AGAR TREE CULTIVATION AND ITS ECONOMIC IMPORTANCE: A CASE STUDY OF MOULVIBAZAR DISTRICT

A THESIS

BY

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DECEMBER 2016

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REG.NO.:15-06975

A Thesis
Submitted to the Department of Agroforestry and Environmental Science
Sher-e-Bangla Agricultural University,Dhaka-1207
In partial fulfilment of the requirement
for the degree
of

MASTER OF SCIENCE
IN
AGROFORESTRY AND ENVIRONMENTAL SCIENCE
SEMESTER: JULY-DECEMBER, 2016

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CERTIFICATE

This is to certify that the thesis entitled **"AGAR TREE CULTIVATION AND ITS ECONOMIC IMPORTANCE: A CASE STUDY OF MOULVIBAZAR DISTRICT"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE AGROFORESTRY AND ENVIRONMENTAL SCIENCE*** embodies the result of a piece of bona fide research work carried out by ***NASRIN AKTER*, Registration No. 15-06975** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated:
Dhaka, Bangladesh.

Professor Dr. Nazmun Naher
Supervisor
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Dedicated to

My Beloved Parents

ACKNOWLEDGEMENT

*At first the author expresses all praises to the '**Almighty Allah**' who enables her to complete a piece of research work and prepare this thesis for the degree of Master of Science (M.S.) in Agroforestry and Environmental Science*

*The author likes to express her deepest sense of gratitude, sincere appreciation to her respected supervisor **Prof Dr. Nazmun Naher**, Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, for her scholastic guidance, support, encouragement and valuable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript.*

*The author also expresses her gratefulness and best regards to respected co- supervisor, **Prof. Dr. Md. Forhad Hossain**, Department of Agroforestry and Environmental Science,Sher-e Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimable help, valuable suggestions throughout the research work and preparation of the thesis.*

*The author states her sincere respect to **Prof. Dr. Nazmun Naher**, chairman, Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka for valuable suggestions and cooperation during the study period. The author also expresses heartful thanks to all the teachers of the Department of Agroforestry and Environmental Science, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.*

The author expresses sincere appreciation to her brother, sister, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

December, 2016

SAU, Dhaka **The Author**

AGAR TREE CULTIVATION AND ITS ECONOMIC IMPORTANCE: A CASE STUDY OF MOULVIBAZAR DISTRICT

ABSTRACT

Agar tree (*Aquilaria malacensis*) is the resinous, fragrant and highly valuable heartwood under Thymelaceae family.The study was conducted at Baralekha upazila in Moulvibazar district during the month of February-December, 2016 to determine the existing cultivation practices, plantation profitability and, problems of Agar tree. Forty agar cultivators were selected randomly for agar processors and agar tree chips/oil traders from three villages of Barlekha in Moulvibazar were randomly selected for the above purposes. Data were collected through direct interview of individual respondents. SPSS Computer package program 16.0 was used to analyze the data. The number of trees in homestead of the farmers ranged from 0 to 500 with an average 68. About 30% of the respondent farmers sold total Agar garden and 70% did not. The farmers who does not sell garden directly, among them 21.43% is involved in raw wooding, 64.29% is involved in processing atar and 14.29% is involved in both raw and processed. Two marketing channels are prevalent in the study area. About 64% of the farmers sell agar trees before artificial wounding, by agreement between the agar farmers and the agar-based enterprise owners. About 36% of the farmers sell agar trees after artificial wounding. Agar tree dust was mainly used as a by-product for the raw materials of agar production. The profitability of Agar production (raw) revealed that the discounted benefit cost ratio (6.55), and the internal rate of return (30%). So Agar tree production was found to be the most desirable and highly profitable.

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LIST OF ABBREVIATIONS

BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
0_C	=	Degree Celsius
DAE	=	Department of Agricultural Extension
e. g.	=	Example
et al.	=	et alia (L.) and other
etc.	=	et cetra
FAO	=	Food and Agricultural Organization
Fig.	=	Figure
FYM	=	Farm Yard Manure
GDP	=	Gross Domestic Product
ha	=	Hectare
ha^{-1}	=	Per Hectare
i.e.	=	id est (that is)
kg	=	Kilogram
km	=	Kilometer
M.S.	=	Master of Science
mm	=	millimeter
No.	=	Number
%	=	Percent
SSP	=	Single Super Phosphate
t ha^{-1}	=	Ton per hectare
Tk.	=	Taka (Bangladeshi Currency)
Viz.	=	Namely (L. Vide Licet)

CHAPTER I

INTRODUCTION

Agar tree (*Aquilaria malacensis*) is the resinous, fragrant and highly valuable heartwood in the Indo-Malaysian tree genus Aquilaria under Thymelaceae family. It is a large evergreen tree growing over 15-30 m tall and 1.5-2.5 m in diameter, and has white flowers (Chakrabarty, *et al*., 1994). They are best grown monsoon regions where annual rainfall is 2000 millimeters and hills and mountains of the tropical areas. Agar tree grows well in well drained high to medium high soil where moist and shady conditions are prevailed. It can also grow in poor sandy soil and tolerate cold or hot weather.

It is a fact that Agar tree is over harvested in the wild. IUCN-The World Conservation Union Red list categories of these six species are considered at risk from over-exploitation for agar wood (Anon, 2001). According to convention on International Trade in Endangered species of wild Fauna and Flora (CITES), *Aquilaria malaccensis* rated vulnerable and *A. crassna* is "critically endangered" while there seems to be some confusion over *A. agallocha.* This species is considered a synonym for *Aquilaria malaccensis* (Anon, 1994; Anon 1998a; Ng *et al*, 1997; Schippman, 1999) although some believe *A. agallacha* to be distinct species.The species, which attains a height of about 40 m, is tropical evergreen in nature and sometimes is also named as *A. malaccensis* (Chang, *et al*., 1997; Chowdhury, *et al*., 2003; Hayder, *et al*., 2005).

Agar tree is an aphrodisiac, both in oil form and in incense. There are generally used in tropical areas but the oil is also sold in Vietnamese pharmacies for internal use with the same goal. Chinese medicine uses powdered *Aquilaria* as treatment for cirrhosis of the liver and as a detector or focuser for other medicines. It has also been used as a treatment for lunge and stomach tumours. Mainly the Arabs are the proud customers of agar wood products. Agar wood incense has been burned to produce a pleasant aroma for centuries, on important religious ceremonies, by Buddhists, Hindus and Muslims (Ng and Azmi, 1997).

The essence extracted from agar wood is now widely used as a fragrance to manufacture beauty soaps and shampoos. Agar wood is highly prized incense that is extremely rare. It has at least a 3000 year history in the Middle East, China and Japan. Agar tree is the soft, dark heartwood that is produced by any of various south-east Asian evergreen trees (genus,especially *A. malaccensis* synonym *A. agallocha*) when they become infected with a fungus and that contains a fragrant resin used chiefly to produce incense, perfumes, and traditional medicines. When the inside of the tree becomes infected usually by insects, fungus or mold develops and bores into the tree, which attempts to defend itself by creating agarwood. Agar, eaglewood, gaharu are alternative names for the resinous, fragrant and highly valuable heartwood produced by *A. Agallocha* (Thymelaceae) and other species of the Indo-Malaysian tree genus *Aquilaria* (Barden *et al*., 2000; Das and Alam, 2001).

The history of agar in Bangladesh is very ancient and grows naturally in Sythet, Chittagong, Cox's Bazar and Chittagong hill tracts from time immemorial but at present natural grown agar tree is very hard to find. Agar is found irregularly in the forests of Sylhet, Chittagong and the Chittagong Hill Tracts (CHTs). Agar has never been cultivated commercially at wide range. At present, approximately 30 to 35 families of Patharia, Dakshinbhag and Sujanagar under Baralekha upazila in Moulvibazar district are directly involved with agar production and processing. Agar trees are grown in their homestead in combination with other trees. Agar is one of the most promising non-timber forest products (NTFPs) of Bangladesh, and earned Tk.1300 through exports of attar (agar oil) in 2004 (Hayder *et al.* 2005).

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.

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. Of the 121 registered agar-based factories nationally, 111 are located within this region, making a major contribution to regional employment and gross domestic product (Hayder *et al*., 2005). Furthermore, there are potential opportunities that would arise in the future for improving the livelihoods of poor people in the region by providing income generating means. 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. In view of this situation the present study was attempted to analyze cultivation practices, processing and the cost and returns of agar production in Bangladesh. It was expected that present study would be very effective and informative for national research development and policy formulation. So the objectives of the research work were:

1. To investigate the existing cultivation practices of Agar tree;

2. To evaluate the economic benefits of cultivating agar plants in Bangladesh and
3. To explore the relationship between the selected variables and yield of agar cultivation.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter is to review the past research works that are related to the present study. Only a few studies on Agar tree production have been conducted in abroad but no study has yet been conducted on socio-economic aspects of Agar tree production in Bangladesh. However the review of some related studies on Agar tree production have been furnished below under the following sections:

2.1 History of Agar tree

Agar wood is the infected wood of the *Aquilaria* tree. Called the wood of the Gods, its uses range from incense for religious ceremonies, perfume for the Arabic world, medicinal wine in Korea and ornamental functions in China. As a healthy tree the *Aquilaria* is worth next to nothing, but wounded its defence mechanisms produce agarwood and the tree becomes a valuable commodity. Agarwood is the heartwood produced by a number of *Aquilaria* species in Southeast Asia, with Indonesia, Malaysia, Vietnam, Cambodia, Thailand, Laos and Papua New Guinea as the main producing countries and Singapore being the main trade centre. The resin-impregnated heartwoods fragrant and as a result, is highly valuable. This resin is produced as a result of pathological or wounding processes. It is also thought that resin production is a response to fungal infection. Interestingly however, not all *Aquilaria* trees produce resin and it is extremely difficult (or even impossible) to judge from the outside of a tree whether or not it is infected. Cutting the tree is the only way to find out whether the tree contains the resin (Alam, 2004).

Plate 2.1: Agar plant and leaves with flower

2.2 Distribution and habitat

Aquilaria malaccensis is widely distributed in south and Southeast Asia. There are differing accounts of the countries in which it occurs. According to Oldfield *et al.* (1998), *A.malacensisis* found in 10 countries viz. Bangladesh, Bhutan, India, Indonesia, Iran, Malaysia, Myanmar, Philippines, Singapore and Thailand. The supporting statement accompanying India's proposal to list this species in the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) also names of Laos and Vietnam as range States. The status of *Aquilaria malaccensis* is these two countries requires confirmation, Oldfield *et al.* (1998) noting that they are range states for *A. crassna,* which is also heavily exploited for Agar tree. *Aquilaria* species have adapted to live in various habitats, including those that are rocky, sandy or calcareous, well-drained slopes and ridges and land near swamps. They typically grow between altitudes of 0-850 m, in locations with average daily temperatures of 20-22°C (Afifi, 1995; Keller, and Sidiyasa, 1994; Wiriadinata, 1995).

2.3 Soil, environment and climatic requirement

Agar tree grows well in hot and cold weather of warm and temperate region. Therefore, sandy-loam or clay-loam, non-base, light acidic soil of the area, and more rainfall is suitable for agar cultivation. The soil acidity (pH) 5.5 to 6.0 is well for agar cultivation. The Agar tree cannot tolerate waterlogged condition. This tree is well grown in association with Mango, Jackfruit and Jarul tree. Agar is highly exacting in its climatic requirement. A milder sub-tropical climate with an average rainfall of 600 to 2000 mm well distributed throughout the year is best suited for its normal growth. The plants are permanently injured when the temperature falls to zero (Chowdhury, M. 2014).

2.4 Conservation status

Considerable harvest pressure was noted in range States such as Indonesia, Malaysia and Thailand at the time when the species was proposed for inclusion. Recent information indicates that overexploitation remains a significant concern. A report by Chakrabarty, *et al* (1994) documenting India's trade in Agar tree concluded that *A.beccariana* highly threatened in that country due to exploitation of the species for commercial purposes. Seven other *Aquilaria* species are also considered threatened according to the IUCN Red List Categories, five of which are considered to be at risk from overexploitation for Agar tree: *A. beccariana* (Vulnerable); *A. crass*= (Critically Endangered); *A. cuiniugiana* (Vulnerable); *A. him* (Vulnerable) and *A. microcarpa* (Vulnerable) (Oldfield, *et al.*, 1998).

2.5 Wild and cultivated agar wood

In the past most agar wood has been harvested from the wild. Because it is extremely difficult, if not impossible, to see whether a tree contains agar wood or not most of the *Aquilaria* trees are chopped down indiscriminately. High quality agar wood can fetch as much as US$1000 per kilogram. Throughout history there has been an ever-moving frontier of agar wood exploitation across Asia as traders, continuously search for untouched forests containing *Aquilaria* trees (Barden *et al*., 2000). The trees were fetching high prices and as a result, the news about agar wood harvesting spread like gold fever. Large sums of money and all kinds of luxury items were offered to the forest dwelling communities, the traditional producers of agar wood. Usually this fever was temporary. Once the largest trees were cut, new harvesting expeditions became less successful and just as in the case of gold, the collecting of small quantities of agar wood became a less rewarding activity. The high prices for agar wood and the local depletion of resources in the wild have led to a variety of efforts to stimulate the growth of agar wood. The most common is the deliberate wounding of trees with large knives or the hammering of nails into tree trunks. In general such efforts do not yield very productive results.

Plate 2.2: Cultivated agar wood

The agar wood produced is of inferior quality and can only be used for home consumption. Moreover, high quality agar wood takes many years to develop. It is only during the last few decades that a more scientific approach has been adapted to cultivation. The main principle of the process was the drilling of holes in the tree trunk and keeping the wound open by putting a small piece of plastic pipe in the hole. A chemical treatment was added to the wound to encourage the trees defence mechanism which stimulates the production of the resin. After years of experimenting with the numbers of holes, the age of the tree, the amount of chemicals and other variables, the first trees were recently harvested and the production of incense made from the cultivated agar wood has begun. The success of the experiment implies that it will not be long before the method spreads to other areas where *Aquilaria* trees are being grown (Broad, 1995).

2.6 Inoculation Methods:

Agarwood is a resinous wood substance that is produced by the tree as a nonspecific host response to wounding, insect and/ or microbial invasion. The resin contains tree extractives that have aromatic terpenes present. *Aquilaria* is unique in that it produces phloem bundles within the xylem. This network of phloem and parenchyma produce and distribute the resin around affected areas as a tree defense reaction (Chowdhury, 2014). There are two kind of inoculation.

1.Natural Inoculation

2.Artificial Inoculation

1.Natural inoculation: In natural maturation process, no induction or injury is required but need years to achieve considerable amount of resin synthesis.Formation of agar wood can be initiated by natural injuries (by ant or snails) and mostly obtained at the junctures of broken branches.

2.Artificial inoculation: Artificial inoculation technique already developed and standardized in lab scale is found to be most effective and reliable method for enhancement of agar wood formation. Some methods are described here:

Nailing method: Wounding agarwood tree using blade or hammering of nails into the trunks has been used widely in the past, however agarwood yielded from this treatment is generally of inferior quality and cannot meet the desired market demand .Iron nails are placed into the trunk spirally in this method.

Drilling method: Drilling on the stems, roots and large brunches is a common method. The drilled pores were placed in a spiral fashion on the tree from the ground line up into the crown. Wounds were placed 3 to 5 cm apart. Wounds were kept open to ease access of natural agents into the pores. Pores are checked and rewounded every 2-3 months. This was done whenever the wounds appeared to have any wound closure.

2.6 Formation of agar

Three hypotheses exist regarding Agar formation, in that it is the result of pathological, wounding/pathological and/or non-pathological processes (Ng and Azmi, 1997). According to Ng *et al.* (1997), studies had not provided conclusive evidence for any of these hypotheses. Oldfield *et al.* (1998) states that resin production was in response to fungal infection, and Heuveling van Beek (TRP, *in lit/.* to TRAFFIC International, 2 May 2000) stated that it was in response to wounding. He adds that fungal infection can increase resin production as a host response to increased damage due to fungal growth. *Aquilaria* trees were naturally infected by a variety of fungi including: *Aspergillus* spp., *botlyodyplodia* spp., *Diplodia* spp (Wiriadinata, 1995). The ecological interaction between the host tree and the wound and/or the fungi in order to produce Agar tree was poorly understood. Other factors such as the age of the tree, differences in the tree caused by seasonal variation, environmental variation and genetic variation of *Aquilaria* spp. may also play

an important role in Agar tree formation (Ng *et al.*, 1997). Not all *Aquilaria* trees produced Agar tree, Gibson (1977, cited in Ng *et al.*, 1997) estimating that only approximately 10% of wild *Aquilaria* spp. produced resin. According to Chakrabart y*et al.*(1994), infected trees produce resin from the age of 20 years and onwards, suggesting that the best yields are obtained from trees aged 50 years and over. Recent studies undertaken by The Rainforest Project (TRP) in Vietnam had shown that Agar tree formation can occur in cultivated trees as young as three years of age, as confirmed by chemical analysis (TRP, *in lift.* to TRAFFIC International, 2 May 2000). The yield and qualities of the resinous Agar tree produced also varied considerably (Wiriadinata, 1995). Research conducted in West Kalimantan, Indonesia, demonstrates that the yield of *Aquilaria* resin did not correspond with tree diameter or timber volume, even when trees had similar indications of infection. Agar consisting of irregular patches of dark wood highly charged with oleoresin is found in the interior of comparatively old trees. The agar bearing trees have a somewhat disease appearance, and the oleoresin is usually found where the branches fork out from the stem. Agar is found frequently in young trees about 20 years old. But the disease takes sometimes mature and, about fifty years old have the highest concentration. Sometimes, all the tissues under the bark of tree may be found converted into agar.The presence of an exposed, open wound seemed to be of more importance than the presence of certain species of fungi within a wound. This supports Gibson's hypothesis (1977), that in *A. agallocha* agar deposits are the results of wound interaction within the tree similar to that found in a wide range of species and are not due to the primary of a particular fungus.

2.7 Management practices and domestication considerations

2.7.1 Planting site

Agar tree is suitable for growing on field boundaries and for dividing whole plot into sub-plots. Not only this, agar tree is also grown on borders of gardens, school compounds, office compounds, parks and residential sites. The good capacity for pollarding and coppicing has made it suitable to fit in agro-forestry. Besides, agar tree has been successfully grown for strip planting along banks of ponds, tanks, canals and roads. In hilly areas/tillas as in Barak valley it can be planted on poor soils on hill slopes, tilla tops. Agar tree could successfully be introduced in Social Forestry and also in afforestation programe. Due to the increasing demand of agarwood, it is being introducing as shade tree in tea gardens (Alam, 2004).

2.7.2 Transplanted in poly bags

From 25 days onward when the cotyledons just drops down the seedlings are transplanted carefully to poly bags arranged under temporary shade. Normal management price should be adopted after planting young seedlings in poly bags. They are arranged in bed supported by bamboo poles around (Priyadi, 1999). At monthly interval the shifting of bags should be done to prevent the penetration of roots into the soil. Shifting of seedlings should be followed by light watering to avoid wilting due to disturbances in the root system. Root trainer may be used successfully.

2.7.3 Propagation techniques

This species is easily planted and domesticated by seedlings and can be obtained through either wildings or raised seedling in the nurseries. The seedling is hardy, easily transported but hardening processes are required for adaptation to the site.

2.7.4 Land preparation

From the growth data and species trials, *A. malaccensis* and other promising species of *Aquilaria* can be domesticated from the wild. The species grows well under full sunlight although some early light shade is recommended. The species is shade tolerant during seedling stage and are known to regenerate freely under mother tree (Alam,2014).However, there must be minimum soil disturbance during clearing and with planned planting activities during wet seasons.

2.7.5 Lining and holing

This is no different from other forest plantation. It is an important aspect as this will assist in the planting direction, systematic lining and spacing with respect to the site conditions. Planting holes should be flexible and avoid any water-logged, rocky, big stump and boulders (Fratkin, 1994).

2.7.6 Planting pattern and spacing

Unlike other plantation grown species, a small square planting is recommended for *Aquilaria* cultivation with spacing of 2 x 2 m at 1020 trees per acre and 2.5 x 2.5 m at 653 trees per acre depending on the objectives of the trials or programmes. However, no large planting distance are required if monoculture is to achieve the purpose but intercropping with short term cash crops are allowed in wider spacing (Burkil, 1996).

2.7.7 Pruning and inducement techniques

Similar to other timber tree species, pruning for *Aquilaria* is necessary to promote optimum growth and determine the number of branches to be retained for tree with multiple stem branches although a single straight stand is recommended during inducement selections. Pruning can be carried out within 3-6 months whereby first pruning is called corrective pruning to shape the tree with balanced canopy-stem ratio favourable for so-called wood production (Burfield et al. 2005). It can also be a continuous process at least during the first three years of the tree when the desired tree height or form is achieved. No thinning is required. With the current interest in plantation of

Aquilaria, research into the most suitable age for inducement and the conditions in which higher grades of agarwood are produced are needed. However, as a prerequisite rule, trees at age four to five and reaching a diameter of 10 cm should be ready for any inducements.

2.8 Plant density

Total number of branches of ten months old plant has been counted and it has been found that the average number of branches of a plant was around 21. At different height from the ground level, perimeter of the plants with branches was measured and was observed that the maximum perimeter of the plants was at 90 cm height (Burfield et al. 2005). Perimeter of the sample plants were measured at the height of 60, 90 and 120 cm from the ground level and also mean vale was calculated.

2.9 Pest and diseases

Aquilaria are susceptible to various pests and diseases. Care should be taken to ensure good hygienic surrounding conditions of the saplings and trees during nursery, early growth and at the site Ahmed, (2010). No serious incidence has been reported except larvae attack by Heortiavitessoides belonging to the Hymenoptera group, scale insects, stem borers, pink disease on the stem and branches, wood borers and in some cases root *Fusarium* wilt problems (Fungicides such as Bourdeaux Mixture, copper oxychloride and Mancozeb, systematic pesticides such as Furadan G or any active ingredient containing parallethrin of Class IV can be applied wherever necessary).

2.9.1 Control measure

Hand collection and destruction of the young caterpillars while in clusters. At severe attack spraying with Ekalux EC 25, Endosalfan 35 EC Thiodan, Fenitrothion 50 EC (Sumithion) or Uvacron 40 EC is done twice at 10-15 days interval. While plant protection measures by Ahmed, (2010) esticide application is resorted to, it is to be remembered that the beneficial insect borer associated with agar formation is not affected particularly in the later

stages of growth. Severe infected tree should be treated with an extra dose of nitrogen.

2.9.2 Manuring

It is not necessary to apply inorganic fertilizers at the time of planting. Fertilizers should be applied after complete establishment and only from second year of planting. Well decomposed cowdung/FYM @ 10-15 kg/pit of size 50 cm may be applied in pit and well mixed with soil prior to planting. Under composed FYM or fresh cowdung should not be applied in any case. The *rhizosphere* of Agar tree (0-45 cm) exhibits a higher rate of microbial population when organic manures are used (Ahmed, 2010).

2.10 Intercropping

Vegetables/pulses or aromatic crops like Patchouli (*Pogostemon cablin*), Sugandhmantri may be cultivated as short season/short term intercrops during first three to five years of plantation. In the later stages shade loving medicinal plants like Sarpagandha (*Rouvolfiaser pentina),* long pepper *(Piper longum)* may also be grown for another few years depending on plant population and land type. Ginger/Turmeric may also be planted leaving about 50 cm around plant base (Ahmed, 2010). Both the crops are exhaustive in nature for which some special care has to be taken. This type of crops should not be taken more than two seasons.

2.11 Harvesting

The physical age, growth rates and/or wood volume or physiological maturity do not govern the harvesting age of agar tree for commercial purpose. It is the infected tree and whose further growth is arrested due to physiological imbalance is harvested and yields agarwood and oil (Chowdhury, 2014). Generally, the bad and deformed trees attain harvestable first unlike other forest species. The healthy trees are left to undergo stresses or subject to infection either naturally or artificially to induce oil formation. The harvesting is done on selection and continues for a longer period from a plantation raised at the same time.

2.12 Cultural operation

Soil working to a radius of 50 cm is to be done once in 3-4 months. Fertilizer application should also be followed by these operations preferably twice in a year, before and after monsoon from second year onwards. Agar seedlings are foraged by goats or cattle. To protect plantation, fencing is necessary (Ahmed, 2010). Initial 4-5 years period should be protected from farm animals.

CHAPTER III
MATERIALS AND METHODS

This materials and methods includes: (1) Geographical location 2) Methods of investigation, site selection (3) Variables of the study and development of research instrument, and (4) Data collection, processing and analyses.

3. Geographical location and physical environment of the study area

3.1 Geographical location

The study was conducted in the Baralekha upazila under Moulvibazar district. 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 Fenchuganj (Sylhet) upazilas. The villages Dakshinbhag, Patharia and Sujanagar were selected for the study in respect of agar production (Figure 3.1).

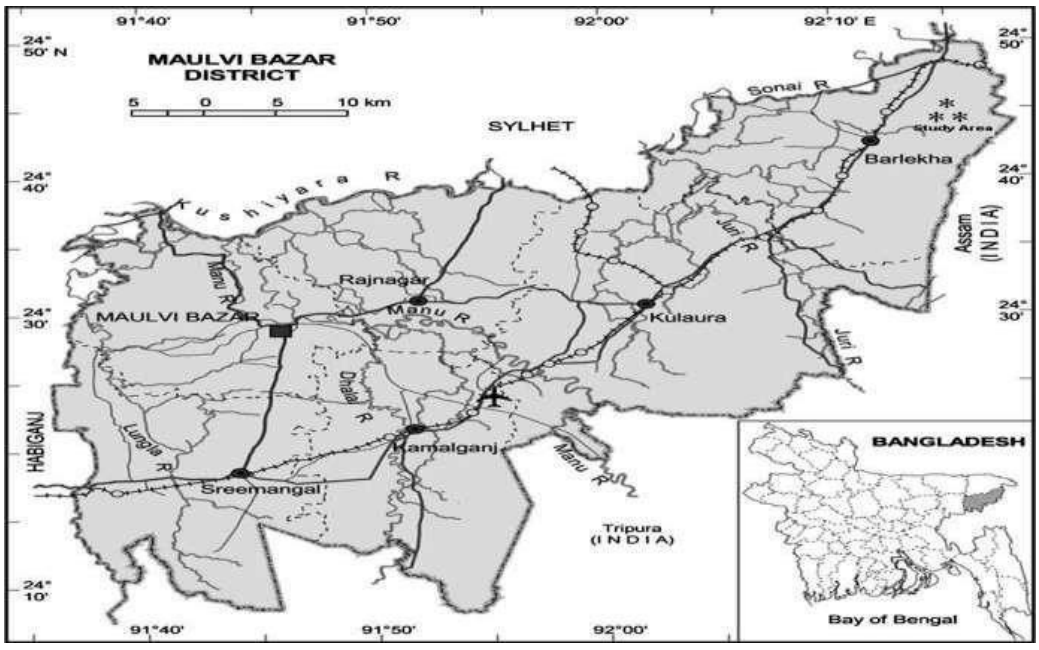

Figure.3.1 Map of Maulvibazar district in Sylhet

Methods of investigation, site selection and sampling procedure

3.2.1 Methods of investigation

The farmers of Bangladesh do not usually maintain records and accounts of their farm operations. So, the survey method was followed to achieve the objectives of the study. To minimize errors, several repeated visits were made to collect the data properly. The steps followed in the present study were the selection of the area, specific records of the relevant factors, sampling technique, period of investigation, preparation of the interview schedule, rapport building with respondents, collection of data, processing and analyses of data.

3.2.2 Site selection

Selection of a study area is one of the most important parts of any socioeconomic research. The area in which a business survey is to be carried out depends on the particular purpose of the survey and possible co-operation from the farmers (Yang, 1962). A survey was carried out in Baralekha upazila of Moulvibazar district during February 2016 to December 2016.

3.3 Socio-economic profile of the respondents

3.3.1 Age

The age of respondent was measured by counting the period of time from his birth to the time of interview on the basis of response of the respondent and was expressed in terms of years.

3.3.2 Education

The education level of the respondents of the study area was divided into 5 (five) categories like 0 (those are having no schooling), primary level (class I-V and only can sign), secondary level (class VIX), higher secondary level (XI-XII), and above (BA, BS, BSc, MS).

3.3.3 Family size

Family size of a respondent was determined in terms of the total number of members. The family member included respondent himself, spouse, sons, daughters and other dependents. The scoring was made by the actual member of family expressed by respondents. If a respondent had five members in his family, his score was given as 5.

3.3.4 Farm size

Farm size of the respondents of the study area was divided into 5 (five) categories like landless (having 0-0.20 ha land), marginal (having 0.21-0.60 ha land), small (having 0.61- 1 ha land), medium (0.01- 3.04 ha land), and large (above 3.04 ha land).

3.3.5 Cultivation Practice of Agar tree

Cultivation practice of Agar tree of the planters was determined by planting materials used, source of planting materials, time of seedling, fertilizer use, maturity symptom and harvesting time.

3.3.6 Source of planting materials

Planting materials for agar tree cultivation of the study area was divided into 3 (three) categories. Those are having seed which farmer collected from their own garden for further cultivation, seedling which farmer collected from nearest nursery and stem cutting which farmer practices in own garden.

3.3.7 Planting time of seedling

Planting should be done when the plants have the greatest chances of survival. The best time is during the rainy season (May-September).

3.3.8 Fertilizer use

Some farmer use fertilizer during cultivation and some are not. Farmer who are used to fertilizer they used Cowdung, Urea and both of those (Urea and Cow dung). Fertilizer used more in application during plantation only.

3.3.9 Problem faced by farmers' during agar cultivation

Problem was measured one way such as, using the closed form of questions as shown in item number 40 of the interview schedule (Appendix I). The respondents were requested to give their opinion in 9 selected problems, which were identified during designing of the questionnaire along with their extent of confrontation in use of agar tree cultivation. Usually four points scale was used for computing the problem confrontation score of a respondent.

4. Training received

Training received of farmers was measured according to the duration of their training. For measuring the training attended by farmers a score of 1 assigned for one day training, 2 for two days training and zero (0) score was assigned for no training experience as shown in item No. 40 of the interview schedule (Appendix I).

5. Annual income

This variable was measured by the total income yearly earned by a respondents family (respondent himself and other family members) from agricultural (crops and homestead etc.) and non-agricultural sources (service, business etc.). It was expressed in Taka per year.

6. Maturity symptom

There are some external signs that a tree may contain maturity round hole is created in the surface of agar tree and ants comes from it due to fungal infection. It has long been known that colour is dark brown or black.

7. Harvesting time

Although the collection of agar trees for oil extraction as well as for Agaru is done almost throughout the year, the best time is during February-May, the dry season when the plants remain almost dormant or less active. During this period maximum concentration of oil with less waxy substances is obtained.

8. Marketing system

Two marketing channels are prevalent in the study area for agar wood as a raw material for agar enterprises. One involves selling agar trees before artificial wounding, by agreement between the agar farmers and enterprise owner. The other channel of agar marketing involves selling the trees after harvesting directly to the agar-based enterprise owner. Middlemen are also prevalent in this channel.

9. Procedure for computation of cost and return

To determine the profitability, it was considered to compute all the cost items and deduct them from the gross value of outputs (only wood chips as raw material), which the farmer produces. It was estimated by the following procedures:

9.1 Estimation of costs

The farmers producing Agar had to incur costs for different inputs, which are used in the production process. The input items were valued at the prevailing market price and sometimes government price in the study area, or at the period of which farmers bought on the basis farmers assumptions from present year to previous 12 years of Agar tree. In calculating the production cost, the following components of cost were considered in the study area.

9.2 Application cost

Interest on operating capital was calculated taking into account of nonmaterial inputs like human labour for pit preparation, cost of fencing and repair, application of fertilizer and irrigation, care cost, etc. and material inputs like seedlings, bamboo stick, fertilizers, irrigation etc. used in the Agar production. For calculating interest on operating capital, the following formula was used:

$$\text{Interest on operating capital} = \frac{\text{Operating cost} \times \text{Rate of interest} \times \text{Time period } (1^{st}\ \text{yr})}{2}$$

9.3 Gross margin

Gross margin was calculated by deducting the variable cost from the gross return, using the following formula:

Gross margin = Gross return - Variable cost

9.4 Benefit-Cost Ratio (BCR)

Benefit-cost ratio is the ratio of discounted benefit divided by discounted cost. It implies the benefit derived from one unit of cost.

$$\text{Benefit-Cost Ratio (BCR)} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

Where, B = Gross benefit in i^{th} year

C_t = Total cost in i^{th} year

t = Number of years (1, 2, 3, ... n)

i = Interest rate

10. Data collection, processing and analyses

10.1 Sampling technique and data collection procedure

This study was conducted in Moulvibazar district that was selected. Moulvibazar district is consisting of 7 upazilas.Out of 7,1 upazilas namely Baralekha was randomly selected. Baralekha upazilas has 253 villages. Among them 3 villages namely Dhakshinbhag, Patharia and Sujanagar were randomely selected. There are total 105 agar production respondents families in these selected villages. Out of 105 families, a sample of 40 respondents Dhakshinbhag, Patharia and Sujanagar (15, 13 and 12, respectively) were selected randomly from the selected areas. A structured questionnaire was used to collect information on agar production from the selected respondents. Final selection has been done by the (Yamane, 1967) formula:

$n=N/\{1+N(e)^2\}$

Where,

n = Sampling size

N = Population

e = Error of precision

Table 1: Distribution of population and sample size in three selected villages

Upazila	Villages	No. of total respondents	No. of selected respondents
Baralekha	Sujanagar	30	12
	Dakshinbhag	40	15
	Patharia	35	13
Total	3	105	40

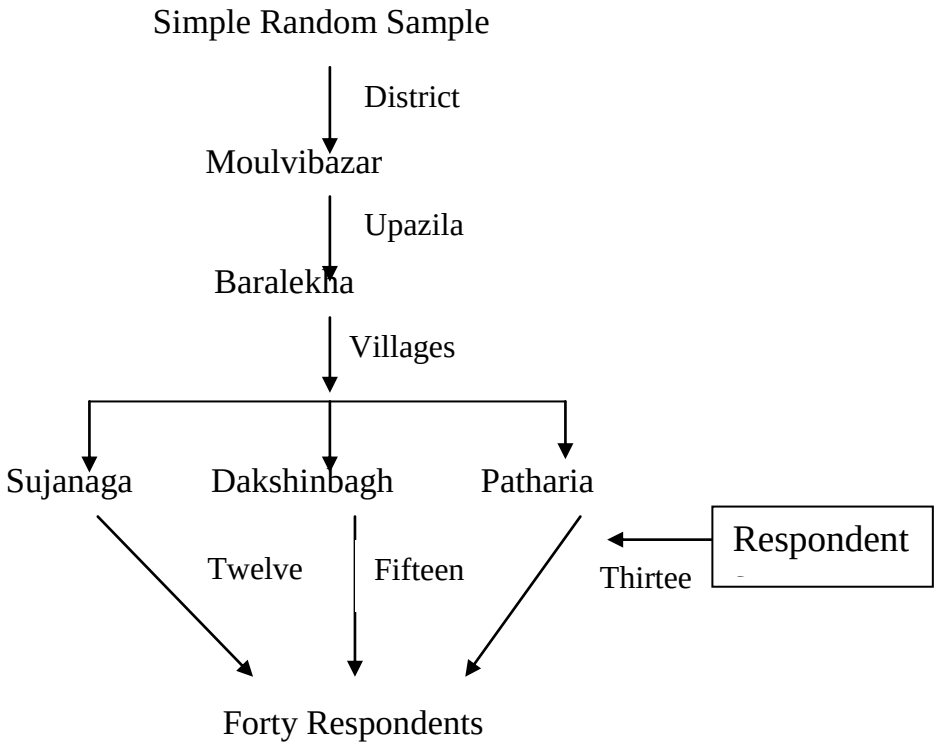

Fig.2: Flow Chart of sampling technique

10.2 Preparation of the interview schedule

As per the objectives of the study, an interview schedule was prepared for collecting the desired data from the sample farmers. On the basis of the pre-test of this schedule, necessary modification, addition and alteration were made to improve the validity and applicability of the schedule. The interview schedule is presented in Appendix I.

10.3 Method of data collection

As per the objectives of the study, an interview schedule was prepared.On the basis of the pre-test of this schedule,necessary modification,addition and alteration were made to improve the validity and applicability of the schedule.

Independent Variables: Age, Education, Family size, Number of tree in homestead area, Problem faced by farmers' during agar cultivation, Maturity symptoms.

Dependent Variables: Agar Production

10.4 Secondary data

In the context of this study, secondary data were not available in our country. Very limited information was collected from the Forest Department, Agricultural University and other sources.

10.5 Processing and tabulation of data

After collection of data, the first step was to look over the data of each and every interview schedule whether every question was replied properly or not. These were converted into standard units for the preparation of final tables. All the collected data were summarized and scrutinized carefully and recorded in Microsoft Excel 2010 program, computer software. Finally, a few relevant tables were prepared according to the necessity of analysis and interpretation and to meet purpose of the study. Data were averaged and standard deviation was calculated wherever necessary by SPSS-16.

CHAPTER IV

RESULTS AND DISCUSSION

The results and discussions were presented according to the objectives of the study. The results were however discussed under the following sections:

4.1 Demography of the respondent farmers

Socio-economic characteristics of the farmers are the important factors that affect their production pattern. People differ from one locality to another in many respects. Behaviour of an individual is largely determined by the characteristics. The general profile of agar tree growers, processors and traders such as age and educational level are discussed below:

4.1.1 Age

The sample farmers of the study area were categorized on the basis of their age viz. 20 to 30, 31 to 50 and above 50 years (Table 1). The highest portions of agar producers were in the age group of above 50 years and the corresponding percentage was 37.50 and the lowest in the age group of 20 to 30 and the corresponding percentage was 27.50, while the rest of the respondents (35%) belong to the age group of 31 to 50 years. The findings indicated that relatively aged farmers were involved with agar production. However, young generation (20 to 30 aged group) was also interested to Agar production gradually. Similar findings were reported by Alam (2004).

Table 1. Age status of the respondents at Baralekha upazila of Moulvibazar district

Farmer Age (yr.)	Number of farmer	Percent
20-30	11	27.50
31-50	14	35
Above 50	15	37.50
Total	40	100

4.1.2. Education

Education has impact on outlook, attitude and tendency of the farmers' towards modernization of traditional agriculture. Educated farmers would be more aware about scientific information and would take more rational economic decisions. The levels of education of the sample farmers are shown in Table 2. In accordance with different levels of education, all the sample farmers were grouped into five classes, namely no schooling, primary, secondary, higher secondary and above higher secondary level. Table 2 showed that most of the farmers of agar wood planters had primary education (up to class five) and their corresponding percentage was 32.50%, while about 25.0% had secondary (up to SSC), 17.5% above higher secondary, 15% had no secondary and 10% had higher secondary education.These findings supported by Alam (2004).

Table 2. Education status of the respondents at Baralekha upazila of Moulvibazar district

Education level	Number of farmer	Percentage
No Schooling	6	15
Primary	13	32.50
Secondary	10	25
Higher secondary	4	10
Above higher Secondary	7	17.5
Total	40	100

4.1.3. Family size

The family size scores of the farmers ranged from 1 to 8 with standard deviation 4.16 (Table 3). Most of the farmers (45%) had medium family size compared to (30%) large and 25 percent small family size. The Table 3 indicated that 45% of the respondents were in medium size family which was also a representative of typical family size in Bangladesh. In Bangladesh it is very common to live together with parents and with brothers and sisters and sometimes with relatives (GOB, 2001). Similar results were reported by Ahmed (2010).

Table 3. Family size of the respondents at Baralekha upazila of Moulvibazar district

Family size	Number of member	Percentage
Small (1 to 4)	10	25
Medium(5 to 8)	18	45
Large (above 8)	12	30
Sd	4.16	10.40
Total	40	100

4.1.4. Homestead size

The homestead of the sample farmer ranged from 0.02-1.70 ha with an average of 0.42 ha with standard deviation of 2.73 (Table 4). Among the farmers 20% were landless, 12.5% were marginal, 22.5% were small, 15% were medium homesteads while last large was 30%. Among the respondents most of the respondents was under large category (30%). On the other hand, the marginal farmer was the lowest (12.5%) in the studied area. The average homestead size in the studied area was more than the national average (BBS, 2010). There are about 25.49 million of homesteads in our country covers about 0.80 million ha of lands (BBS, 2010). Chowdhury, M. (2014) found the similar findings in their studies.

Table 4. Homestead sizes of the respondents at Baralekha upazila of Moulvibazar district

Homestead category	No. of respondents	Percentage
Landless	8	20
Marginal	5	12.5
Small	9	22.5
Medium	6	15
Large	12	30
Range	5-12	12.5-30
Sd	2.73	6.84
Total	40	100

4.1.5 Farm size

In the study area most of the farmers are under medium category (30%) followed by marginal (25%), small (20%), landless (20%) and lowest under large category (only 10%) in respects of farm size (Table 5). There was variation among landless, marginal, small and medium category farmers (Table 5). The average farm size in the studied area was more than the national average which is 0.81 hectare (BBS, 2004).

Table 5. Farm sizes of the respondents at Baralekha upazila of Moulvibazar district

Farm size category	No. of respondents	Percentage
Landless	6	15
Marginal	10	25
Small	8	20
Medium	12	30
Large	14	10
Sd	3.16	7.90
Total	40	100

4.1.6 Number of trees in homestead

Number of trees in homestead of the farmers ranged from 0 to 500 with an average value of 68 with no. of respondents standard deviation of 3.21 (Table 6). The study showed that the most of the farmers (42.5%) had medium plantation, 30 percent farmers had large plantation and 27.5 percent farmers had low plantation (Table 6).Similar Findings were reported by Chowdhury, (2014).

Table 6. Categorization of respondents according to number of trees in homestead at Baralekha upazila of Moulvibazar district

Category	No. of respondents	Percentage
Low (up to 26)	11	27.5
Medium (27-100)	17	42.5
Large (above 100)	12	30
Sd	3.21	8.03
Total	40	100

4.1.7 Planting materials

The findings of the study indicated that most of the respondent farmers (95%) used seedling which collected from nursery for agar cultivation, where as only 5% of the respondent farmers used seed (Table 7). From this table, it is clear that most of farmers depends on seeding from nursery for better agar cultivation .Alam (2014) found the similar result.

Table 7. Categorization of respondents according to their planting materials for Agar cultivation at Baralekha upazila of Moulvibazar district

Planting materials	Number	Percent
Seed	2	5.0
Seedling (nursery)	38	95.0
Stem cutting	0	0.0
Total	40	100

4.1.8 Source of planting materials

Results in the Table 8 showed that Generally Agar tree is wild in nature and propagates by natural regeneration and farmers usually collect seedlings from nursery source. Most of the respondents (85%) used seedlings as planting materials, while 7.5% respondents collected from natural wilding. Results stated that farmer collected planting material from own home garden that was 5.00% and next neighbour was (2.5%). Alam (2004) found the similar result.

Table 8. Categorization of respondents according to their of source planting materials for agar cultivation

Source of planting materials	Number	Percent
Own home garden	2.00	5.0
Market	0	0.0
Govt, organization	0	0.0
NGO	0	0.0
Natural wilding	3	7.5
Neighbour	1	2.5
Nursery	34	85
Total	40	100

4.1.9 Fertilizer and manure

The investigation showed that a number of few of the farmers (20%) used fertilizer and manure for Agar tree production but most of the farmers 80% did not use any fertilizer and manure. Fifty percent farmers used fertilizer and manure during May-June, while 37.50% and 12.50% respondent applied during Jun-July and April - May respectively (Table 9).These findings also supported by Alam (2004).

Table 9. Categorization of respondents according to use of fertilizer and manure for Agar cultivation at Baralekha upazila of Moulvibazar district

Use of Fertilizer and manure	Number of farmer	Percent
Yes	8	20
No	32	80
Total	40	100

4.1.9.1 Types of fertilizer and manure

From the Table 10 it is observed that most of the farmers (50%) used both fertilizer and manure for Agar tree production and among those only cow dung and urea used 37.50% and 12.5%, respectively. It also observed that investigated farmers did not use TSP and MOP. Hundred percent farmers used fertilizer and manure during plantation but none applied fertilizer afterwards (Table 10).

Table 10. Categorization of respondents according to types of fertilizer and manure used for agar cultivation during plantation

Types of fertilizer and manure	Number	Percent
Urea	1	
Cowdung	3	
TSP	0	0
MOP	0	0
Both Urea and cowdung	4	50
Total	8	

4.1.10 Problems of agar tree cultivation

Results presented in Table 11 indicated that the respondent farmer mainly noticed nine problems. Among those growers indicated the major problem is the lack of advice from extension personnel. Extension officers are not available through local area. The second problem is the marketing problem; actually marketing system just depends on buyers who are in aboard. The third one is credit facility; Commercial Bank and NGOs usually do not provide loan for Agar purpose.

Table 11. Problem faced by the respondents during agar tree cultivation at Baralekha upazila of Moulvibazar district

Problems	**High**	**Medium**	**Low**	**Not at all**	**Total**	**Rank**
Technical knowledge	27	6	4	3	40	6(27)
Credit facility	31	6	3	0	40	3 (31)
Formal Training	24	7	6	3	40	8 (24)
Quality seed and seedling	28	5	6	1	40	5 (28)
Lack of advice from extension personnel	36	3	1	0	40	1 (36)
Availability of space	29	4	7	0	40	4(29)
Marketing	33	4	3	0	40	2 (33)
Low price of the product	26	5	6	2	40	7 (26)
Others	21	9	6	4	40	9 (21)

4.1.11 Irrigation

Most of the respondent farmers (72.50%) did not practices of irrigation but 27.50% farmers applied irrigation for Agar tree cultivation. Data in the Table 12 indicated that 54.55% farmers applied irrigation during May-June, whereas 27.27% and 18.18% farmers applied irrigation during June-July and April-May, respectively.Similar findings were supported by Alam (2004).

Table 12. Categorization of respondents according to irrigation practices for agar cultivation at Baralekha upazila of Moulvibazar district

Irrigation Practice	Number	Percent
Yes	11	27.5
No	29	72.5
Total	40	100

Table 12. If used then the time was according to irrigation practices for agar cultivation at Baralekha upazila of Moulvibazar district

Irrigation Practice	Number	Percent
April-may	2	18.18
May-June	6	54.55
June-July	3	27.27
Total	11	100

4.1.12 Marketing system

In the study area, 30% of the respondent farmers sold total Agar garden and 70% are not. The farmers who did not sold garden the directly response marketing system of agar cultivation. among them Raw wooding (21.43%), Processing atar (64.29%) and both raw and processed was 14.29%. Two marketing channels are prevalent in the study area for agar wood as a raw material for agar enterprises. One involves selling agar trees before artificial wounding, by agreement between the agar farmers and the agar-based enterprise owner. The agreement mainly sets out who would ultimately bear the expense of wounding because artificial wounding is a highly expensive task. Sometimes middlemen are involved in this process. The other channel of agar marketing involves selling the trees after harvesting directly to the agar-based enterprise owner. Middlemen are also prevalent in this channel. About 64% of farmers sold agar trees directly to the enterprise owner. The remaining 36% sold their trees to the enterprise owner with the help of a middleman either before or after artificial wounding. Nevertheless, the involvement of middlemen in the marketing channel in the study site resulted in up to 5 % reduction in price of agar trees compared with direct selling to enterprise owner.

Table 13. Marketing system of different materials of agar at Baralekha upazila of Moulvibazar district

Selling pattern	Number	Percent
Whole garden		
Yes	12	30.0
No	28	70.0
Total	40	100.0

4.1.13 Training received

In the study area, 30% of the respondent farmers have received training on different aspects of Agar cultivation and processing from different government and non-government organizations and 70% had no training. The computed training participation scores of the farmers varied from 0-30. It was observed that the highest proportion of farmers (46.43%) had low training participation, 32.14% had medium and 21.43% had high categories training participation on all agricultural aspects (Table 14).Similar findings were reported by Alam (2004).

Table 14. Training participation of the respondents at Baralekha upazila of Moulvibazar district

Extent of training received	Number of planters	Percent of planters
No (0 Score)	28	70.0
Low (1-10 Score)	6	15.0
Medium (11-15 Score)	3	7.5
High (16 and above)	3	7.5
Total	40	100.0

4.1.14 Annual income

In this study annual income of respondents was calculated (Table 15). Annual income from agar tree, field crop (rice), fruit, vegetables, nurseries and livestock was Tk 23464.12, 13640.85, 4378.87, 4378.87, 1200.66 and 5437.41, respectively. Ahmed (2010) findings the similar result.

Table 15. Annul income after received the training at Baralekha upazila of Moulvibazar district

Income source	Taka/Year
Agar	24364
Field crop	13641
Fruits	4379
Vegetables	4965
Nurseries	1201
Livestock	5437
Fisheries	1543
Services	6454
Businesses	8459
From family members works other than services and businesses	1833
Others	1166
Total	73442

4.1.15 Uses of Agar wood at Baralekha upazila of Moulvibazar district

From the present study it observed that agar wood is mostly used as fragrance where 77.50% respondent‟ s uses agar for this purpose and 12.50% uses agar wood as agarbati (Table 16). And also uses of agar by respondents were agar wood medicine 2.5%, agar wood beads 2.50%, decorative sculptures 2.5% and others 2.5%.

Table 16. Uses of agar at Baralekha upazila of Moulvibazar district

Uses	Respondents	Percent
Atar (fragrance)	31	77.5
Agar bati	5	12.5
Agar wood medicine	1	2.5
Agar wood beads	1	2.5
Decorative sculptures	1	2.5
Others	1	2.5
Total	40	100.0

4.1.16 Maturity symptoms

There are some external signs that a tree may contain maturity. Investigation showed that 55% respondents think that agar tree maturity sign when some round hole with black colour and also sign of maturity were attack by ants and assisted by insects was 25% and 20% respectively (Table 17).

Table 17. Maturity symptoms of agar according to the at respondents Baralekha upazila of Moulvibazar district

Sign of Maturity symptoms	Respondents	Percent
Round black hole with colour	22	55.0
Attack by ants	10	25.0
Assisted by insects	8	20.0
Total	40	100

4.1.17 Harvesting period

From the study the investigation showed that respondents are usually harvested agor as row product mainly three periods for commercial purposes. Most of the respondents 55.00% harvest agar during April – June because the extracted oil during April - June possesses the finest odour (Table 18). Rest of the respondents harvest agar tree during July – September and February - March which were 27.50% and 17.50% respectively. Chowdhury, M., (2014) reported the similar result.

Table 18. Harvesting period of agar of the respondents at Baralekha upazila of Moulvibazar district

Harvesting period	Respondents	Percent
February – March	7	17.5
April – June	22	55.0
July – September	11	27.5
Total	40	100.0

4.1.18 Measures of Agar preparation

Two types of commercial products are obtained from a harvested agar tree (a) agar or agar wood that is used as incense and (b) Essential oil or agar oil or agar attar. Agar is obtained from older trees while oil is distilled from old as well as younger trees. After felling a tree, the leaves and smaller branches are removed. Then the tree is cut into logs (pieces of 2-2.5 ft.). Thereafter, the logs are spitted to separate out the infected and non-infected woods. The agar wood of any grade if detected is first separated out with the help of indigenous tools like hacksaw blade and „*Batali*" and graded them based on the oleoresin impregnation, colour density, specific gravity and finally the odour. These are then dried, cleaned by removing the white woody portions as far as practicable, polished and graded for marketing. Agar oil is obtained

by steam distillation of harvested wood chips or coarse powder in special type of distillation unit. Distillation is continued for 5-10 days or more using firewood as the energy source.

4.1.19 Cost of Agar cultivation

Cost of production of the respondents were Tk 60500 ha^{-1} for first year including cost of fencing and repair, land preparation, pit making, cost of seedlings, planting cost, compost, fertilizer, irrigation, application cost, after care/year, and miscellaneous cost were Tk 1500, Tk 5000, Tk 8500, Tk 3400, Tk 9000, Tk 15000, Tk 5000, Tk 3400, Tk 5000 and Tk 1300 respectively. For the 2^{nd} year after care/year and miscellaneous cost were Tk 5000 and Tk 1600 respectively and total cost Tk. 6600. Cost of 3^{rd} year cost of fencing and repair, after care/year and miscellaneous cost were Tk 5000 and Tk 1600 respectively and total cost Tk 9600. For the 4^{th} year cost of after-care/year and miscellaneous cost Tk 5000 and Tk 1600 respectively and total cost Tk 6600. For the cost of 5^{th} year cost of fencing & repair, after care/year, miscellaneous cost was Tk 5000, Tk 6000, Tk 1500 respectively and total cost Tk 12500.For the cost of 6-8^{th} year cost of fencing & repair was Tk 5000, cost of fencing & repair was Tk 20000, inoculation cost Tk 15000, miscellaneous cost Tk 3000 and total cost Tk 33000. For the cost of 9-15^{th} year cost of fencing and repair was Tk 7000, cost of care per year was Tk 30000, inoculation cost was Tk 20000 and miscellaneous cost was Tk 7000. And total cost was Tk 37000 (Table 19). Total expenditure up to 8^{th} year =Tk 128,800; Next 7^{th} years =Tk 37, 000 ; Total Tk 165800.

Table No.19: Cost of Agar cultivation of the respondents at Baralekha upazila of Moulvibazar district

Heads of exp.	1st year	2nd year	3rd year	4th year	5th year	6-8th year	9-15th year
Cost of fencing & repair	1500	-	3000	-	5000	5000	7000
Land preparation		-	-	-	-	-	-
Pit (30cm x 30cmx30cm) making	3400	-	-	-	-	-	-
Cost of seedlings 1700 x Tk.5.00	8500	-	-	-	-	-	-
Planting cost @ Tk. 2.00/plant	3400	-	-	-	-	-	-
Compost	9000	-	-	-	-	-	-
Fertilizer	15000	-	-	-	-	-	-
Irrigation	5000	-	-	-	-	-	-
Application cost Tk. 2.00/plant	3400	-	-	-	-	-	-
After care/year	5000	5000	5000	5000	6000	20000	30000
Inoculation @ Tk. 100/tree	-	-	-	-	-	15000	20000
1500 trees							
Miscellaneous Cost	1300	1600	1600	1600	1500	3000	7000
Total Tk	60500	6600	9600	6600	12500	33000	37000
Total TK						165800/	

4.1.19.1 Anticipated yield and income of the respondents at Baralekha upazila of Moulvibazar district

Assuming 1500 numbers of trees at 8th year out of the total, we may harvest about 40% of the selected trees i.e. 600 with a view to thin out the population for remaining 900 trees for further growth and development. The final harvesting of 900 trees would be done at 15th year.The investigation showed that yield of distillable wood from 8-10 years old tree approx. 20 kg/tree @ Tk 10.00/kg and yield of 15th year was 50 kg/tree @ tk 50.00/kg. Yield of Batali mal (agar wood) was 0.5 kg @ Tk 2000/kg from about 500 trees. That‟ s why gross return for 7-8th years was Tk 1,20,000, from final harvest Tk 22,50,000 and agar wood was Tk 5,00,000 and finally total Tk 28,70,000 (Table 20). After 15th years net return was (Tk 28,70,000 – Tk. 165800) = Tk 27,04,200.

Table No.20: Returns from Agar tree cultivation of the respondents at Baralekha upazila of Moulvibazar district

Age of Agar tree (Year)	**Returns from Agar tree (TK)**		**Total (TK.)**
	Distilled Wood	Agar wood	
1-6	0	0	0
7	50000	0	50000
8	70000	0	70000
9-14	0	0	0
15	22,50,000	500000	2750000
Total TK.			2870000/-

4.1.19.2 Evaluation of intertemporal budget for Agar cultivation at Baralekha upazila of Moulvibazar district

Cultivation system showed that the cash flow at th 1st-5th year were negative,but it became positive from the 7th and 8th year were Positive. Again in 9-14 year were negative and in 15th year it was positive.The discounted benefit cost ratio (6.55),net present value (Tk 667950.93) and internal rate of return (30%) clearly indicated that agar cultivation system was productive and economical.The discounted benefit cost ratio indicated that if a farmer invests Tk. 100, he would get return of Tk. 650.Again, the difference between discounted gross benefit and discounted gross cost indicated that the net present value was Tk. 667950.93 (Table 21).These findings were supported by Hasan, (2008).

Benefit Cost Ratio:

$$BCR = \frac{\text{Gross return}}{\text{Total cost}}$$

$$= \frac{788305.69 \text{ Tk}}{120354.76 \text{ Tk}}$$

$$= 6.55$$

Table 1. Benefit Cost Ratio (BCR) of Agar tree production for 15 years

Age of Agar tree (year)	Gross cost (Taka)	Gross return (Taka)	Cash Flow (CF) (Taka)	Discounted CF at 30% DR (Taka)	Discounted CF at 40% DR (Taka)	Discounted gross cost at 11% DR (Taka)	Discounted gross return at 11% DR (Taka)	Net Present Value of Tk. at 11% DR (Taka)
1	60500.00	0	-60500.00	-60,500.00	-60,500.00	60500.00	0	-60500.00
2	6600.00	0	-6600.00	-5,076.92	-4,714.29	6000.00	0	-6000.00
3	9600.00	0	-9600.00	-5,680.47	-4,897.96	7933.88	0	-7933.88
4	6600.00	0	-6600.00	-3,004.10	-2,405.25	4958.68	0	-4958.68
5	12500.00	0	-12500.00	-4,376.60	-3,253.85	8537.66	0	-8537.66
6	11000.00	0	-11000.00	-2,962.62	-2,045.28	6830.13	0	-6830.13
7	11000.00	50000.00	39000.00	8,079.87	5,179.60	6209.21	28223.69	22014.48
8	11000.00	70000.00	59000.00	9,402.61	5,597.01	5644.74	35921.06	30276.32
9	5500.00	0	-5500.00	-674.24	-372.68	2565.79	0	-2565.79
10	5500.00	0	-5500.00	-518.65	-266.20	2332.53	0	-2332.53
11	5500.00	0	-5500.00	-398.96	-190.14	2120.49	0	-2120.49
12	5500.00	0	-5500.00	-306.89	-135.82	1927.72	0	-1927.72
13	5500.00	0	-5500.00	-236.07	-97.01	1752.46	0	-1752.46
14	5500.00	0	-5500.00	-181.59	-69.29	1593.15	0	-1593.15
15	5500.00	2750000.00	2744500	69,703.78	24,698.51	1448.32	724160.94	722712.62
Total				3,269.14	-43,472.66	120354.76	788305.69	667950.93

CF = Cash Flow, DR = Discounted Rate
Result: BCR at 11% = 6.55, NPV at 11% = Tk. 667950.93, IRR is 30%

Table 22: Relationship between the dependent and independent variables

Dependent Variables	Independent Variables	Co-efficient of Correlation	Tabulated Value at	
			0.05 level	0.01 level
Yield (kg)	Farmers Experience	0.285*	0.2348	0.2751
	Education	0.051^{NS}		
	Family size	0.223*		
	Planting materials (Seedling)	0.750**		
	Maturity symptoms (Round hole with black colours)	0.893**		
	Problem faced during agar tree cultivation	0.113^{NS}		

NS=Not Significant

**= Significant at 1% level

*= Significant at 5% level

Relationship between yield and farmers experience is positive significant at 5 percent level.There is no significant relationship between yield and education status.The calculated value of the co-efficient of correlation was 0.051 which was smaller than the tabulated value at 5 percent level of significant. Relationship between yield and family size is positive significant at 5 percent level. Relationship between yield and Planting materials (seedling) is positive significant at 1 percent level. Relationship between yield and Maturity symptoms (Round hole with black colour) is positive significant at 1 percent level. There is no significant relationship between yield and Problems faced during agar cultivation.The calculated value of the co-efficient of correlation was 0.051 which was smaller than the tabulated value at 5 percent level of significant (Table 22).

Plate 1: Infected Agar tree Garden

Plate 2: Harvested Agar tree

Plate 3: Patched wood Agar wood

Plate 4: Small pieces of Agar wood

Plate 5: Chipping of harvested wood

Plate 6: Water soaked Agar wood

Plate 7: Distillation process of Agar Wood chips

Plate 8: Agar Oil

Chapter V

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary:

The study was conducted at Baralekha upazila under Moulvibazar district during the month of February to December, 2016 to explore the selected characteristics namely age, education, family size, homestead land size, farm size, number of trees in homestead, problem confrontation during citrus cultivation, total annual income, annual income from citrus, training participation, organizational participation, socio-economic aspect and number of agar tree species in homestead.

Age of the respondents ranged from 20 to above 50 years where the highest 37.50% of the farmers was above 50 years age, 27.50% was in 20-30 year ages. The education level of the farmer in the study showed that most of agar wood planters had secondary education (up to SSC) and their corresponding percentage was 25.00%, while about 15.00% planters had no education.

The family size scores of the farmers ranged from 01 to above 08 years with standard Deviation 4.16. The study showed 45% of the farmers had medium family size compared to 30% large and 25 percent small family size. The homestead of the sample farmer ranged from 0.02-1.70 ha with an average of 0.42 ha with standard deviation of 2.73. Among the farmers 20% were landless, 12.5% were marginal, 22.5% were small, 15% were medium homesteads while last large was 30%.

The farmers were categorized under medium which was 30% and marginal, small and landless was 25%, 20%, and 20%, respectively where lowest category only 10% in respects of farm size. Number of trees in homestead of the farmers ranged from 0 to 500 with an average value of 68 with number of respondents standard deviation was 3.21.

The study showed that the 42.5% of the farmers was medium plantation and 30 percent farmers was large plantation. From the present study, the respondents 85% used seedlings as planting materials, while 7.5% respondents collected from natural wilding. Directly 30% of the respondent farmers sold total Agar garden and 70% are not. The farmers who did not sold garden the directly response marketing system of agar cultivation. Sometimes middle men are involved in marketing system. It also observer that 30% of the respondent farmers have received training with agricultural means from different govt. and non govt. organizations and 70% has not.

Though agar wood is mostly used as fragrance, in the form of agar wood chips, agar wood dust or agar wood oil, there were other five uses of agar like decorative sculptures, beads, medicine, liquor, and tea. There are some external signs that a tree may contain maturity, when some round hole is created in the surface of agar tree and ants comes from it, the agar farmer identify that the tree is prepared for taking agar wood or resin. When stress is more bio-molecule concentration is also more. The extracted oil during dry season possesses the finest odour and note compared to that obtained during rainy season when the plant remains active in growth.

Production of agar as raw materials is a long time process and it near about fifteen years to get raw materials. Total cost of 8^{th} year was Tk 1,28,800; next 7 years was Tk 37, 000 and cost of production for 15 th years in total was Tk 1,65,800. After 15^{th} years Gross and net return was TK. 2750000 and 2744500 respectively.The discounted benefit cost ratio (6.55), net present value (Tk.667950.93) and internal rate of return (30%) clearly indicated that agar tree cultivation system was productive and economical.

Conclusion:

Agar tree though known in Bangladesh is highly demand as commodity and the premiums it commands today not only in the local market but also in the international markets.From this experiment, Assuming 1500 number of trees at 8th year out of the total, we may harvest about 40 % of the selected trees i.e. 600 with a view to thin out the population for remaining 900 trees for further growth and development and also to generate an interim income. The final harvesting (900 number of trees) would be done at 15th year. Production of agar is a long time process and its about fifteen years to get raw materials.85% respondents used nursery seedling for agar production. Marketing is a good problem for agar production. The discounted benefit cost ratio (6.55) clearly indicated that agar tree cultivation system was productive and economical. There is a need to boost up its production, identifying the week points for furthering the returns. There was a significant positive correlation between maturity symptoms and agar production.

Recommendations:

1. Agar wood cannot be stored for many days because the dried wood chips decreasing oil production. So, storing mechanism should be studied.
2. Further research on the quality of agar chips, agar wood is to be conducted.
3. Proper propagation method (seeding by traditional or tissue culture method) are introduced through research for maximum production.
4. Leaflet, poster and reports are to be prepared for wide scale adaptation, cultivation of *Aquilaria malaccensis* among the farmers.
5. Institutional credit facilities should be made available to farmers on easy terms and conditions.

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Appendix I. An English version of the interview schedule

Questionnaires

AGAR TREE CULTIVATION AND ITS ECONOMIC IMPORTANCE: A CASE STUDY OF MOULVIBAZAR DISTRICT

Sample no. : Village: Union: Upazila:

Name of respondent:
1.Age:

2.Year of Schooling
No schooling... Primary.... Secondary..... Higher secondary....

3.Family size (State the number of your family members including you)
Male:.....
Female:.....
Total:.....

4.Homestead size: (Please indicate the extent of use of your homestead (area)

Description (Nature of use)	**Number**	**Amount of area**	
House		**Local unit**	**Hectare**
Cowshed			
Area under vegetables			
Area under fruit trees			
Area under Agar			
Area under timber trees			
Area under medicinal trees			
Yards			
Fallow			
pond			
Total			

6. Number of trees in homestead

Types of trees species	Species	Number	Total
Agar trees			
Timber species			
Fruit tree species			
Medicinal species			
Aesthetic (Flower and Ornamental)			
Other			
Grand total			

7. Planting materials of agar (put tick √): Seed/ Seedling/ Stem

8. Source of planting materials (put tick √)

a.Own home gardens b. Market c.Government Organization

d. Natural wilding e. Neighbours f. NGO

9. Age of planting materials if stem/branch is used:

10. Method of preparation of stem cuttings:

11. Planting time of seedling/planting material:

12. Whether any fertilizer is used or not: Yes/no

13. Amount of fertilizer applied for each tree:

14. Irrigation application (when and how):

15. Diseases found in agar plants:

16. In the nursery bed:

17. After plantation:

18. Control measures of diseases:

19. Insect found in agar plants:

20. Problems during agar cultivation:

Sl. No.	Problems	Nature of problem			
		High	Medium	Low	Not at all
1	Technical knowledge				
2	Credit facilities				
3	Formal training				
4	Quality seeds and seedling of agar trees				
5	Lack of advice from extension personnel				
6	Availability of space				
8	Marketing problem				
9	Low price of the product				
10	Insect pest infestation				
11	Diseases infestation				
12	Others				

21. Training participation:

Have you received any training on agricultural aspects?

Sl. No	Name of the training	Duration (days)	Name of the organization	Month	Year
1					
2					

22. Annual income

Income source	Taka
Agar	
Field crops	
Fruit	
Vegetables	
Nurseries	
Livestock	
Fisheries	
Services	
Businesses	
From family members works other than services & businesses.	
Others	
Total	

23. Uses of agar tree:

24. Income from agar trees:

25. Income from other sources:

26. **Maturity Symptoms (either by eye observation or any other way):**
27. **Harvesting age:**
28. **Measures of atar preparations:**
29. **Marketing system:**
30. **Cost and returns of agar cultivation:**

.....
Signature of interviewer

Date

.....
Signature of farmer

Date

Thanks for your kind information

Appendix:II

SYLHET CLIMATE TABLE // HISTORICAL WEATHER DATA

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	18.5	20.5	24.3	26.1	26.7	27.5	28	28.1	27.9	26.4	23.2	19.8
Min. Temperature (°C)	12.1	13.8	17.8	21	22.6	24.5	25.1	25.1	24.6	22.3	17.7	13.6
Max. Temperature (°C)	25	27.3	30.8	31.3	30.9	30.6	30.9	31.2	31.2	30.6	28.7	26.1
Avg. Temperature (°F)	65.3	68.9	75.7	79.0	80.1	81.5	82.4	82.6	82.2	79.5	73.8	67.6
Min. Temperature (°F)	53.8	56.8	64.0	69.8	72.7	76.1	77.2	77.2	76.3	72.1	63.9	56.5
Max. Temperature (°F)	77.0	81.1	87.4	88.3	87.6	87.1	87.6	88.2	88.2	87.1	83.7	79.0
Precipitation / Rainfall (mm)	13	27	108	319	549	780	751	595	468	227	31	8