Preprints.org

Article

Not peer-reviewed version

Economic Analysis of Agarwood Cultivation in Assam, India: An Empirical Investigation

Pranjal Protim Buragohain * and Anshumi Dutta

Posted Date: 16 January 2024

doi: 10.20944/preprints202401.1162.v1

Keywords: agarwood; economic viability; net present value; benefit cost ratio; internal rate of return & upper assam

Preprints.org is a free multidiscipline platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

Article

Economic Analysis of Agarwood Cultivation in Assam, India: An Empirical Investigation

Anshumi Dutta [1,*] and Pranjal Protim Buragohain [2]

[1] M.Phil. Research Scholar, Department of Economics, Dibrugarh University, Dibrugarh, Assam, India, 786004

[2] Associate Professor, Department of Economics, Dibrugarh University, Dibrugarh, Assam, India, 786004; pranjalprotim@dibru.ac.in

* Correspondence: anshumidutta809@gmail.com

Abstract: Agarwood, a highly valuable fragrant wood of Aquilaria spp. has been widely used in perfumes, traditional medicine, religious rites and cultural activities. Due to the presence of aromatic and medicinal properties, the Agarwood has gained its economic importance in recent years. It has been providing livelihood and employment facilities to many people who are cultivating those. Owing to high demand and profitability, the people of Assam has started to cultivate Agarwood in a commercial manner in recent days. This study was conducted to examine the economic viability of Agarwood cultivation in Assam and to understand the problems of the cultivators to consider Agarwood cultivation as the primary source of income. The primary data were collected during the months of May and June, 2022 from 210 households using structured questionnaire. The cost-benefit analysis revealed that INR 100 of initial investment yields a net benefit of INR 623 which indicates that the return from the Agarwood cultivation among the cultivators are very high. Thus, the present study argues that the government should encourage the cultivators by providing the necessary support in the form of a legalized market, credit requirement, creating the awareness about the demand of Agarwood and making provision of training.

Keywords: agarwood; economic viability; net present value; benefit cost ratio; internal rate of return; Upper Assam

1. INTRODUCTION

Aromatic plants play an important role among the mankind since the pre-historic time due to its aroma and medicinal use (Inoue et al., 2019). Today, medicinal and aromatic plants have contributed significantly towards employment creation and income generation among the underprivileged people and thereby economic development especially in the biodiversity rich developing countries of the world (Myers, 1990; Richman, 2002; Taghouti et al, 2021; Weiss et al, 2020). According to a report by Market Research Future, the value of aromatic market is estimated at USD 200.9 billion in 2022 and is projected to increase to USD 328.1 billion by 2032 with a compounding growth rate of 5.60 per cent for the forecasted period[i]. On the other hand, the estimated annual growth of global medicinal and aromatic plants market is around 10-20 per cent and is expected to reach $ 5 trillion to $ 7 trillion by 2050 (Silalahi et al, 2023). Thus, with ever growing demand for both medicinal and aromatic plant-based products there is a scope to consider cultivation of aromatic plants as an additional source of livelihoods and thereby to provide economic benefits to the poor (Guleria et al., 2014). In a country like India, therefore, the economic importance of the aromatic and medicinal plants never be denied. Assam falls under one of the biodiversity hotspots of the world is home to many aromatic and medicinal plants. Agarwood is one of such aromatic plants cultivated by the farmers widely in many parts of Assam. Of late owing to the growing global demand, people of Assam started to cultivate agarwood commercially.

© 2024 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

Agarwood, locally known as *Agar* in Hindi, *Agaru* in Sanskrit, and *Xashi* in Assamese, is a highly prized tree for its fragrant dark resinous content formed as a result of injury and fungal infection (Ahmed & Bhagabati, 2021). It is one of the species of Aquilaria (*Aquilaria malaccensis* Lamk) of the family Thymelaeaceae. (Mamat et al. 2010) and among all the species of *Aquilaria*, the *Aquilaria malaccensis* Lamk is the principal source of Agarwood (Sarkar, 2019). Other agarwood-producing species are *Aquilaria crassna, Aquilaria agallocha, Aquilaria sinensis, Aquilaria filaria,* and *Aquilaria subintegra*.

For thousands of years, Agarwood has been used for medical, aromatic and religious purposes in the Middle East and in India. The high economic value of Agarwood had drawn great attention for *Aquilaria* from different societies around the world. In Arabian society, Agarwood was mainly demanded for perfumery use, in Indian society, the demand was increased for its religious application. The use and trade of Agarwood have had a rich history in India and it was also considered to be of great commercial value. In the *Arthashastra*, Agarwood and other aromatics were also subject to a state tax at one-tenth or one-fifteenth of the sale price of the products (Lopez-Sampson & Page, 2018). A study done by Lopez-Sampson & Page (2018) stated that wild Agarwood was used for the cremation of priests and princes and thus confirmed the high of this at that time. In India, the trade based on Agarwood is mainly derived from *A. Malaccensis;* and for a long-time trade in Agarwood and its products has been a monopoly of the country. The production and trade in Agarwood products included wood, chips, powder and oil which were used for mainly perfumes, incense and medicines including Ayurvedic, Chinese, Malay and Tibetian (Chakrabarty et al., 1994; Ali et al., 2016). High grade agarwood powder is used in Chinese medicine for the production of pharmaceutical tinctures. In Bangladesh, it is used to treat rheumatism; in Malayasia for the treatment of stomach pain in pregnancy, after delivery, fever, rheumatism, body pains, women diseases, small pox and dropsy (Gimlet, 1930; Burkill, 1966; Chakrabarty et. al., 1994). It is also used traditionally to treat snake bite, vomiting, paralysis, diarrhea and others. In East Asia, it is used as sedative, analgesic and digestive medicine. Further, in middle east, agarwood is a symbol of status, wealth and hospitality (Chang et. al., 2002). The Agarwood is also used in toiletry products such as soap and shampoo; used as writing material; used as incense stick etc. (Chakrabarty et. al., 1994). Further, due to its therapeutic properties, agarwood oil is widely used in aroma therapy. Many pharmacological studies have also been completed and found agar as anti-depressant (Takemoto et al., 2008), anti-cancer (Dahham et al., 2016), anti-inflammatory (Chitre et al., 2007), anti-diabetic (Feng et al., 2011; Pranakham et al., 2015) and anti-oxidant (Tay et al., 2014). Because of such studies, importance of Agarwood has increased further.

The demand for agarwood oil has been increasing continuously due to its wide varieties of uses. As per reports Indian Agarwood Oil extracted from the Agar trees of the North East India, specially from Assam are the most expensive amongst the available varieties of agarwood. Due to the presence of high-quality agarwood in the state, Assam is also known as the Agarwood capital of India. The Agarwood chips per kg costs between USD 1000 to USD 5000; while the pure grade Agarwood oil varies between USD 32000 to USD 40000. Extensive medicinal, aromatic and religious uses made it is the most expensive wood in the world and for which the agarwood is also known as the "Wood of the Gods" or "God's Wood" (Mir et al., 2017). However, due to high economic value of the Agarwood, people used to harvest the plant indiscriminately which led to drastic fall in the number and extent of *Aquilaria malaccensis* in the tropical forests. Moreover, smuggling and poaching of agarwood is adding fuel to the problem. Consequently, it was enlisted in the Appendix II of the Convention on International Trade in Endangered Species of Wild Life Fauna and Flora (CITES) in 1995 to ensure its sustainability (Barden et. al., 2000). This species is also included in the red data list of the IUCN (Harvey-Brown, 2018). On the other hand, in India, *Aquilaria malaccensis* is considered critically endangered and thereby the government of India has restricted the import of Agarwood and regulated the export of Agarwood from India. However, even then in India, especially in North East India, the sale and purchase of the Agarwood has been continued and cater the need of the people at the time of adversity.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

The North-Eastern States mainly Assam is the home of *A. malaccensis* which is basically harvested in the homestead of the Upper Assam, especially by the people of Golaghat, Jorhat and Sivasagar district along with other useful plants (Saikia & Khan, 2013). It is also found in Hojai, Cachar and Karimganj Districts. While the extraction, distillation and primary processing are primarily carried out at Hojai; and from Mumbai it is traded and exported. Many numbers of small-scale agar industries are also operating in some districts of Assam providing a livelihood opportunity to the local people (Chakrabarty et al., 1994).

Thus, due to high economic potential, Agarwood cultivation in Assam and the adjoining parts of Northeast India has received significant importance in recent years (Saikia & Khan, 2013; 2014). Agarwood trees and Agarwood-based products could be the ones through which a great amount of return is possible. Considering the uses and high economic value of Agarwood, the people of Assam have started to grow this species in their home gardens as well. Gradually, commercial planting of Agarwood has also started in upper Assam. Moreover, People of Assam consider planting of Agarwood in their homestead as the Life Insurance. Further, studies revealed that Agarwood has great economic prospects in the home gardens of Upper Assam and home gardens be used for the conservational purpose of the Agarwood trees (Saikia & Khan, 2014). The government of Assam has also recognized the importance of such home gardens to bring economic prosperity among the rural people. And considering the importance of Agarwood cultivation, the government of Assam notified "The Assam Agarwood Promotion Policy, 2020" to ensure agarwood's sustainable utilization and trade. The policy intended to promote research on sustainable harvesting of the species and cultivation practices.

With this background and limited existing literature, the study is undertaken to understand the economic profitability of Agarwood cultivation in Assam. Further, the Agarwood tree growers have faced many problems with agar cultivation and its marketing. Therefore, there is also the need to study the problems associated with both Agarwood cultivation and its marketing. Hence, the present study is about to assess the economic viability of Agarwood cultivation and to study the problems associated both with Agarwood cultivation and its marketing. It is expected that the findings of the study will be helpful to the Agarwood growers, researchers and policy makers to make right decisions regarding the cultivation, production, marketing, and policy formulation of Agarwood in Assam.

2. MATERIALS & METHODOLOGY

The present study uses both the primary and secondary data for the analysis. However, for the analysis, primary data is mostly used. Secondary data is used only when required. For the present study, three districts of Upper Assam, viz., Golaghat, Jorhat and Sivasagar is considered purposively to carry out the research work as Agarwood cultivation is mainly concentrated in three districts of Upper Assam. After selection of the districts, blocks and villages are selected purposively based on pilot survey and data provided by the village headman and officials from the blocks. In the last stage, as reliable data on the exact number of Agarwood growers in Assam are not available which makes it difficult to locate the target population. Therefore, snowball sampling method was employed to select the samples. Once the samples are selected, using structured questionnaire data are collected. The Figure 1 shows the districts of Assam and the selected area for the study.

A total of 70 sample growers were selected from each of the districts and the total number of selected sample growers became 210. The primary data were collected through a structured interaction with the sample growers by providing questionnaires. These data were collected during May to June 2022.

However, secondary data have also been used wherever required. The secondary data was collected from Government publications, works of several authors, Reserve Bank of India Databases etc. Moreover, various books, research journals, research theses, and dissertations were also used to carry out the study. While assessing the economic viability of Agarwood cultivation in Upper Assam financial measures like Net Present Value, Benefit Cost Ratio and Internal Rate of Return is being

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

calculated. And the problems faced by the sample Agarwood growers in the study area were studied through the Garrett Ranking Technique.

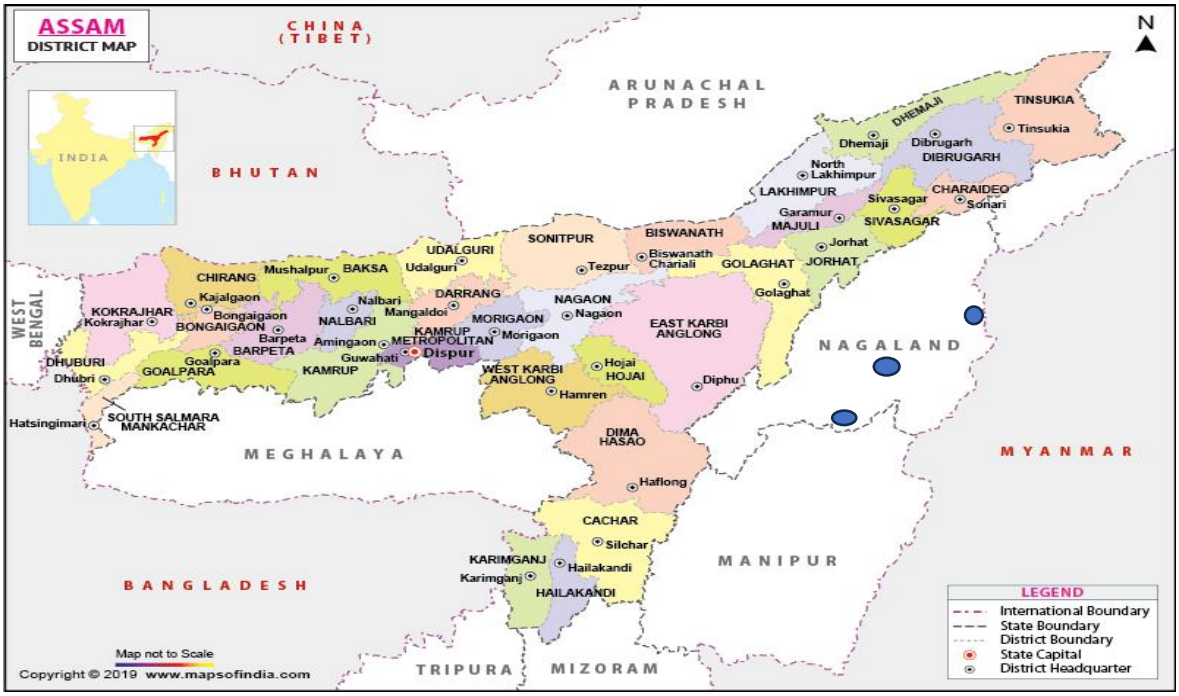

Figure 1. District map of Assam. The map is modified from the www.mapsofindia.com. Represents the selected districts Golaghat, Jorhat and Sivasagar.

Net Present Value (NPV):

NPV is a useful tool to analyze the profitability of a projected investment or project. It can be used for assessing the financial viability which estimates the worthiness of an investment. It is the sum of all cash flows in each period discounted to the present by using the time value of money (Goswami et al. 2019). It is the present worth of net benefits or cash flow stream (Sharma et al. 2014).

The PV of cost is being calculated by using following formula:

$$\text{PV of Cost} = \sum_{t=0}^{n} \frac{E_t}{(1+r)^t}$$

Where, E_t denotes cost (cash outflow) in year t; n denotes investment lifespan; r is the rate of discount rate; t denotes time measured in years

The PV of benefit is being calculated by using following formula:

$$\text{PV of Benefit} = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t}$$

B_t denotes benefit (cash inflow) in year t; n denotes investment lifespan; r is the rate of discount rate; t denotes time measured in years

The NPV or the PV of net benefits is calculated by using the following formula:

$$\text{NPV} = \sum_{t=0}^{n} \frac{B_t - E_t}{(1+r)^t}$$

Where, B_t denotes benefit (cash inflow) in year t ; E_t denotes cost (cash outflow) in year t; n denotes investment lifespan; r is the rate of discount rate; t denotes time measured in years

In general, any investment is viable if calculated NPV is positive. The zero NPV implies that the investment breaks even.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

Benefit-Cost Ratio (BCR):

The BCR indicates the profitability of any project. It is an indicator showing the relationship between the relative costs and benefits of an investment. The BCR is the ratio of discounted benefits and discounted costs of an investment project (Das et al., 2018). The value of BCR essentially provides the guidance for relative economic justification of an investment project. A project is considered to be viable if the calculated BCR is greater than one. The BCR in the present study is calculated by using the following formula:

$$\text{BCR} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{E_t}{(1+r)^t}}$$

Where, B_t is the benefit at time t; E_t is the cost at time t; and r is the discount rate.

3.4 Internal Rate of Return (IRR):

The IRR is the rate of interest at which PV of cost and PV of returns are equal. In other words, it is the rate at which NPV is zero. The higher the IRR, the more profitable the project concerned. Specifically, if the IRR is greater than the discount rate it implies that the investment is viable and smaller IRR than the discount rate implies that the investment is not viable. The following equation represents the relationship between NPV and IRR.

$$\text{NPV} = \sum_{t=0}^{n} \frac{C_t}{(1+IRR)^t} = 0$$

Where, C_t is the cash flow at that point in time.

3. RESULTS & DISCUSSIONS

3.1. Demographic and Socio-economic Profile of the Agarwood Growers

The demographic and socio-economic parameter analysis for the Agarwood growers have also been carried out in the study. The study shows that among the growers 14.29 per cent are belonging to joint family; while 85.71 per cent belong to nuclear family. Out of 1220 number of populations, 49 per cent are female and 51 per cent are male. The average size of the family is 5.81. On the other hand, mean age of the agarwood growers is 47.6 years. Educational status of the Agarwood growers reveals that 96.67 per cent are literate and among them 66.67 per cent have education up to class X. Thus, majority of the respondents are either low skilled or semi-skilled. On the other hand, the study reveals that 78.57 per cent of the agarwood growers have land under Agarwood cultivation is below 7.5 bigha. They are the marginal Agarwood growers. Only 4.76 per cent are the large growers. The average size of the land under the Agarwood cultivation is estimated as 4.76 bigha The Study further reveals that baring few most of the grower have considered Agarwood cultivation along with other source of income. Thus, it is found that 42.86 per cent of the respondents have depended on both agriculture and agarwood as their source of livelihood; while 40.48 per cent consider both Agarwood and business; and the rest 16.66 consider service and agriculture as their source of livelihood. In fact, during the survey it was found that except few, most of the Agarwood growers have cultivated Agar tree as a mixed crop along with either tea or betel nut or vine or pepper. Moreover, it was estimated that average income from 1 bigha of Agarwood was highest for the large growers (INR 1034330) and lowest for the marginal growers (INR 172360). This may be due to longer waiting period to sale their Agar trees to the middleman. Higher the age of the trees more is the value of the Agarwood. Further large growers have devoted exclusively a few Bigha land for Agarwood cultivation (shifting from mixed cropping to mono cropping). Bigger the size of the homestead and agarwood plantation, the more is the agar tree and more the income. This is also found in the study made by Ahmed and Bhagabati (2021).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

Table 1. Demographic and Socio-Economic Profile of the Agarwood Growers.

Family Profile	
Total number of family members	1220
Percentage of Female members	49
Percentage of male members	51
Average Size of the family	5.81
Nuclear family	14.29
Joint family	85.71
Mean age of the Agarwood growers	47.6
Educational Status	
Literate	96.67
Up to Class X	66.67
Between Class X and XII	18.10
Graduate and above	11.90
Land Holdings under Agarwood (in Bigha)*	
Below 7.5 Bigha (Marginal Grower)	78.57
Between 7.5 to 15 Bigha (Small Grower)	16.67
Above 15 Bigha (Large Grower)	4.76
Average size of the land holdings (in Bigha)	4.79
Livelihood Status	
Agriculture and Agarwood Cultivation	42.86
Business and Agarwood Cultivation	40.48
Service and Agarwood Cultivation	16.66
Average income from 1 Bigha of Agarwood Cultivation	
For Marginal Grower	172360
For Small Grower	692916
For Large Grower	1034330

* 1 Bigha= 0.134 Hectare.

3.2. Economic Viability of Agarwood Cultivation:

The benefit-cost analysis (BCA) is usually used as the main tool for assessing the economic viability of a project. This involves expressing the cost and benefits in monetary terms to make comparisons between the two. If at the end of the exercise, the benefit exceeds the cost, the project can be considered to be economically viable and vice-versa. In the context of the Agarwood cultivation also economic viability may be assessed through a benefit-cost analysis (BCA). A BCA is performed by measuring the Present Value (PV), Net Present Value (NPV) Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) criteria as discussed above.

The Agarwood cultivation involves both overhead and variable costs. The overhead costs include clearing of the cite for the cultivation, fencing of the cite and purchasing of the seedlings or production of the seedlings by self. On the other hand, the variable costs include labour (both hired and family) used for cultivation, pruning, weeding, fertilizing and watering; fertilizer occasional fencing of the cite and rent on land. In the study area, rarely artificial wounding was found. The Agarwood cultivators prefer natural fungal infection of the woods over the artificial wounding of the trees and hence no cost involved in the artificial wounding of the trees. Thus, while calculating the costs of Agarwood cultivation all such costs are included and found that the relative cost is more up to age 6 and after that it starts declining (Table 2).

The economic viability for Agarwood cultivation was determined for a farm of 1 bigha (0.134 Hectare) of land for 10 years as the average maturity period of Agarwood trees is ten years according to the sample growers in the study area. Cash outflow, cash inflow and the incremental net benefit (INB) i.e., the net cash flow per bigha of land with their present values for 10 years are shown in Table 1 It is observed that most of the costs of agar cultivation are incurred in the first six years of operation.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

As the cash flows that occur after ten years may have different meanings in the present day that is why NPV is calculated for ten years by discounting the future cash flows. The choice of discounting rate in this context is very important. Generally, the cost of capital i.e., the lending rate is taken as the discounting rate to calculate NPV. However, it was observed that no sample growers in the study area take credit from the bank to grow Agarwood plants. At the same time, it was observed that the sample growers make savings in banks. Therefore, Savings Deposit Rate is taken as a proxy for the lending rate in the present study to calculate the NPV. The average Savings Deposit Rate of the Reserve Bank of India for the last ten years (2011-12 to 2020-21) throughout which the Agarwood farmers invested money in Agarwood cultivation was found as 3.76 per cent. Hence for the present study 3.76 per cent is considered as the discounting rate and accordingly, the PV of cash outflows, cash inflows and net cash flows are being estimated (Table 2).

Table 2. Cash Flows in Agarwood Cultivation for 1 bigha of Land (in INR).

Year	Cash Outflow	Cash Inflow	Incremental Net Benefit (INB)	PV of Cash Outflows	PV of Cash Inflows	PV of Incremental Net Benefit (INB)
Establishment Year	12361.1	-	-12361.1	12361.08	-	-12361.1
1	6019.63	-	-6019.63	5801.496	-	-5801.5
2	6019.63	-	-6019.63	5591.264	-	-5591.26
3	4737.33	-	-4737.33	4240.757	-	-4240.76
4	8612.52	-	-8612.52	7430.373	-	-7430.37
5	8665.21	-	-8665.21	7204.921	-	-7204.92
6	7321.27	-	-7321.27	5866.874	-	-5866.87
7	4677.68	-	-4677.68	3612.61	-	-3612.61
8	1208.2	-	-1208.2	899.2893	-	-899.289
9	1208.2	-	-1208.2	866.7013	-	-866.701
10	1208.2	493619.28	492411.1	835.2942	341265.6	340430.3

Source: Field Survey (Author's calculation).

To check the economic viability of Agarwood cultivation for 1 bigha of land, the NPV, B-C ratio and IRR are calculated which are shown in the Table 3.

Table 3. Economic Viability of Agarwood Cultivation for 1 bigha of land in the study area.

Sl. no.	Particulars	Value
1	Net Present Value	286554.9
2	Benefit Cost Ratio	6.238
3	Internal Rate of Return	33

Source: Field Survey (Author's calculation).

From the Table 3, it appears that the NPV calculated at a 3.76 per cent discount rate is INR 286554.9. Similarly, the benefit-cost ratio is 6.238 which mean that INR 100 of initial investment yields a net benefit of INR 623. The IRR is 33 per cent which is very high compared to the required rate of return i.e., 3.76 per cent. The positive values of NPV and IRR and the high BCR confirm the fact that agar cultivation is economically viable in the study area.

4. PROBLEMS EXPERIENCED BY THE AGARWOOD GROWERS OF THE STUDY AREA

It is found that the Agarwood growers of the study area have a high economic potential for Agarwood production. But although the Agarwood growers have the natural advantage in cultivating those trees at their homesteads, at the same time, they have also faced certain problems with the production as well as in the marketing of Agarwood. This section of the paper is an attempt

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

to identify and recognize the problems faced by the sample Agarwood growers in both cultivation and marketing.

The problems faced by the sample Agarwood growers in the study area were studied through the Garrett Ranking Technique. To find out the most significant problem which had influenced the growers, the respondent's ranks on different problems were converted into the score value with the help of the following formula:

$$\text{Per cent Position} = 100(Rij - .5)/Nij$$

Where,

Rij = Rank given for the ith variable by the jth respondents

Nij = Number of variables ranked by the jth respondents

With the help of Garrett's Table, the Per cent Position estimated is converted into scores by referring to the table given by Garrett and Woodworth (1969). Then for each problem, the scores of each individual are added and then the total value of scores and mean value of scores are calculated. The problem having the highest mean value is considered to be the most important problem.

4.1. Problems Associated with the Cultivation of Agarwood:

The problems associated with the production of Agarwood in the study area are studied and presented in descending order of their relative importance in Table 4 with the help of Garrett's Ranking Technique.

Table 4. Problems Faced By Agarwood Sample Growers in Cultivation.

Sl No	Problems	Mean Score	Rank
1	Lack of Credit	73.58	1
2	Lack of Training	59.75	2
3	Lack of knowledge about pest and disease	57.49	3
4	High input cost	49.74	4
5	Long waiting period	42.33	5
6	Possibilities of diseases	36.03	6
7	Research & development activities	29.07	7

Source: Field Survey Data (Author's Calculation).

From the above Table 4, it is observed that the first and foremost problem identified by the sample growers is the lack of credit for agar cultivation. It is found from the analysis that the lack of credit facilities for Agarwood cultivation is a regular complaint of the Agarwood growers. The financial constraint in any business hinders the path of development. In India, most farmers generally depend on the credit facility provided by the banks to sustain their farming business. It would help the framers with the capital that might not otherwise be available to them. With this capital the farmers can buy the required farming equipment, seeds etc. they need to operate a successful farm. Unfortunately, due to the lack of credit facilities for Agarwood farming; most of the interested farmers find it difficult to adopt this farming practice.

Lack of training was ranked second in order of important problems of Agarwood growers. It is important to have some sort of knowledge of the farming practice. It is evident from the different studies that farmers' pieces of training can help to increase agricultural productivity. For better production, training in agar cultivation and management is very much essential. The farmers should know the methods of cultivating agar and the way to improve their agriculture. The pieces of training improve the skills and knowledge of farmers in planting techniques, applying fertilizer or pesticides etc. But in the study area, it had been observed that the training facilities regarding Agarwood cultivation were lacking which further creates problems for the farmers.

Another important problem met by the sample growers is the lack of knowledge about the pest and diseases of the Agarwood tree. Again, this problem arises mainly due to the lack of training

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

facilities for agar cultivation in the study area. Most farmers do not have proper knowledge about agar farming techniques. Because of the lack of scientific knowledge about farming, many farmers are not able to get the maximum return many a time.

High input cost is another problem met by the Agarwood growers in the study area. In recent years, there has been a phenomenal rise in the price level. The prices of fertilizer, insecticides, Agarwood seedlings etc. also continue to rise and create a financial burden for the growers.

Another important problem identified by the sample growers is the long waiting period for the Agarwood tree to be matured. On average, it takes ten years to mature an Agarwood tree. After that, only the growers can get the minimum return from selling the tree. Thus, the long waiting period to get the return creates a hurdle for the growers. The possibility of the Agarwood tree being affected by the disease is another problem met by the sample growers. They do not possess scientific knowledge about the possible diseases of Agarwood and its cure. In general, most farmers do not have sufficient knowledge about Agarwood cultivation.

A crucial problem experienced by sample growers is the lack of research and development activities regarding Agarwood cultivation. Due to the lack of research and developmental activities, many farmers don't have the proper knowledge about Agarwood farming.

4.2. Problems Faced by Sample Growers in Marketing:

The different marketing problems faced by the Agarwood growers in the study area are also studied through the Garrett Ranking Technique. Table 5 presents the marketing problems identified by sample growers as per the rank assigned by them.

Table 5. Problems Faced by Agarwood Sample Growers in Marketing.

Sl No	Problems	Mean Value	Rank
1	No Regulated Market	68.09	1
2	Do not get actual price for middlemen	59.20	2
3	Rigid Legislation	50.39	3
4	Lack of information	44.82	4
5	Price Fluctuation	25.49	5

Source: Field Survey Data (Author's Calculation).

The first and foremost problem identified by the sample growers is the lack of a regulated market for Agarwood. Due to the lack of a properly regulated market for selling and buying Agarwood chips and logs, the cultivators and the local traders have to depend on traders from outside to sell the Agarwood chips. The second important problem faced by the growers is that due to the existence of middlemen, they sometimes aren't able to get the actual price of their product. The rigid legislation also creates difficulties to sell and transport Agarwood products. Though the government now is removing the restrictions on Agarwood cultivation and its trade, most people are unaware of this. Furthermore, the lack of information about the market price of Agarwood or relating to marketing facilities of Agarwood is another important problem faced by the sample growers. The fluctuating price of Agarwood also impacts the livelihood earnings of Agarwood growers. These constraints are responsible due to why people sometimes do not want to adopt Agarwood farming as their livelihood strategy.

5. CONCLUSION

The findings of the study suggest that the cultivation of Agarwood is profitable and economically viable. From the economic viability analysis of Agarwood cultivation for a farm of 1 bigha (0.25 Hectare) of land and a period of 10 years, it is estimated that NPV is INR 286554.9 at a 3.76 per cent discount rate, BCR is 6.238 and IRR is 33 per cent which is very high as compared to the required rate of return. The positive NPV value and high IRR indicate that Agarwood cultivation in the study area is economically much beneficial. The high benefit-cost ratio also represents the high

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

profitability of Agarwood farming. Agarwood farming has bright prospects and it would help improve the socio-economic status of the farming community of Upper Assam. To sum it up, the present study found that agar plantation in Upper Assam is economically feasible and can be a genuine opportunity for livelihood to uplift the socio-economic conditions of the people. Fortunately, the agroclimatic condition of the upper part of the state is suitable for growing Agarwood and thus it can be an excellent producer of cultivated Agarwood. The government of Assam should take steps to promote Agarwood cultivation as per its "The Assam Agarwood Promotion Policy, 2020" and take necessary steps to conserve the Agar tree through Agarwood cultivators.

Funding: No funding is received from any organization to carry out the present research work.

Acknowledgement: We would like to express our deep sense of gratitude to all the Agarwood grower for allowing us to carry out the field work.

Declaration of Interest: The authors have no conflict of interest.

References

Adhikari, S. R., Pokhrel, K., & Baral, S. D. (2021). Economic Value of Agarwood and Its Prospects of Cultivation. *International Journal of Applied Sciences and Biotechnology, 9*(1), 23-31.

Ador, M. H., Farabi, F., Ahmed, R., Khatun, R., & Haque, M. M. (2021). Agar (Aquilaria agallocha Roxb.) based small-scale enterprises in Bangladesh: Management, production, marketing and role in socio-economic development. *Trees, Forests and People*.

Ahmed, F. R., & Bhagabati, A. K. (2021). Agarwood pratice and Rural livelihoods in Naharani Area of Golaghat District, Assam, North-East india. *Indian Journal of Traditional knowledge, 20*(2), 582-594.

Arzen, P. D., Lee, S. Y., Emang, D., & Mohamed, R. (2018). History and Perspectives of Induction Technology for Agarwood Production from Cultivated Aquilaria in Asia: A Review. *Journal of Forestry Research*, 1-11.

Aurangzeb, M., Nigar, S., & Shah, M. K. (2007). Benefit Cost Analysis of the Maize Crop Under Mechanized and Traditional Farming Systems inthe NWEP. *Sarhad J. Agric, 23*(1).

Barden, A., Anak, N. A., Mulliken, T., & Song, M. (2000). Heart of the Matter: Agarwood Use and Trade and CITES Implemation For Aquilaria malaccensis. *TRAFFIC Network Report 46*.

Blanchette, R. A., Jurgens, J. A., & Beek, H. H. (n.d.). Growing Aquilaria and Production of Agarwood in Hill Agro-ecosystems.

Chakrabarty, K., Kumar, A., & Vivek, M. (1994). *Trade in Agarwood.* New Delhi: Traffic India and WWF India.

Chitre T, et al. (2007). Analgesic and anti-inflammatory activity of heartwood of Aquilaria agallocha in laboratory animals. Pharmacology online 1: 288–298.

Dahham, S.S., Hassan, L.E.A., Ahamed, M.B.K. *et al.* (2016). In vivo toxicity and antitumor activity of essential oils extract from agarwood (*Aquilaria crassna*). *BMC Complement Altern Med* **16**, 236 (2016). https://doi.org/10.1186/s12906-016-1210-1

Das, P., Sabur, A. S., Palash, M., & Hasan, M. (2019). An Economic Analysis of Agar-Wood Production in North-Eastern Bangladesh. *Asian Journal of Economics, Business and Accounting, 9*(3), 1-8.

Feng J and Yang X (2011) Liposolubility constituents from leaves of Aquilaria sinensis. *China journal of Chinese materia medica* 36(15): 2092-2095.

Given, L. M. (n.d.). *The SAGE Encyclopedia of Qualitative Research Methods.* SAGEGoswami, K., Choudhury, H. K., Hazarika, A., & Tripathi, R. (2019). An Assessment of Economic Viability of Jatropha Plantation in North East India. *International Journal of Energy Sector Management*.

Gujarati, D. N., Porter, D. C., & Gunasekar, S. (2012). *Basic Econometrics.* Chennai: McGraw Hill Education (india) private Limited.

Harvey-Brown Y, Aquilaria malaccensis, The IUCN Red List of Threatened Species, 2018

Jha, K. K. (2014). AGARWOOD PLANTATION AND PRODUCTS AS LIVELIHOOD STRATEGY: A CASE STUDY FROM BAN KHLONG SAI VILLAGE, NORTHEAST THAILAND. *IJRDMS, 8*(1), 45-59.

Kuwornu, J. K., Nafeo, A. A., & Osei-Asare, Y. B. (2013). Financial Viability, Value Addition and Costraint Analyses of Certified Organic Pineapple Production and Marketing in Ghana. *African Journal of Basic & Applied Sciences, 5*(1), 12-24.

Lee, Y. S., & Mohamed, R. (2016). The Origin and Domestication of Aquilaria, an Important Agarwood-Producing Genus. *Tropical Forestry*, 1-20.

Lopez-Sampson, A., & Page, T. (2018). History of Use and Trade of Agarwood. *Economic Botany, 72*(1), 107-129.

Mamat, M. F., Yacob, M. R., Fui, L. H., & Rdam, A. (2010). Costs and Benefits Analysis of Aquilaria Species on Plantation for Agarwood Production in Malaysia. *International Journal of Business and Social Science, 1*(2), 162-174.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 January 2024 doi:10.20944/preprints202401.1162.v1

Manishimwe, R., Niyitanga, F., Nsabimana, S., Kabayiza, A., & Mutimawurugo, M. C. (2019). Socio-Economic and Instituitional FActors Influencing the Potato (Solanum tuberosum L.) Production at Smallholder Farmers Level in the Gicumbi District in Rwanda. *Tropicultura*.

Mech, A., & Buragohain, P. P. (2020-21). Economics of Cultivation in the Fringe Areas of Wetland: A Case Study of 47 No. Moraklong Beel of Morigaon District of Assam. *Assam Economic Journal*, 118-139.

Mehmood, Y., Anjum, B., & Sabir, M. (2011). Benefit Cost Ratio Analysis of Organic and Inorganic Rice Crop Production; Evidence from District Sheikhupura in Punjab Pakistan. *Pakistan Journal of Science, 63*(9), 174-177.

Mehmood, Y., Anjum, B., & Sabir, M. (2011). Benefit Cost Ratio of Organic and Inorganic Rice Crop Production; Evidence from District Sheikhupura in Punjab Pakistan. *Pakistan Journal of Science, 63*(3), 174-77.

Mutema, M., Basira, K., Savadye, D., & Parawira, W. (2019). Assessment of Oyster Mushroom Production and Profitability in Harare Urban and Periurban Areas (RUWA), Zimbabwe. *Tanzania Journal of Science, 45*(1), 114-130.

Nath, .P et al. (2020) . Stand structure and functional attributes of agarwood (Aquilaria malaccensis Lam.) based smallholder farms in Northeast India, Trees, Forests and People, Volume 2, 2020, 100027,ISSN 2666-7193,https://doi.org/10.1016/j.tfp.2020.100027. https://www.sciencedirect.com/science/article/pii/S2666719320300273)

Pranakhon R. et al. (2015). Effects of iriflophenone 3-C- beta-glucoside on fasting blood glucose level and glucose uptake. Pharmacogn Mag 11: 82–89. DOI: 10.4103/0973-1296.149711

Rahman, M., Nath, N. M., Sarker, S., Adnan, M., & Islam, M. (2015). Management and Economic Aspects of Growing Aquilaria agallocha Roxb. in Bangladesh. *Small-scale Forestry*.

Saikia, P., & Khan, M. L. (2012). Agar (Aquilaria malaccensis Lam.): a promising crop in the homegardens of Upper Assam, northeastern India. *Journal of Tropical Agriculture*, 8-14.

Saikia, P., & Khan, M. L. (2014). Homegardens of upper Assam, northeast India: a typical example of on farm conservation of Agarwood (Aquilaria malaccensis Lam.). *International Journal of Biodiversity Science, Ecosystem Services & Management*.

Sampson, A. L., & Page, T. (2018). History of Use and Trade of Agarwood. *Economic Botany*, 107-129.

Sarkar, P. K. (2019). Improving Livelihood Through agarwoood (Aquilaria malaccensis Lam.) based Agroforestry Systems: An Option. *Agriculture & Food, 1*(6), 140-147.

Selvan, T., D, N., & Kaushik, P. K. (2014). Agarwood Production for Intensive Income Genertation. *Review of Research, 3*(5), 2-9.

Sharma, M., Thakur, D. R., & Mehta, D. P. (2014). Economic Feasibility Analysis of Major Flower Crops in Himachal Pradesh State of India. *International Journal of Advanced Research in Management and Social Sciences, 3*(9), 24-40.

(2020). *The Assam Agarwood Promotion Policy*. Government of Assam, Department of Industries and Commerece.

Taghouti et al. (2021). The Contribution of Non-Wood Forest Products to Rural Livelihoods in Tunisia: The Case of Aleppo Pine, Forests, 2021, 12 (12), 1793; https://doi.org/10.3390/f12121793

Takemoto H. et al. (2008). Sedative effects of vapor inhalation of agarwood oil and spikenard extract and identification of their active components. J Nat Med 62: 41–46. DOI: 10.1007/s11418-007-0177-0

Tay PY. et al. (2014). Assessment of extraction parameters on antioxidant capacity, polyphenol content, epigallocatechin gallate (EGC)G), (epicatechin gallate (ECG) and iriflophenone 3)-C-β-glucoside of agarwood (Aquilaria crassna) young leaves. Molecules 19: 12304–12319. DOI: 10.3390/molecules190812304

(2021). *The Assam Gazette.* Govenment of Assam, Industries and Commerce Department.

Uddin, M. S., Mukul, S. A., Mohammed Abu Sayed A. Khan, M. A., Alamgir, M., Harun, M., & Alam, M. S. (2008). Small-scale Agar (Aquilaria agallocha Roxb.) Based Cottage Enterprises in Maulvibazar District of Bangladesh: Production, Marketing and Potential Contribution to Rural Development. *Small-scale Forestry*.

Ullah, M. A. (2020). Boosting up the economy of Pakistan through agarwood production. *International Journal of Horticulture and Food Science, 2*(2), 25-35.

Wei, W., Mushtaq, Z., Ikram, A., Faisal, M., Wan-Li, Z., & Ahmad, M. I. (2020). Estimating the Economic Viability of Cotton Growers in Punjab Province, Pakistan. *SAGE*.

Weiss G. et. al. (2020). New Values of Non-Food Forest Products, *Forests*, 11, 165, doi: 10.3390/f11020165

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

---

[i] https://www.marketresearchfuture.com/reports/aromatics-market-930.