore, activities of the AP producers, backward and forward linkages to the AP production enterprise and estimation of cost, return and benefit-cost ratio (BCR) as parts of profitability and break-even analysis are discussed below.

Functions of AP Production Enterprise:

Some activities such as seed and sapling collection and growing; land selection and preparation and sapling planting; intercultural operation; nail setting on agar plants; and harvesting and selling of agar plants are mainly done for agar plant production in gardens. So, these activities are mentioned in detail in the following.

(a) Seed and Sapling Collection and Growing: Both naturally and nursery grown mature saplings are only used by the growers for production of APs in their gardens. The mature saplings are grown from the seeds and immature saplings collected from four major sources such as own supply of AP producers; other local AP producers; local seed and sapling collectors; and local sapling growers. Some AP producers collect seeds and immature saplings from their own and others' plant gardens for growing mature saplings and sometimes naturally grown saplings are also used in the gardens without transplanting. Besides, several local AP producers also collect seeds and saplings from their own and other producers' gardens and sell the same along with own seeds and saplings to other producers. Moreover, some local collectors procure seeds and saplings from the local AP gardens and then sell them to the local AP producers. The peak periods of the seed and sapling collection are middle March - middle April and middle April – Middle June, respectively. On the other hand, some local sapling growers grow the saplings commercially in their nurseries and the AP producers collect the mature saplings from the nurseries. The price per saplings collected by the producers from all the sources ranged from Tk 1 to 5 being average of Tk 2.75.

(b) Land Selection and Preparation and Sapling Planting for AP Production: Land is the most important factor for AP production and all activities of the production are performed by the producers in their AP garden. In the study area, it was depicted that a large portion

(56.46%) of total land under cultivation of the producers was utilized for AP production. As a forest plant, agar is usually cultivated under local traditional method. No intensive care or special prescribed method is practiced for producing the plants. Agar plant is seriously water sensitive, so the plants are always cultivated in sloped high land where no water logging exists. Saplings are ordinarily planted round the year, but middle April – middle July is the peak period of planting. On the other hand, due to natural calamity like storm, heavy drought, heavy rain, theft, pest and disease attack; a considerable number of plants are damaged and lost in the garden. Many activities like tillage, cleaning and leveling of land, making pit (hole), mixing fertilizer with soil in pit, collection of saplings, planting saplings, etc. are done sequentially by the producers. But for natural plant garden, no such activity is done. Moreover, all the activities are performed by using both home supplied and hired labors. Hired labors are employed both daily and contract basis. Generally, no female labor is involved in these activities. In the case of contractual labor, all the activities are considered as a package and total wage is determined in advance through open bargaining in terms of cash payment. Some basic information regarding cultivation of the plant is presented in Table 1. It is displayed in Table 1 that area under plant garden, plant per garden and damage & loss rate of plant ranged 2 to 1000 decimal (average 86.71 decimal), 30 to 100000 (average 4112) and 20 to 30 % (average 27 %), respectively. On the other hand, variation in area of garden and number of plants in the gardens were found 998 decimals and 99970 plants, respectively. Moreover, high variation also existed for pit depth (12 inch), pit diameter (16 inch), distance in line to line (5 feet) and distance in sapling to sapling (5 feet). So, it is realized from the variations of all the factors that no standard method is followed for cultivation of agar plants in the study area.

Table 1: Information about Cultivation of Agar Plant

Item	Unit	Min	Max	Ave
Area per plant garden	Deci	2	1000	86.71
Produced plant per garden	No.	30	100000	4112
Produced plant per hectare	No.	3705	24700	11713
Damage & loss rate of plant	%	20	30	27
Pit depth for sapling planting	Inch	6	18	11.88
Pit diameter for sapling planting	Inch	2	18	11.05
Distance- line to line for sapling planting	Feet	1	6	2.81
Distance- sapling to sapling for planting	Feet	1	6	2.55

Source: Authors own calculation

(c) Intercultural Operation for AP Production: Some intercultural activities like weeding, fertilizer and pesticides application and irrigation are done by some producers as per necessity within the period of 1 to 5 years after planting sapling in gardens. But for natural plant gardening, no intercultural operation is needed. Besides, it was observed that in hill track (high land) areas no intercultural operation is generally performed by the most of the producers. Saplings are mainly planted in rainy season, so irrigation is usually unnecessary except heavy drought. Both chemical fertilizer and manure are applied in pits. Irrigation and fertilizer are not needed for fertile land. In rare case, some unknown pests (locally named ulupoka, bisapoka) attack and damage the stems and leave. Appropriate pesticides and method for controlling the pests are unknown to the producers. For these reasons, pesticides application is very limited practice. On the other hand, caretakers are recruited by the producers in mainly large size gardens for intercultural operations, protecting theft, making contact & contract, financial transaction, and liaison with local financial organizations (banks, NGOs), forest office, public security administration (like police, BGB). It is found in Table2that all the producers are not involved in intercultural operation and input application. The maximum of 66.75 percent producers did weeding on average 2 times, whereas the minimum of 5 percent applied compost 1 time. The maximum percent (66.75%) followed by 48.75, 30, 28.75, and 17.50 percent of producers who applied urea, cow dung, TSP, MP, respectively whereas 7.50 percent was involved in both pesticides' application and irrigation only for one time. But it is found that only 1.25 percent producers applied urea, pesticides and irrigation for 14, 6 and 48 times, respectively (Table 2).

Table 2: Information on Intercultural Operation of AP Production

Activity		No. of application			Producers involved in activity	
		Min	Ave	Max	No.	%
Weeding		1	2	6	53	66.25
Fertilizer application	*Cowdung*	1	1	2	24	30
	Compost	1	1	1	4	5
	Urea	1	1	14	39	48.75
	TSP	1	1	2	23	28.75
	MP	1	1	1	14	17.50
Pesticides application		1	1	1	6	7.50
Irrigation application		1	1	48	6	7.50

Source: Authors own calculation

(d) Nail Setting in Agar Plants for Production: For creating infection in the plants artificially, nails are set in the agar plants. Mainly two factors- age and growth of plants are significantly considered for setting nails in plants. Before setting in the plants, the nails are at first sorted and then the sorted nails are rectified through boiling in water or heating in sunlight or burning in fire. In case of advance selling, nails are always set in the plants by purchasers (local processors) after purchasing the plants. But for normal selling, nails are always set by the producers. In few areas, agar wood is mostly made in the plants by natural (agar) pests and in this case, nail is not set in the plants. Nails are usually set in the plants by local skilled hired labors before 2 to 5 years of plant harvest.

It is revealed in Tab-3that age of nail setting, quantity of nail and number of labors differed from plant to plant and the variations were 11 years, 8 kg and 8 persons, respectively. The variations were created due to mainly variation in size (length and diameter) of the plants. Moreover, more of purchasers (36.25 percent) compared with producers (32.50 percent) were involved in nail setting in the agar gardens.

Table 3: Setting of Nails in Agar Plants for Production of Agar wood

Particular	Unit	Min	Ave	Max
[1] Age of plants during nail setting	Year	5	10	16
[2] Quantity of setting nail per plant	Kg	4	8	12
[3] Plants setting nail by a labor in a day	Nos.	2	5	10
[4] Producers involved in nail setting	Nos.	26 (32.50)		
[5] Purchasers involved in nail setting	Nos.	29 (36.25)		
[6] Producer not involved in nail setting	Nos.	25(31.25)		

Source: Authors own calculation; Figures in parentheses are percentages

(e) Harvesting and Selling of Agar Plants in Producers' Level: Generally, agar plants are harvested round the year. But for the better quality, majority of the plants are harvested in dry (winter) season. It was found that the plants are always sold to the local processors in standing position before cutting. Due to non-uniformity growth of the plants and financial necessity, all the plants are not sold at a time; the plants are sold gradually in several times.

It was informed that agar plant is one kind of long live forest plant in the world and naturally perfect maturity period of the plants is about 150 years. Therefore, any specific age of the cultivated plants is never considered for harvesting or selling at producers' level. Several factors like growth size of plant, existing selling price of plant and financial necessity of producers are mainly considered for selling the plants. As a result, in both advance and

normal selling, plants are sold in different age and advance sale is done only for meeting financial needs of the producers. On the other hand, in fixing the selling price, life of the plant is not considered. So, in this case the factors which are considered in price determination are length of plant, diameter of plant and available attack syndromes (hole) by pests in plants. In normal selling, plants are harvested by purchasers during or just after selling, or as per non-written mutual and verbal contract between the producers and the purchasers. But for advance selling, all conditions are written on government non-judicial revenue stamp. Moreover, in all types of selling, price is fixed through open bargaining and payment is completed in cash during selling. Information about purchasing and selling of the plants is delivered between the agar plant producers and the agar product processors (purchasers) through several ways. For purpose of purchase, the processors always communicate directly with the producers at the producers' residences. Besides, information is also exchanged between the producers and the sellers through refreshment gathering at tea shops in local markets and over cell phones. It is depicted in Table 4that the maximum age of plants during advance selling, normal selling and harvesting from gardens were 22, 25 and 27 years, respectively and the minimum were of 3, 9 and 8 years being average of 9, 15 and 16 years, respectively. Again, during harvesting the highest length and diameter of plant culminated to the peak of 50 feet and 60 inches, respectively being the lowest 12 feet and 6 inches with average of 29 feet and 22 inches, respectively.

Table 4: Sale of Agar Plants by Producers

Particular	Unit	Min	Max	Ave
[1] Selling plant per hectare	No.	2841	18006	8493
[2] Age of plant during advance selling	Year	3	22	9
[3] Harvesting year of plant after advance selling	Year	1	12	4
[4] Age of plant during normal selling	Year	9	25	15
[5] Life duration of plant till harvesting	Year	8	27	16
[6] Length of plant during harvesting	Feet	12	50	29
[7] Diameter of plant during harvesting	Inch	6	60	22
[8] Price per plant for advance selling	Tk	400	6500	2413
[9] Price per plant for normal selling	Tk	1000	8000	4014
[10] Producer involved in advance selling	No.	62 (77.50)		
[11] Producer involved in normal selling	No.	18 (22.50)		

Source: Authors own calculation; Figures in parentheses are percentages

For advance and normal selling, the smallest prices per plant were Tk 400 and 1000 and the largest prices were Tk 6500 and 8000 yielding average Tk 6500 and Tk 80000, respectively.

Moreover, majority of the producers (77.50 percent) were associated with the advance sale of plants in the study area. The age and price variations of plant were found for both advance and normal selling. Age variation for advance selling and normal selling was 19 and 16 years, respectively and the same case, price variation was Tk. 6100 and 7000, respectively. Therefore, the largest age variation was related to advance selling, while the same for price was associated with normal selling. Moreover, age variation for harvesting from the gardens was also 19 years. It is understood from the table that due to non-consideration of age, plant duration differs for advance and normal selling and also for harvesting. Besides, price for all kinds mainly varied due to difference in length and diameter of plants and natural whole (attack) syndromes in plants. Activities related to production and marketing of agar plant identified in the present study are land selection and preparation, seed sowing, sapling planting, fertilizer application, pest and disease control, irrigation, nail setting, sale, etc. Boxes *et al.* (2009) and Chowdhury *et al.* (2018) in Bangladesh and Selvan *et al.* (2014) in India described some of these activities in their studies. Besides, Talucder, M. S. A. *et al.* (2016*)*, Blanchette1y, R. A. *et al.(2016),* Partomihardjo,, T. & Semiad, G., (2010), Aktar, N. & Neelim, A. Z. (2008), Tan, C. S. *et al*. (2019), Abdin, M.J. (2014), Aktar, S. (2013), Banik, B. R. and Chowdhury, M. N. A. (2014), and Barakoti, T. P. (2013) also identified similar and dissimilar activities compared to the activities mentioned in the present study. But all the activities have been systematically described in the present study which was not done in any previous ones. Some numerical information (results) relating to agar plant production determined in present study are produced plant/ha, planting distance of sapling, age of plant during nail setting, quantity of nail setting per plant, duration of plant till harvesting, length and diameter of plant during harvesting, average selling price /plant, etc. This information is supported by the information exhibited in the study of Boxes *et al.* (2009). But the figures differentiate due to difference in time of study of the two research works.

Backward and Forward Linkages of AP Production Enterprise: Based on the investigated areas, backward and forward linkages of AP production enterprise were identified under this study. AP producers are principal (central) actors of the linkage. So, apart from the producers, AP sapling growers are active in the backward linkage while agar product processors are involved in the forward linkage. Moreover, seed and sapling collectors, and plant producer of AP seed and sapling supply are also involved as vital stakeholders in the backward linkage. As a result, a strong supply chain consisting of the backward and forward linkage actors and stakeholders was promoted in the study area. The actors along with these supply groups

(stakeholders) are depicted fig-2. The functions of the actors and the stakeholders are discussed as follows.

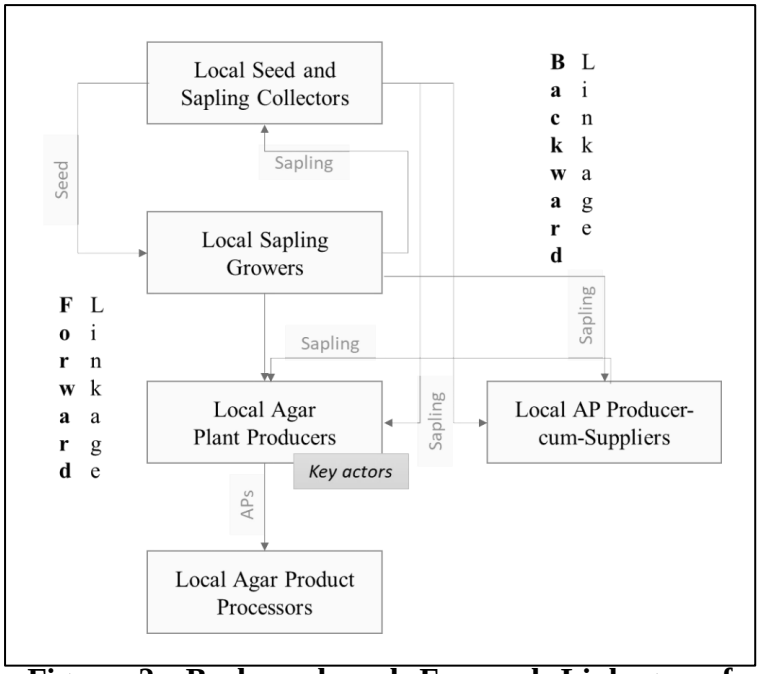

Figure 2: Backward and Forward Linkages of Agar Plant Production Enterprise

Local AP producers

Plant producers are considered as the key (major) actors in the supply chain. They add value through selling and create only 'possession utility' with the plants. Some kinds of activities related to agar plant production and marketing are done by the producers. These activities are collection and growing of agar seeds and saplings, sowing and planting agar seeds and saplings, land preparation, intercultural operations (fertilizer and pesticide application, irrigation, weeding, nail setting, etc.), harvest and selling of plants. The producers sell their plants only to the local processors always from their plant gardens. It was observed that all the activities are operated and done in their plant gardens and residence houses.

(a) Local AP Sapling Growers: Sapling growers are the backward linkage actors in supply chain. They add value to saplings through selling and thus create only 'possession utility'**.** They are involved in several activities like seed and sapling (immature) collection and growing, bed preparation, immature sapling planting, intercultural operations (fertilizer and pesticide application, irrigation, weeding, sapling replacement in beds), sapling selling, nursery management, etc. The saplings are sold mainly to the local agar plant producers, but very few of them are sold to outside producers of surrounding areas of Barlekha upazila. It was found that the growers always perform all the activities in their nurseries.

(b) Local AP Processors: Processors are one of the forward linkage values adding actors in AP supply chain. They add value through processing and create mainly 'form utility' of the agar plants. The processors are only the actors who are engaged in the multi-types and most difficult activities related to plant and product processing. These activities are plant (factory) establishment, plant purchase, harvest and procurement of purchased plants,

converting plants into agar oil, wood and chips, packaging, storing, selling etc. The processors purchase plants only from the local producers and sell their products only to the local exporters and local suppliers. The processors conduct and perform all the functions of the processing enterprise from their residence houses and processing plants.

(c) Local AP Seed and Sapling Collectors: Local seed and sapling collectors work as backward linkage stakeholders in the supply chain. Some local boys and girls seasonally collect seeds and immature saplings from local agar gardens and then sell the same to local sapling growers and producers. All the functions of the collectors are based on own residence.

(d) Local AP Producer Suppliers: Some agar plant producers also work in backward linkage stakeholders of supply chain. The producers collect seeds and immature saplings same as collectors from their own and others' gardens seasonally. Then they sell them to local plant producers and sapling growers. The producer suppliers always conduct their supply activities from their residence.

A strong backward and forward linkage of AP production enterprise consisting of 3 actors (producers, sapling growers and processors) was determined in present study in the investigated area. Moreover, some other stakeholders like local seed and sapling collectors is also to be involved directly in the linkage. Uddin *et al.* (2008) in Bangladesh determined marketing flow chart of agar-based products where the included some stakeholders were growers, processors, local traders, retailers, exporters and international traders. Antonopoulou *et al.* (2010) of Malaysia and Maiti and Geetha (2013) of India identified several such participants in the distribution channel of UAE and Indian agarwood market, respectively. Moreoverover, Chowdhury, M. *et al*. (2016), Chua, L.S. L. (2008), Compton, J. and Ishihara, A. (2010) and Selvan, T. *et al.* (2014) also determined some entrepreneurs/actors, stakehokders and buyers in their studies that show consistence and difference with theses actor groups identified in the present study due to variation study method, period, areas, sizes, activities, etc. So, all the actors and stakeholders of the previous studies support directly or indirectly the actors and stakeholders of the present study.

Profitability of AP Production Enterprise: For the purpose of profitability analysis, different types of costs and return associated with the AP production enterprise were studied. Average total cost per hectare was the summation of all individual cost items, whereas average gross return per hectare was the total sale value of the plants. On the other hand, average net return per hectare for AP production enterprise was determined from the difference between gross return and total cost while BCR was estimated from the gross return divided by total cost. All

the costs and the returns were calculated from average value encountered by the AP producers. In these circumstances, all costs and returns per hectare for the APs were calculated based on their average life duration. Therefore, the costs and returns involved in the AP production are as follows.

(a) Costs of agar plant production enterprise: Some major costs involved in agar plant production were determined as input, labour & machinery, caretaker and opportunity costs and total cost was determined from the summation of the major costs. Sapling, fertilizer, pesticides, irrigation and nail costs are added under input cost, whereas sapling planting, intercultural operation, nail setting and land preparation cost are associated with labor & machinery cost. On basis of the collected information and field observation, it was mentioned that all these costs occurred in irregular basis within 1 to 5 years after planting in the gardens. As a result, calculation of these costs is not possible each year basis. On the other hand, Costs of garden land and interest of operating capital are identified as opportunity cost; while salary of garden caretaker is considered as caretaker cost. Based on the average harvesting age of agar plant (16 years), average opportunity cost of garden land and salary of garden caretaker were determined.

It is revealed in Table 5 that average total cost per hectare was estimated at Tk. 6394047 of which the highest share of 62.10% was occurred for opportunity cost and it was followed by care taker (36.03%), input (1.02%) and labour & machinery (0.85%) costs.

Table 5: Costs of Agar Plant Production (per hectare)

Cost item			Total cost (Tk)	% in total
Variable cost			**179823**	2.81%
Sapling			21328	0.33%
Fertilizer:	*i.*	*Cow dung*	801	0.01%
	ii.	*Compost*	591	0.01%
	iii.	*Urea*	2378	0.04%
	iv.	*TSP*	1593	0.02%
	v.	*MP*	1010	0.02%
Total of fertilizer cost			6373	0.10%
Pesticide			351	0.01%
Irrigation			1406	0.02%
Setting nail			36046	0.56%
Labour&	*i.*	*Sapling planting*	29698	0.46%
machinery	*ii.*	*Intercultural operation*	14474	0.23%
cost:	*iii.*	*Nail setting*	4750	0.07%
	iv.	*Land preparation*	5051	0.08%

Total of labour& machinery cost	53973	0.84%
Fixed cost	**6274570**	98.13%
Garden caretaker salary cost (Tk 12000/month)	2304000	36.03%
Opportunity cost of land	1644032	25.71%
Opportunity cost of operating capital (at 12%)	2326538	36.39%
Total cost (per hectare for 16 years life)	**6394047**	**100.00%**

Source: Authors own calculation

(b) Returns of agar plant production enterprise: For determining net return and BCR, at first gross return and total cost of the enterprise was estimated. All calculated returns and BCR are depicted in Table 6. It is revealed in Table 6 that per hectare average gross return, total cost and net return were determined at Tk.28162788, Tk. 6394047 and Tk. 21768741, respectively; while the corresponding figures per plant appeared at Tk 3316, Tk.753 and Tk. 2563, respectively. On the other hand, BCR of agar plant production enterprise was calculated 4.40. The BCR means that the producers earned a gross return of Tk. 4.40 or net return Tk 3.40 by investing Tk 1 (one) in agar plant production enterprise for the period of 16 years. It is resulted from the net return and the BCR that agar plant production enterprise is highly profitable in consideration of long-term period of 16 years, but in consideration of short-term period, operation of the enterprise is not possible.

Table 6: Gross Return, Net Return and BCR for Agar Plant Production Enterprise

Particular	Unit	Amount
Returns (Plant or Tree)	(no./ha)	8493
Selling price	(Tk/plant)	3316.21
Gross return	(Tk/ha)	28164571.53
Gross margin	(Tk/ha)	27984748.53
Net margin/ha	(Tk/ha)	21770524.53
Net margin/plant	(Tk/tree)	2563.35
BCR	Ratio	4.40

Source: Authors own calculation

Major 5 cost items of agar plant production identified in the present study were input cost, labor cost, opportunity cost of land, garden caretaker salary and opportunity cost of operating capital. Mamdat *et al.* (2010) in Malaysia identified similar four 4 cost items for plantation of aquilaria species of agar plant. Although cost items in both studies are of same nature, they differ in terms of importance which might be due to time and spatial variations between the areas of studies under consideration. BCR estimated in current research shows that agar production in study area is highly profitable. Mamdat *et al.* (2010) in Malaysia also found

such high profitability, while, Boxes *et al.* (2009) found profitable agar farming in their studies. So, all these findings clear that the studies support each other in terms of profitability of agar production in home and abroad.

Level of risk bearing ability in AP production at different risks: A summary of the results from the breakeven analysis is included in table-7 and figure-3 focusing results to the *AP* upon calculations for yield and output price. Results shows that the break-even points of yield of *AP* is 1,946 plant per hectare. This means that production of *AP* will be profitable only if their yield turns out to be above 1,946 plants per hectare. Similarly, it will be profitable if the producers able to receive their prices above Tk. 759.97 per plant.

Table 7: Break-even point and margin of safety for AP production

Indicators	Unit	Break-even points	Margin of safety	Direction
Yield	No. of plant/ha	1,946	77.08%	-
output price	Tk/kg	759.97	77.08%	-

Source: Authors own calculation

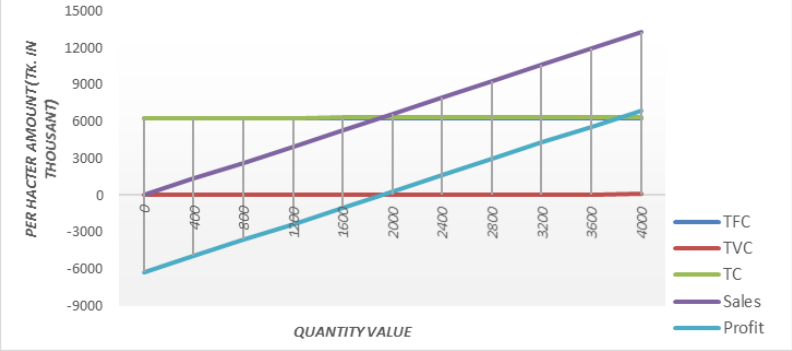

Figure 3: Break-even point for AP production

Figure-3 implies that the break-even analysis of *AP* production resists a large drop of yield and price before incurring a loss, which gives the farmers a comfortable margin of safety and a risk bearing ability.

Table-7 also shows that in the case of yield and price, the margin of safety percentage of AP is 77.08%. It means that at the current level of yields or prices and cost structure, a reduction in yields or prices of *APs* at 77.08% will result in just breaking even, vice-versa.

CONCLUSION

There are huge scopes for expanding commercial production of APs in country-wide and export markets of AP products in the middle-East as well as the whole of world which might become a reliable and important source of income of the producers and employment generation and foreign exchange earnings for the country. But in fact, majority of the farmers

as well as agro-entrepreneurs in our country are totally unaware about the benefits of AP production on commercial basis. Few producers in limited areas in our country are now growing APs commercially with their own initiatives and experience. In these circumstances, almost appropriate and scientific methods for performing all activities of the AP production are yet not prescribed by the GOs and NGOs. But to establish potential, widespread and sustainable production of the APs in the country and export markets of the AP products in the world, all the activities of AP commercial sector should be completed through standard and scientific ways. All the ways and methods need to be identified in order to provide appropriate suggestions and supports for the promotion of the AP commercial sector which are almost absent in both GOs and NGOs levels. Therefore, strong and committed endeavors regarding research, extension and export activities are essential for the integrated development of AP commercial sector in both country and abroad. Finally, a suitable support policy covering all aspects of AP enterprise sector should be developed and implemented by the coordination among GOs and NGOs

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