# From Soil to Fragrance: Empowering Bhutanese Farmers Through Agarwood Production

## A Comprehensive Business Plan

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# 1 Executive summary

The international Agarwood market presents Bhutan, a unique opportunity for economic development amidst escalating global demand and constrained supply dynamics. Bhutan's abundant Agar tree populations across seven districts position the nation favorably to emerge as a pivotal player in the Southeast Asian Agarwood trade. A meticulous assessment of market dynamics underscores the substantial potential for revenue generation through the cultivation and commercialization of Agarwood seeds, seedlings, and trees, both domestically and internationally.

Critical to the understanding of this opportunity is a comprehensive financial analysis. Initial capital outlays, encompassing fixed assets procurement, raw material expenses, and administrative overhead, are substantial but commensurate with the long-term revenue prospects inherent in Agarwood cultivation. Detailed financial metrics, including net present value, internal rate of return, and benefit-cost ratio, elucidate a progressive pathway toward profitability as Agarwood trees reach maturity and yield marketable products.

Mitigating the inherent risks associated with Agarwood cultivation demands a systematic approach grounded in scientific principles. Sustainable farming practices, crop diversification strategies, and robust contingency planning for natural calamities and market volatility are indispensable components of a comprehensive risk mitigation framework. Collaborative engagements with local stakeholders, government agencies, and international partners are imperative to ensure the efficacy of risk management initiatives.

The Agarwood sector holds transformative potential for Bhutan's rural economy. Through prudent utilization of its natural resources and strategic collaboration, Bhutan can position itself as a premier producer of high-quality Agarwood products in the global marketplace. By adhering to scientific principles and prioritizing sustainability, Bhutan can unlock the full economic potential of its Agarwood industry, fostering enduring prosperity for its citizens and contributing to the nation's socio-economic advancement.

# 2 Introduction

The Agar tree, *Aquilaria malaccensis*, found in Bhutan, is a large evergreen tree belonging to the family Thymelaeaceae, of the 21 recognized *Aquilaria* species worldwide (Mabberley, 2008). It is distributed from Assam to South China and New Guinea growing in a seasonally dry tropical biome (Yin et al., 2016 and POWO, 2024). In Bhutan, *A. malaccensis* is distributed in the broadleaf forests of subtropical foothills in various habitats, including rocky, sandy, or calcareous, well-drained slopes and ridges (Grierson and Long, 1983; CITES, 2003; Rabgay et al. 2020). It grows at an elevation range of up to 0 - 850 masl with average daily temperatures of 23-25° C (Kundu and Kachari, 2000). *A. malaccensis* is listed as critically endangered under criteria A2cd of the IUCN Red List Assessment (Harvey-Brown, Y. 2018) and Appendix II of the Convention on International Trade of Endangered Species (CITES, 2023). The global population of *A. malaccensis* for the last three decades is estimated to have declined by over 80% (Peng et al., 2015). Agar tree is listed under Schedule II of the Forest and Nature Conservation Act, regulating the collection and trade of the species (FNCA, 2023).

The depletion of wild Agar tree populations is driven by the high price fetched from naturally infected Agarwood which fosters illegal trade and overexploitation. This trend was observed in countries such as India, China, Vietnam, Laos, Thailand, Malaysia, Indonesia, West Papua, and Papua New Guinea (Barden et al., 2000; Angela et al., 2002; Wyn and Anak, 2010). There is limited data regarding the illegal trade and depletion of its population in Bhutan. The formation of Agarwood is constrained by its intricate process, and interplay among the infecting agent, host tree, and surrounding environment and assessing its quality. These complexities have impeded Bhutan's capacity to produce Agarwood similar to other countries (Mohamed, 2016). Due to Bhutan's limited technological advancements in developing inoculation techniques and delivery systems, Agar tree growing farmers resort to unreliable and expensive inducers from neighbouring countries for Agarwood induction. These makeshift inducers may contain harmful chemicals, compromising the quality of Bhutan's Agarwood in the international market and also hindering the development of eco-friendly inducers within the country.

Various economic products of Agarwood products are marketed including plant pieces, wood blocks, wood chips, oil, and waste powder (Yin et al., 2016). Possession of distinct wood instincts and valued fragrances has become one of the most expensive woods in the world. The price of first-grade Agarwood oil is Nu. 16623-Nu. 831168 (equivalent to INR) per 11.62 grams (tola) (El-Khawad and Ahal, 2019). Globally, it is widely used in perfumes, medicines, incense, alcohol, and herbal products. There is no reliable data on the exact trade volume of agarwood, however, annually it is estimated at several hundred tonnes with a trading scale reaching millions of dollars. Currently, the two major terminal markets in international trade exist: Northeast Asia (Japan, South Korea and Taiwan) and West Asia (Middle East) with Singapore serving as the largest international trading hub for import and export of Agarwood. Data shows the increasing volume

of agarwood trade in the Middle East from 56 tonnes in 2004 to 162 tonnes in 2007 (Yin et al., 2016). Agarwood product diversification at the market facet has increased the price of Agarwood more than 10 times in 2011 from the 2007 price. This has resulted in considerable Agarwood plantations on private land which further attracted worldwide enterprises.

Assam state of India is the heart of multi-core Agarwood trade with about 50,000 farmers with direct benefits and over 1.5 lakhs indirectly benefited. There is no data on the production of agarwood oil, but over 9100 distillation units exist in Assam (El-Khawad and Ahal, 2019) suggesting lucrative business for farmers. Subtropical foothills of Bhutan largely share similar patterns of climate and geophysical conditions to that of Assam providing an opportunity for Agarwood production. Recent feasibility studies on Agarwood oil production, show Bhutan's agarwood can be a high-end future product that is expected to hit the international market. This can be achievable through large-scale production of agarwood and the establishment of basic distillation Agarwood production facilities within the country. Current private Agarwood plantations have been maintained haphazardly without much technological guidance and may face trouble in organizing scientific support for seedling quality, spacing, nutrient application, fungal infection, and monitoring. Considering the market demand in Asia and the Middle East, the availability of land, and farmers' acceptance of economic return, the Agarwood-based model for sustainable Agarwood production in southern Bhutan appears highly viable.

Our comprehensive business plan aims to guide Bhutanese individual farmers and farmers' producer groups into the lucrative realm of agarwood cultivation. The plan includes detailed strategies for the cultivation, harvesting, and processing of agarwood outlining the detailed cost of operation and net return profit for individual farmers (one acre holding) and Farmers Producer Groups (FPG). The relevant data for projections of sales and returns were generated through personal communications with established Agarwood traders, researchers, and private enterprises, who have experience in Agarwood cultivation, trading, nursery development. The secondary data through desktop review of trade, cultivation, and analysis reported in international journals, Agarwood trade reports and trade projections.

Moreover, by fostering a sense of ownership and collaboration among farmers' producer groups, this plan aims to create a supportive ecosystem where farmers can share best practices, collectively access markets, and negotiate better prices for their produce. The business plan aims to empower Bhutanese farmers to become key stakeholders in the agarwood industry, fostering economic resilience and community prosperity.

# 3 Market demand analysis

The global agarwood market has been characterized by high demand, and significant pricing dynamics with limited supply. Agarwood products are exorbitantly priced for natural fragrances not only in the agarwood production regions (China, India, Myanmar, Malaysia, Laos, Singapore, Vietnam, Malaysia, Bangladesh, Philippines, and Thailand), but also in other parts of the world (Barden et al., 2000; Antonopoulou et al., 2010; López-Sampson and Page 2018), Middle East countries, Germany, France, Italy, United States, and Canada. Agarwood is rare and can only be produced under specific conditions making resources limited. There has been a consistent rise in demand for natural fragrances. The heightened demand has increased prices and commercial investment efforts in Agarwood-growing regions. The highest number of top three cultivated Agar trees is in China (~20 million), India (~10 million), and Indonesia (3.4 million) (Azren et al., 2017).

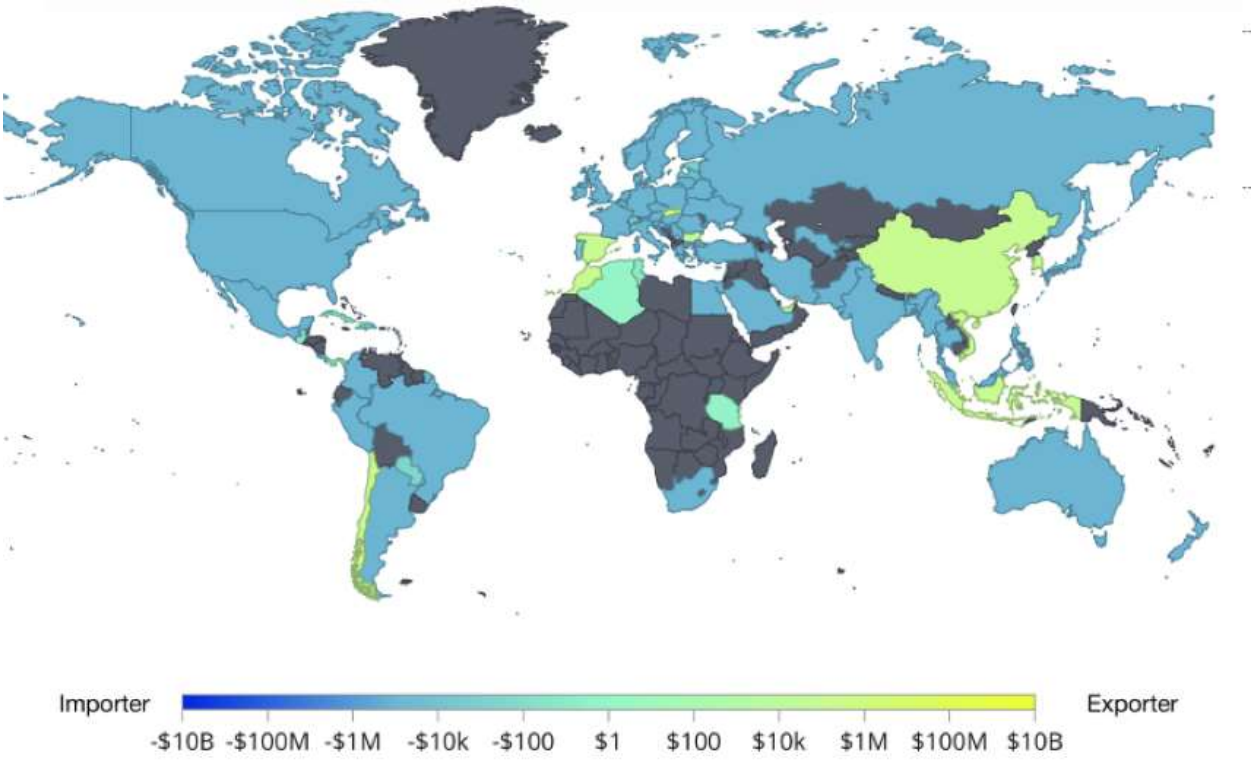


**Figure 1:** Map showing net export and import countries in 2021 (More, 2023)

Sales of Agarwood oil through e-commerce platforms have increased by 4.8% due to customers' preferences for online shopping services. The value of the agarwood market is estimated at USD 0.265 billion (equivalent to Nu. 21.456 billion) in 2023 and it is projected to increase consistently

to USD 0.4350 billion (equivalent to Nu. 35.235 billion) by 2032 with a compounding growth rate of 6.35% (More, 2023). As per Volva's Grow Global (2020) export data, shipments of Agarwood stood at 16.7 thousand tonnes, exported by 1215 world exporters to 3455 buyers. The top three exporters of Agarwood are Vietnam, Indonesia, and India (Tin, 2023). Therefore, given the increasing demand for products, there is an opportunity to explore cultivating these plants as an additional source of livelihood for the rural economy. Agarwood is one of the most expensive woods globally, prices range from hundreds to thousands of dollars per gram, depending on factors such as quality, resin content, and aroma profile. The market of agarwood is expected to grow continuously, driven by increasing demand from the fragrance industry, and consumer awareness of natural products.

Agarwood was the world's 3396$^{th}$ most traded product, with a total trade value of $288M. Between 2020-2022 alone the exports of agarwood products grew by 10.6%, from $260M to $288M. The top exporters in 2021 were China ($83M), Spain ($42.5M), Chile ($28M), Morocco ($24.9M), and Italy ($22M) while the top importers were Japan ($37.5M), United States ($34.9M), Italy ($24.2M), China ($21M), and Russia ($19M) (Fig 1).

The current market demand in the country for Agarwood products such as seeds, seedlings, and trees (inoculated and non-inoculated) currently practiced without the formulated policy and market strategies (pricing and sales) was determined through personal communication with individual farmers, uncertified and certified traders and government officials with knowledge and informed understanding of the Agar tree market practices within the country. However, the sales and marketing forecast for the Agarwood essential oil was not determined as it has not been currently practiced or no relevant data on its trade and grade has been formulated due to a lack of policies, strategies and facilities such as the distillation units.

# 4 Project idea

Bhutan has the potential to be the major hub of natural and cultivated Agarwood trade in the Southeast Asia region. The Agar tree is found in seven dzongkhags of the country namely Mongar, Zhemgang, Sarpang, Pemagatshel, Chukha, Samtse and Samdrup Jongkhar. Natural stands of the tree have been observed in Zhemgang and Sarpang district. A total of 527,173 plantations have been surveyed and documented by the Department of Forests and Park Services (DoFPS) as of 2023. Zhemgang district has the highest records of plantations (395711) Agar trees, Sarpang (72671), Pemagatshel (30514), Samtse (14456), Chukha (407), and the least in Mongar district (44) (i.e., in community forests and state-reserved forest lands). The plantations were mainly carried out with support from DoFPS and some seedlings were procured from neighbouring states of India (Assam). Plantations in state-reserved forest lands (8.18 acres) and community forests (31.72 acres) followed the plantation's norms and standards. However, those planted in private lands were left to the owner's discretion.

Moreover, the lack of appropriate policies and guidelines for Agar tree plantations, inoculation, distillation, and trade in the country resulted in poor returns for the enthusiast agar cultivator. Recently, the UWIFoRT, DoFPS has been conducting inoculation trials using nature-based (organic chemicals and biological) techniques and delivery systems to ascertain agarwood formation and published few agarwood related documents/guidelines. This initiative would greatly help in promoting agarwood cultivation in Bhutan and would ultimately serve as an alternative source of livelihood for farmers in the Agar-growing districts. Based on these considerations, the current business plan model for promoting Agarwood production has been formulated. This business model aims to encourage Agarwood production on private lands, reducing the need for illegal harvesting from natural sources, and enabling the development of readily adoptable technology. The goal is to boost economic gains for farmers and others involved in the Agar industry and provide the framework for establishing the required facilities.

This proposed plan operates under the assumption that a capable local Non-Governmental Organizations (NGO) or government agency will spearhead the organization of farmers/producers at different levels (group, village, and district) while also assisting in the establishment of a Farmer Producer Group (FPG). Interventions are proposed at two levels: the individual farmer level and the FPG level. Support for farmer groups can be provided through either a local competent NGO or government agency, encompassing mobilization and sensitization for agar cultivation adoption, organization into farmer Producer Groups (FPGs), training on agar cultivation practices, facilitating loans, supplying quality agar seedlings, assisting with tree insurance, and facilitating marketing of agarwood at competitive prices. **A cluster approach is proposed, with a minimum of a acre of land targeted for Agar cultivation (seeds, seedlings, trees (inoculated and non-inoculated), nursery, plantation development, and marketing).**

# 5 Farmer producer group: linking to markets

The proposed business model is designed for individual farmers and farmer's groups or cooperatives opting to undertake Agarwood business. In FPG, the farmers or producers are members of the cooperatives/group. As small farmers may not have the individual capacity to establish and gain the benefit of economies of scale, i.e., the proposed model (FPG) provides end-to-end support and services to small farmers, covering technical services, marketing, processing, and other aspects of cultivation inputs. The main aim is to ensure better income for producers through organization of their own. The formation of Agarwood FPGs may follow the guidelines as prescribed in the formation of Community Forestry and NWFP management groups (DoFPS, 2018). The formation and regulations of FPGs could be as outlined below:

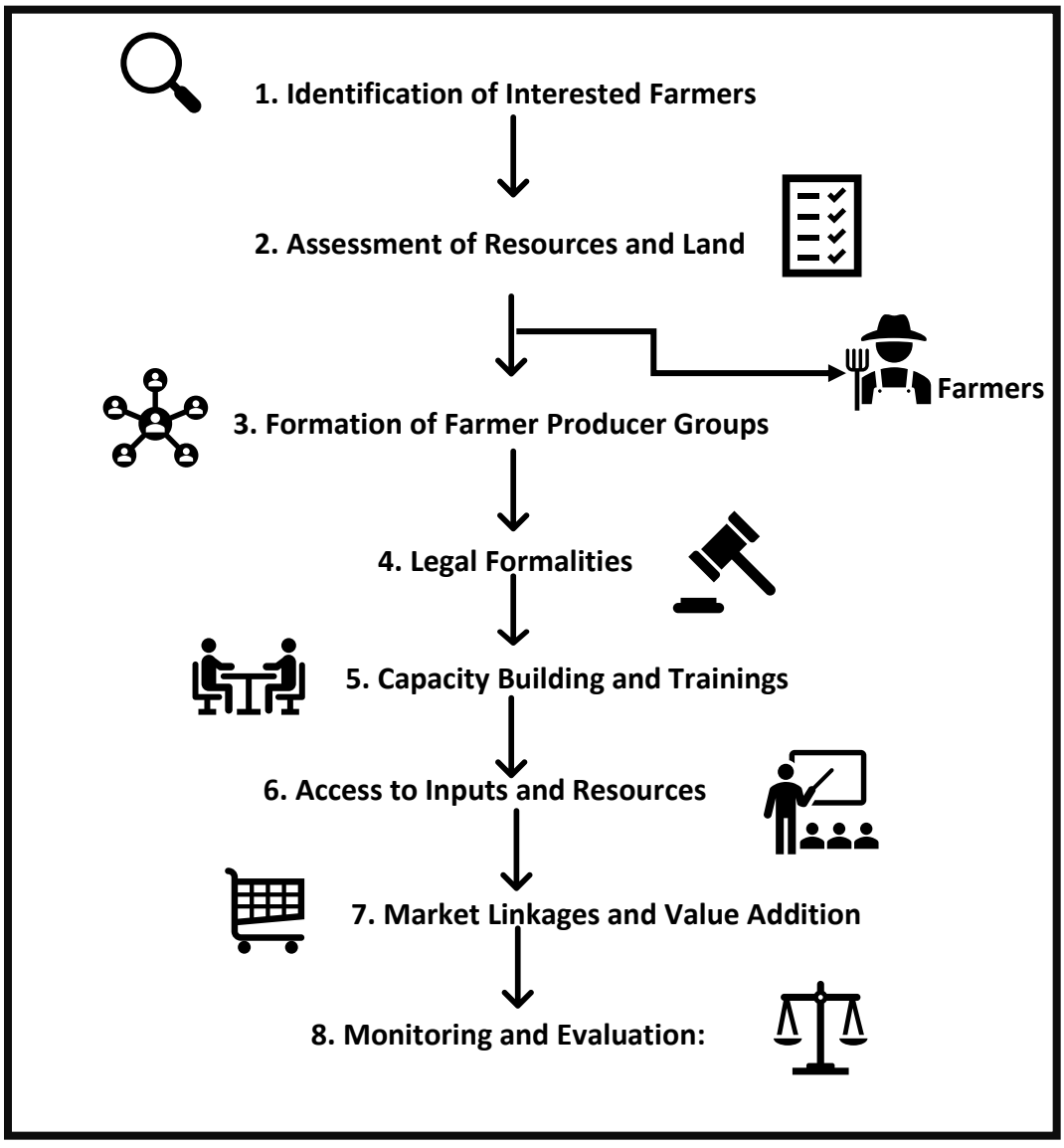

**Figure 2:** Farmer producer's groups (FPG) formation and group dynamics

The process begins with identifying interested farmers and conducting awareness sessions on Agarwood cultivation. Resources and land are assessed, and Farmer Producer Groups (FPGs) are formed through consensus and legal registration. Capacity-building programs to train farmers in cultivation techniques and sustainable practices. Access to inputs is facilitated, including quality planting materials and necessary resources. Market linkages are established for Agarwood products, with an emphasis on value addition. A monitoring and evaluation system tracks progress and adjusts strategies based on feedback and market dynamics. This holistic approach aims to empower farmers, ensure sustainable cultivation practices, and maximize profitability through collective action and market integration.

# 6 Business model for *Aquilaria* cultivation

Under this proposed model, it is assumed that a government agency or an established NGO could initially take up, encompassing mobilization and sensitization for Agar cultivation adoption, organization into Farmer Producer Groups (FPGs), training on Agar cultivation practices, facilitating loans, supplying quality Agar seedlings, assisting with tree insurance, and facilitating marketing of Agarwood at competitive prices. A cluster approach is proposed, with a minimum of one acre of land targeted for Agar cultivation (seeds, seedlings & tree) nursery, plantation development, and marketing.

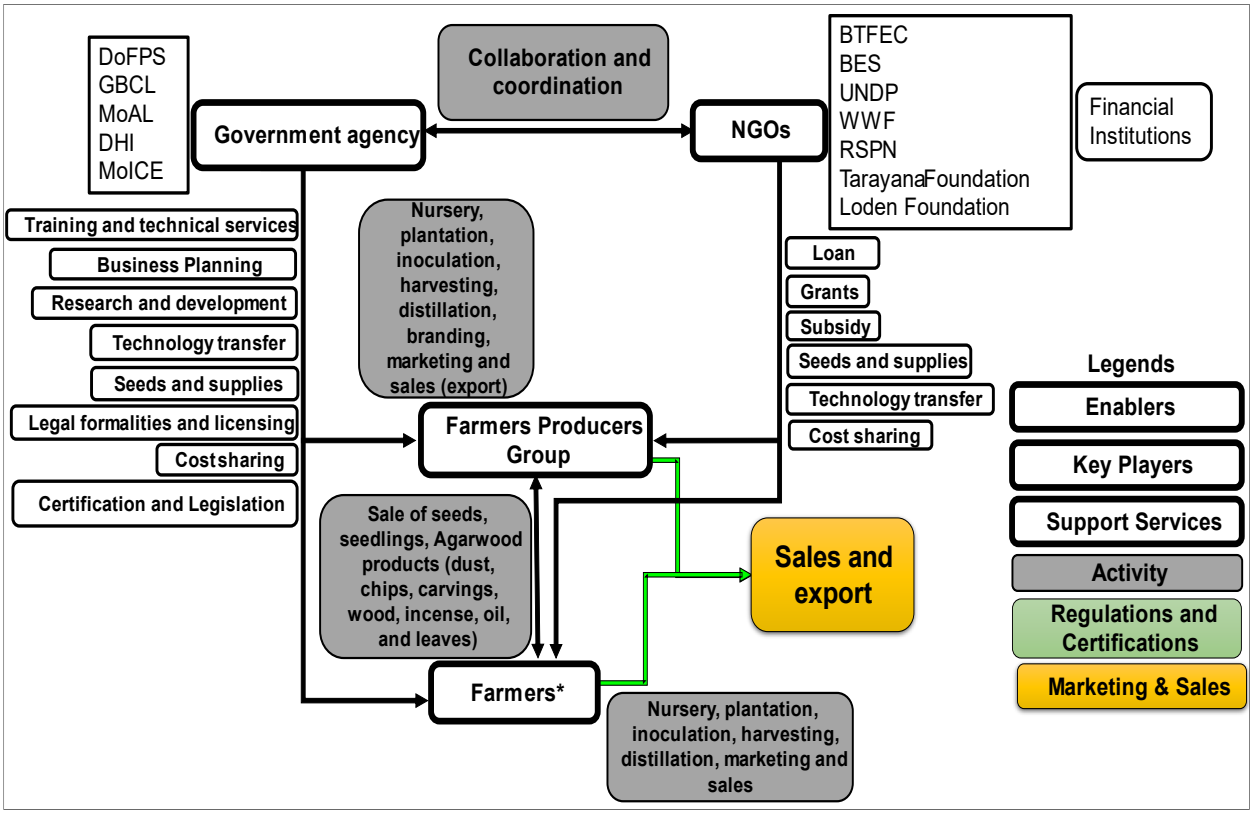


**Figure 3:** Diagrammatic representation of the proposed business model

Individual farmers or Farmer Producer Groups (FPGs) have the option to secure loans, grants, or subsidies from organizations like the NGOs or commercial banks. These funds can be used to develop the necessary infrastructure and systems for cultivating Agarwood produce. Additionally, FPGs can also secure working capital loans to cover operational expenses and purchase individual farmer produce. The NGO or financial institutions may facilitate loans for farmers through banks while retaining a predetermined margin on interest rates to cover administrative expenses. Furthermore, the FPG must also focus on enhancing farmers' capabilities in Agar cultivation, artificial inoculation of Agar trees, and identifying infected Agar trees before harvesting.

# 7 Sales and marketing strategy

The research conducted on the Agarwood trade in India indicates that Bhutanese Agarwood and its derivatives are considered to be of high quality. In an interview, an Emirati Agarwood dealer praised Bhutan for being the source of best quality Agarwood among range states (CITES, 2003).

The marketing of Bhutanese Agarwood will begin as an individual farmer or Farmer Producers' Group in collaboration with government agencies and NGOs to enable a structured trade in the Middle East and other nations, where Bhutanese Agarwood is highly regarded for its exceptional quality (CITES, 2003). The FPG and individual farmers will directly collect and aggregate raw materials for further trade.

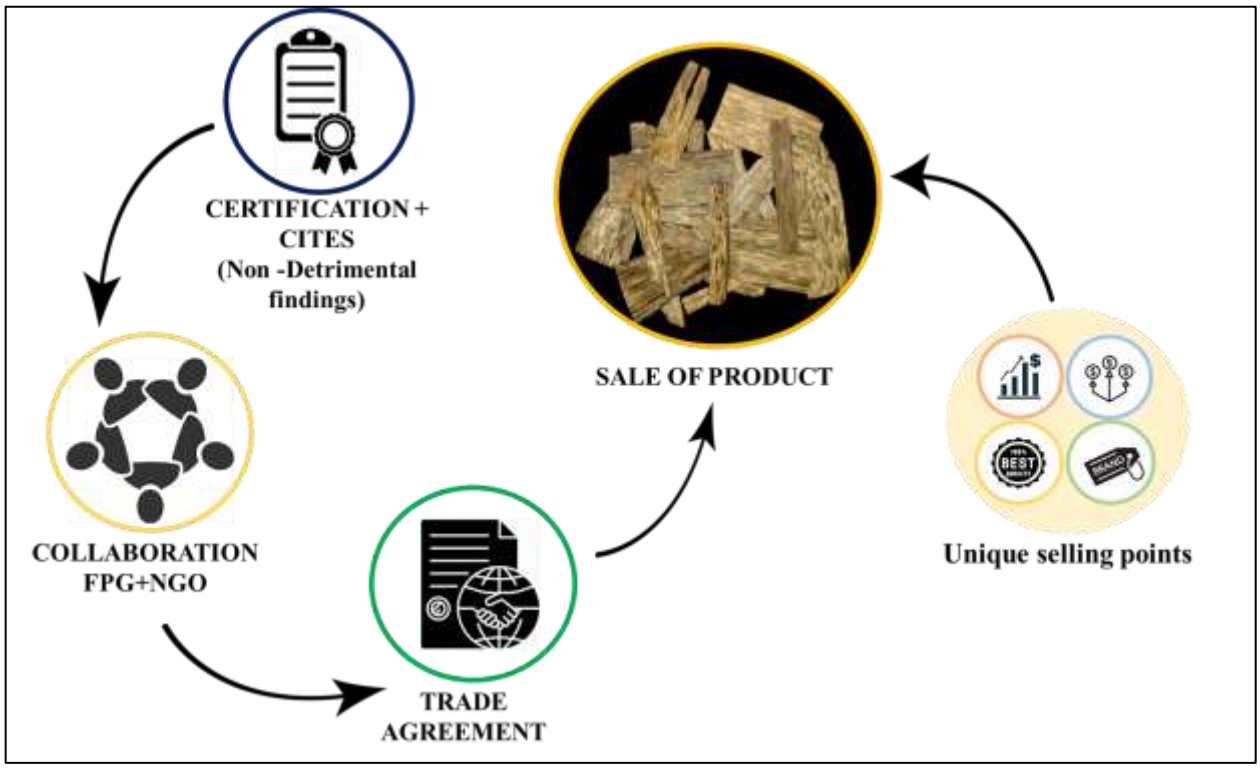


**Figure 4:** Proposed procedures for the sale and marketing of Agarwood in Bhutan

***Certification***

The certification of Bhutanese Agarwood products will follow the organic products certification procedure (BFDA, 2023) and ISO 9001 certification for quality management systems.

***Sales and marketing***

Marketing of Agar-based products involves the branding, value addition, promotion, advertisement, distribution, and export of products by the FPG through the following channels:

1. ***Regular and specialty pharmacies:*** Pharmacies dealing with medications that treat complicated or rare health conditions.
2. ***Supermarkets & hypermarkets:*** Retail stores offering a diverse range of products, including groceries, household items, electronics, clothing, and many more aimed at providing a quick and convenient shopping experience for customers who want to purchase household essentials and other necessities.
3. ***eCommerce:*** E-commerce enables brands to make an array of products available, which are then shipped from a warehouse or various warehouses after a purchase is made.
4. ***Retailer shop:*** Physical establishments where products or services are sold directly to consumers.

Despite the challenges Bhutanese Agarwood products may face as a new entrant in the market, several opportunities exist to expand their presence and diversify offerings, driven by global market growth and demand across different regions. Proximity to India as an established market provides Bhutan with an immediate platform for the sale of unprocessed Agarwood.

# 8 Financial analysis

## 8.1. ASSUMPTION

The figures and data related to the cost of each commodity are based on personal communication and correspondences with existing agarwood enthusiast cultivators and small-scale Agarwood business entities within the country. Secondary data related to trade, market, current value, and return from trade are based on literature review and international trade data.

1. Per tree (> 10 years, dbh = >10cm, inoculated, minimum 10 kg infection evident): Nu. 166,240

2. Per tree (>10 years, dbh = >10cm, non-inoculated): Nu. 6000

3. Agarwood essential oil: 1 tola (11.7g) = Nu. 16623 - Nu. 831168 (equivalent to USD 200–USD 10000) based on the grade and purity of oil.

4. Agarwood chips (infected part): 1 kg = Nu. 16624

5. Unit seedling: Nu. 25

6. Seeds (with pod intact) per kg: Nu. 600

7. Potential Market: Middle East (Kuwait), India, Thailand and Singapore

8. Agarwood (uninfected wood: Incense factory, FoTM): Nu. 80/kg

## 8.2. DISCLAIMER

The projection and forecast related to the final product of Agar essential oil were not considered in the current proposal due to the following reasons:

1. Lack of data for the trade and sale of Agarwood essential oil in the country

2. Non-existent of infrastructure such as the distillation and grading facilities in the country

3. No definite market or trader certified within the country

4. Research and development currently underway for local inoculum culture

However, to recognize the enormous return potential from the extraction of Agarwood essential oil, a financial projection for establishing such infrastructure has also been outlined for future possibilities and implementation.

# 8.1 Demand supply analysis

**1. The demand for Agar tree seeds from naturally growing Agar tree:**

The demand for Agar tree seeds as marketed currently by Agarwood cultivator and nurseries within the Agar tree growing region is estimated at Nu. 600/Kg. The already existing established nurseries, private and institutions was estimated at 50 numbers as the potential market (demand) for Agar seeds.

**2. The demand and supply analysis for the proposed model is designed considering the procedure prescribed in the Revised Norms and Standards for Nursery Plantations (DoFPS, 2020) of Bhutan as listed below:**

**a.** As total of 650 Agar seedlings can be sown in one acreage of land (spacing = 2.5m X 2.5m) (DoFPS, 2020) in the Agar growing regions of Bhutan, the existing demand for seedlings was estimated at 150 numbers of farmers considering the already existing plantation sites within the country as the potential market.

**3. Demand for Agar tree inoculated with signs of infection when blazed:**

**a.** The sale of inoculated Agar trees with potential signs of infection (when blazed) with a diameter at breast height >10cm, and age of tree > 10 years was estimated at Nu. 166240 per tree

**b.** The sale of non-infected inoculated Agar trees (when blazed) with a diameter at breast height >10cm, and age of tree > 10 years was estimated at Nu. 6000 per tree

**Data source:** The current market demand in the country for Agarwood products such as seeds, seedlings, and trees (inoculated and non-inoculated) currently practiced without the formulated policy and market strategies (grade and pricing) was determined through personal communication with individual farmers, uncertified and certified traders and government officials with knowledge and informed understanding of the Agar tree market practices within the country.

Additional secondary sources of data from the trade reports of Agarwood exporters and importing countries, publications and journals were also referred.

**Considerations:**

1. The demand and cost in the proposed model were estimated through the cost and returns from plantation and supply from individual farmers or FPG on 1 acreage land holding.

2. The sales and marketing forecast for the Agarwood essential oil was not determined as it has not been currently practiced or no relevant data on its trade and grade has been formulated due to a lack of policies and strategies.

**Table 1:** Demand analysis for Agar trees, seedlings, and seeds within and outside the country

| Particulars | Potential market | Value (Nu.) | Demand (Nos.) | Total value (Nu.) |
|---|---|---|---|---|
| Agar tree (inoculated & infected) | International (Kuwait, Thailand, Singapore and Others) & Bhutan (certified trader) | 166240 | 520 | 86444800 |
| Agar tree (inoculated & non infected) | | 6000 | 130 | 780000 |
| Agar seedlings | Bhutanese Agar cultivars, Private nurseries and NGO's | 25 | 97500 | 2437500 |
| Agar seed (with pods) | | 600 | 50 | 30000 |
| **Total market demand value** | | | | **89,692,300** |

1. The total market demand value for Agar tree (infected and non-infected), seedlings and seeds were estimated at Nu.  89692300.

2. Out of the total 650 seedling planted in one acreage of land holding, it is estimated that 80% (520 Nos.) of the trees will show signs of Agarwood formation and 20% (130 Nos) as non-infected.

3. The current rate for each Agar seedling in the current Bhutanese market is Nu. 25 per seedling. The demand for seedlings was estimated at an acreage (650 seedlings required) at Nu. 25 per seedling for 150 additional acreage plantations in the Agar growing regions of Bhutan amounting to the market demand of seedlings at Nu. 2437500.

4. The demand for Agar seeds considering the established nurseries, and private and institutional cultivators was estimated at Nu. 30000 with demand from 50 established or enthusiast nursery managers for seeds at Nu. 600/Kg with intact seed pods.

**Note**:

The supply of Agarwood trees (infected and non-infected), seedlings, and seeds has not been formulated at a regulated pricing and volume in the country. Considering the current rate of minimal supply and trade in local markets as discussed through personal communication and literature reviews, the total supply of Agarwood commodities within the country is very minimal.

Further, without important supply data for the above listed Agar commodities, the supply could not be ascertained.

## 8.2 Cost of establishment

### 1. Total production cost

Table two represent the quantities and costs associated with each item required for nursery establishment and plantation site development by individual farmers and FPG on 1 acreage of land:

**Table 2:** Cost of establishment for Agar tree on 1 acreage of land:

| Sl. No | Particulars | Unit | Quantity | Unit cost (Nu.) | Total cost (Nu.) |
|---|---|---|---|---|---|
| **A.1** | **Fixed asset cost** | | | | |
| | **1. Nursery establishment:**<br>Water storage facility (Sintex)<br>Nursery tools and equipment<br>Green net/Agro-net | <br>2000L<br>1 set<br>1 roll | <br>2<br>1<br>1 | <br>12500<br>40000<br>2575 | <br>**25000**<br>**40000**<br>**2575** |
| | **2. Inoculation tool:**<br>Drill machine | 1 set | 18500 | 18500 | **18500** |
| | **3. Plantation site development**<br>Barbed wire (kg)<br>PVC pipe (roll)<br>U-nail | Kg<br>1 roll<br>Kg | 150<br>1<br>4 | 95<br>3000<br>125 | **14250**<br>**3000**<br>**500** |
| **A.1. Fixed asset total cost (1+2+3)** | | | | | **103825** |
| **A.2** | **Direct raw materials cost** | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | Sand/Leaf mould<br>Agar seeds (with pods)<br>Fertilizers<br>Biopesticides | Truckload<br>Kg<br>Kg<br>Lumpsum | | <br>2<br>10<br>1<br>1 | <br>5000<br>600<br>1000 | **10000**<br>**6000**<br>**1000**<br>**10000** |
| **A.2. Direct raw materials total cost** | | | | | | **27000** |
| **A.3** | **Inoculum preparation cost** | | | | | |
| | Inoculum mixture | Kg | 1950 | 500 | | **975000** |
| | **Total establishment cost (A.1+A.2+A.3)** | | | | | **1002000** |

**Total production cost considerations:**

**a. Fixed assets total cost:**

i. The fixed asset total cost was calculated for the nursery establishment, purchase of tools, and plantation site development materials procurement. The total fixed assets cost was estimated at Nu. 103825.
ii. The direct raw material required for the seedling production and inoculum mixture is estimated at Nu. 1002000.

**Considerations:**

The proposed model considers that the establishment of a nursery and the sale of seedlings will help cover the cost of operation and also serve as an additional supply of seedlings for replenishing the dead and diseased seedlings at the plantation site.

**2. Unit cost of production**

The following table provides the unit cost of production for a unit seedling and an inoculated-infected Agar tree for individual farmers and FPG on 1acreage of land:

**Table 3:** The unit cost of production for a unit seedling in the nursery and Agarwood infected tree at a plantation site on 1 acre of land.

| Sl No. | Particulars | Unit | Quantity | Total cost (Nu.) | Unit cost (Nu.) |
|---|---|---|---|---|---|
| **A.1** | **Unit cost of seedling (nursery)** | | | | |
| | 1. Direct raw material total cost<br>2. Factory Overhead Cost<br>3. Unit of production | Nos<br>Lumpsum<br>Nos | 1 acre<br>1500 | 27000<br>640<br>**27640** | **18.5** |
| **A.1 Unit cost of seedling production** | | | | | **18.5** |

| A.2 | Unit cost of Agarwood tree (inoculated and infected) | | | | |
|---|---|---|---|---|---|
| | 1. Direct Raw Material Cost<br>2. Unit of production | 3 Kg<br>Tree Nos. | 1950 | 1004250*<br>65 | **15450** |
| **A.2 Unit cost of agarwood production** | | | | | **15450** |

**Unit cost of production considerations:**

**a. Unit cost of seedling:**

i. The unit cost of seedling was estimated at Nu. 18.5 considering that the proposed nursery size produces a total of 1500 numbers of seedlings annually.

ii. The factory overhead such as the payment for the lease of land at Nu. 640 per annum was determined as prescribed in the land lease rate of Bhutan (NLCS, 2023) for commercial agriculture farm rate per annum.

iii. The unit cost of each seedling was determined by dividing the total cost of production (Direct raw material total cost + factory overhead cost) by the unit of production.

**b. Unit cost of Agarwood tree production through inoculation**

i. The unit cost of production for Agarwood in 1 acre of land amounts to Nu. 15450 after the year of 1$^{st}$ year (year 9) of inoculation.

ii. An estimated 3 Kg of inoculum mixture is required for inducing each tree priced at Nu. 500 as ascertained through the current trial conducted in plantation sites.

iii. A total of 1950 Kg inoculation in 1 acre of land was estimated to be induced (650 trees in 1 acre requiring 3 Kg of inoculum mixture per tree).

iv. The total estimated cost for inoculating in the 9$^{th}$ year is Nu. 1004250 considering an increase of 3% of the price for inoculum mixture of the 8$^{th}$ year of Nu. 975000.

v. To ensure sustainability and better formation of Agarwood, 65 trees were estimated to be harvested in the second year of inoculation (9$^{th}$ year), considering the 8$^{th}$ year as the first inoculation year.

vi. The harvesting practice for sustainability and improved Agarwood formation in the current model is proposed through percentile harvesting in subsequent years.

vii. Annually estimated harvesting practice is recommended as 1st year after inoculation (10%), 2nd year (15%), 3rd year (28%), 4th year (25%), 5th year (22%), and 6th year (22%) of the total 650 trees planted.

**c. Provisional cost for the establishment of Agar oil distillation unit and facilities:**

The probable cost for the establishment of a distillation unit is estimated based on consultation with Agarwood experts in Malaysia. The most efficient, affordable, and effective unit is estimated at Nu. 983936 (equivalent to USD 11870). The facilities include 10 tons log splitter (USD 770), 4KW hammer mill (USD 1700), and 20 Kg distillation pot (USD 9400).

## 8.3 Cost of establishment

**1. Administrative and marketing cost**

The following table provides total administrative expenses for production of Agar seedlings and Agarwood tree for individual farmers and FPG on 1 acreage of land:

**Table 4:** The total administrative cost for the establishment of the nursery, plantation, and maintenance (13-year period)

| Sl.No | Particulars | Unit | Quantity | Unit cost (Nu.) | Total cost (Nu.) |
|---|---|---|---|---|---|
| **A.1** | **Total administrative cost** | | | | |
| | 1. Royalty<br>2. Maintenance | Nos<br>Lumpsum | 128<br>1 acre | 6 | **768**<br>**5000** |
| | **Total administrative cost** | | | | **5768** |

| | | | | | |
|---|---|---|---|---|---|
| **A.2** | **Total market cost** | | | | |
| | 1. Laptop | Nos | 1 | 40000 | **40000** |
| **Total market cost** | | | | | **45768** |

**Total annual administrative considerations:**

**i.** The royalty for the purchase of fencing posts for plantation site fencing was determined as prescribed through the rates in the Online Forestry Services Portal (DoFPS).

**ii.** The number of posts required 128 numbers was determined at a post distance of 2m (perimeter = 255m)

**iii.** The cost of maintenance for 13 years was estimated at a lumpsum value of Nu. 5000 (cost for fencing maintenance, seedling replenishment, and weeding).

**iv.** The total administrative cost for administration and marketing is estimated at Nu. 45768.

## 8.4 Pre-operating activities and costs

**1. Pre-operating activities cost and cost**

**Table 5:** The following table provides the pre-operating activities and related costs before the establishment of nurseries and plantations:

| Activity | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Expenses |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Formation of FPG | | | | | | | | | | | | | |
| Loan processing | | | | | | | | | | | | | 3000 |
| Land acquisition & registration (Plantation) | | | | | | | | | | | | | |
| Procurement of materials and equipment | | | | | | | | | | | | | 15000 |
| Establishment of nursery | | | | | | | | | | | | | |
| Land preparation (plantation) | | | | | | | | | | | | | |
| Transportation (plantation sites) | | | | | | | | | | | | | 2000 |
| Fencing plantation area | | | | | | | | | | | | | |
| Royalty of fencing post | | | | | | | | | | | | | |
| Opening ceremony | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | 20000 |

**2. PoE amortization**

**Table 6:** Pre-operating expense amortization for 5-year period

| POE Total | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| 20000 | 0 | 0 | 6667 | 6667 | 6667 |

**Pre-operating activities cost and amortization considerations:**

**I.** The pre-operating activities and cost include the overall activities before the onset of the nursery, plantation, and marketing of Agarwood (seedling and Agar tree).

**II.** The total PoE cost is estimated at Nu. 20000 incurred before the establishment of an Agar tree in 1 acre of land.

**III.** The amortized period of the pre-operating cost is determined for repayment after the 3rd year amounting to Nu. 6667 till the end of the 5th year.

## 8.5 Total project cost

**Table 7:** The following table provides the total project cost for the establishment of administrative, marketing, and pre-operating costs:

| Items | Equity | | Bank loan | Total |
|---|---|---|---|---|
| | Available | Proposed | | |
| Fixed assets | | | | 1,042,000 |
| POE | | | | 20000 |
| Working Capital | | | | 33408 |
| **Loan amount** | | **328622.4** | **766785.6** | |
| **Total project cost** | | | | **1095408** |

**Total project cost considerations:**

**i.** The total project cost for the establishment of Agarwood in 1 acre of land holding amounts to Nu. 1095408 including the cost incurred from fixed assets procurement, pre-operating expenses, and working capital.

**ii.** The working capital was estimated at Nu. 33408 (administrative cost + direct raw materials cost).

**Loans:**

To meet the total project cost for the establishment of Agarwood cultivation facilities, the model proposes seeking loans from financial institutions.

30% of the total project cost (Nu. 1095408) amounting to Nu. 328622.4 will be invested as an equity or grants.

The additional 70% of the total project cost amounting to Nu. 766785.6 will be availed as a loan from financial institutions.

The total loan amount of Nu. 855565.2 (principal and interest) at an interest rate of 11.5% (small-scale industries loan) for 10 years will be paid with Nu. 7130 per monthly instalment.

# 9 Benefit cost analysis: financial metrics

## 1. Profitability analysis

**Table 8:** Net profit analysis for the sale and return of Agar tree (seedling + Agarwood tree), profitability, return, net present value, internal rate of returns, and cost-benefit analysis.

| Financial metrics | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sales** | 0 | 37,500 | 37,500 | 37,500 | 37,500 | 37,500 | 37,500 | 37,500 | 8,759,980 | 13,775,406 | 27,431,412 | 22,934,010 | 18,436,608 |
| **Net profit** | -121588 | -76080 | -74763 | -66805 | -58872 | -44299 | -36420 | -1003569 | 7697483 | 12690574 | 26323309 | 21792857 | 17261412 |
| **Profitability** | 0.00 | -202.88 | -199.37 | -178.15 | -156.99 | -118.13 | -97.12 | -2676.18 | 87.87 | 92.12 | 95.96 | 95.02 | 93.63 |
| **Return on investment (ROI)** | -11.10 | -6.95 | -6.83 | -6.10 | -5.37 | -4.04 | -3.32 | -91.62 | 702.70 | 1158.52 | 2403.06 | 1989.47 | 1575.80 |
| **Return on Equity** | -37.00 | -23.15 | -22.75 | -20.33 | -17.91 | -13.48 | -11.08 | -305.39 | 2342.35 | 3861.75 | 8010.20 | 6631.58 | 5252.66 |
| **Debt: Equity ratio** | -0.64 | -0.39 | -0.40 | -0.37 | -0.33 | -0.24 | -0.18 | -9.58 | 57.30 | 104.09 | 0.00 | 0.00 | 0.00 |
| **Net Present Value** | | | | | | | | | | | | | 35,042,154.71 |
| **Internal Rate of Return** | | | | | | | | | | | | | 44% |
| **Benefit-Cost Ratio** | | | | | | | | | | | | | 31.9 |

**Profitability analysis considerations:**

- **i.** The net profit from the sale of Agar tree seedlings (2nd year to 13th year) and infected Agarwood trees (9th year to 13th year) shows a negative return till the onset of the sale of Agar seedlings and infected Agarwood trees in 9th year considering 8th year as the onset of inoculation.
- **ii.** Similarly, return on investment, equity, and debt-equity ratio show a similar pattern of return with a positive return after the onset of the sale of Agar seedlings and infected Agarwood trees in the 9th year considering the 8th year as the onset of inoculation.
- **iii.** The net present value for the Agarwood production and sale industry of Nu. 18436608 at the end of the 13th year is equivalent to Nu. 35042154.17 in the current year.
- **iv.** An internal rate of return (IRR) of 44% means that the investment is expected to generate a return of 44% per period over its lifespan.
- **v.** The benefit-cost ratio (over 13 years) for individual farmers and FPG is estimated at the ratio 31.9. A benefit-cost ratio (BCR) of 31.9 means that for every unit of cost incurred, there are 31.9 units of benefit generated over the 13 years

# 10 Break-even analysis

**Table 9:** Total sales and cost of production for Agarwood tree cultivation over 13 years period

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sales** | - | 37500 | 37500 | 37500 | 37500 | 37500 | 37500 | 37500 | 8759980 | 13775406 | 27431412 | 22934010 | 18436608 |
| **Cost** | 1069640 | 1054664 | 1039713 | 1024787 | 1009887 | 995014 | 980167 | 1940349 | 1954810 | 1970178 | 1986481 | 2003747 | 2022004 |

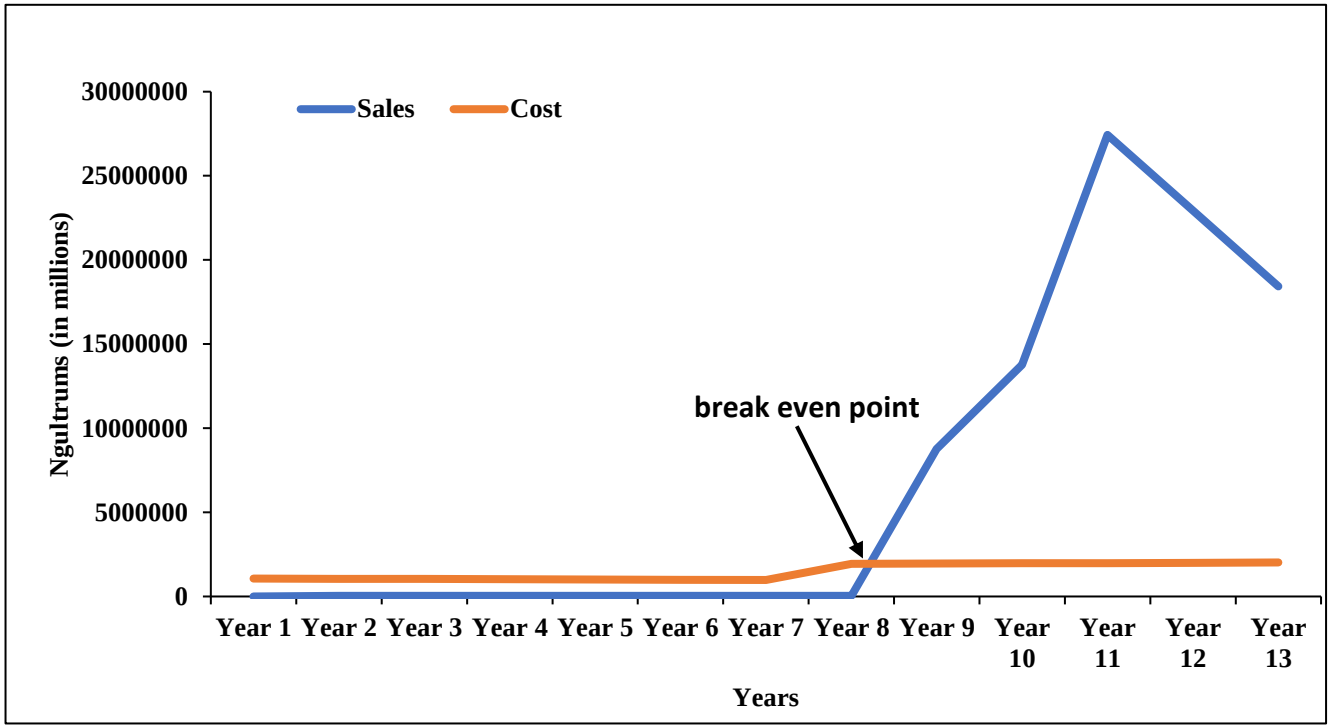


**Figure 5:** Break-even analysis of total sales and total production over the 13 years of operation

# 11 Risk management

In Bhutan, managing risks associated with Agarwood seedlings, plantations, and product sales involves several key strategies. Firstly, it's crucial to identify potential risks, including natural threats like adverse weather conditions and pests, as well as plantation-specific challenges such as crop failure and market volatility. Assessing the probability and impact of these risks might help prioritize mitigation efforts.

Proposed mitigation strategies include diversification of crops, investing in crop insurance, and implementing sustainable cultivation practices. Developing efficient irrigation systems and pest management plans will further enhances resilience. Additionally, conducting thorough market research will help identify demand trends and alternative markets, reducing dependency on a single buyer.

Contingency plan involving established early warning systems for natural disasters, maintaining emergency funds, collaboration with Agarwood experts and government agencies will facilitate knowledge sharing and access to support programs, such as subsidies and grants.

Continuous monitoring of plantations for signs of stress and regular review of risk management strategies will ensure adaptability to changing conditions. By integrating these measures, Bhutan can mitigate risks associated with Agarwood cultivation and sales, promoting long-term sustainability and resilience in both natural and plantation settings.

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