Non-detriment Findings (NDFs) of *Aquilaria malaccensis* Lam. (Agarwood) in India

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Ministry of Environment, Forest & Climate Change
2024

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अहो एषां वरं जन्म सर्व प्राण्युपजीवनम् ।
धन्या महीरूहा येभ्यो निराशां यान्ति नार्थिनः ॥

Oh, how wonderful it is to be born and to sustain all living beings!
Blessed are these trees who never disappoints their suppliants

An agarwood sapling brought from Hojai, Assam, and was re-introduced in the Acharya Jagadish Chandra Bose Indian Botanic Garden, Howrah, by Ms. Leena Nandan (IAS), the Hon'ble Secretary of the Ministry of Environment, Forest & Climate Change, Government of India.

PREFACE

The fundamental principle of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is to ensure that the trade of a particular species remains within sustainable bounds. The Convention states that the Parties shall only be permitted the export of specimens of species included in Appendix I and II if the exporting state's scientific authority certifies that the export "will not be detrimental to the survival of that species". This determination based on Articles III and IV of the CITES is known as a 'Non-detriment Findings' (NDFs). The concept of NDF is pivotal in endangered species' trade and conservation, serving as a critical tool to assess the impact of harvesting on wild populations and ensure that trade does not threaten their survival.

Agarwood, also known as oud or agar, is a highly valuable and aromatic resinous wood that forms within the heartwood of *Aquilaria* and *Gyrinops* trees belongs to the family Thymelaeaceae. Agarwood holds a profound significance in medicine, rituals, and luxury perfumery. In India, agarwood is obtained from the species *Aquilaria malaccensis* Lam., which is found in the wild and extensively in cultivation. *Aquilaria malaccensis* is listed as a Critically Endangered (CR) species in The IUCN Red List of Threatened Species. The species is also listed under CITES Appendix II; therefore, its international trade is under the regulation of CITES.

The Botanical Survey of India (BSI) has been entrusted with the Non-detriment Findings study of *Aquilaria malaccensis* Lam. (agarwood) on a priority basis by the MoEF&CC (WL), Government of India. The BSI has completed the study in four months in a fast-track mode and produced the outcomes in the form of this book. Through this study, we endeavour to bridge the gap between scientific research, policymaking, and on -the-ground conservation efforts. This comprehensive work is an output of exhaustive field surveys, market surveys, and agarwood processing facility visits. Data were also gathered from forest departments, representatives of agarwood associations, vendors, purchasers, stakeholders, and other related sources.

The data of this NDF study is presented under different sections *viz.* Introduction, Methodology, and the core NDFs assessment part. The assessment section includes two major parts *viz.* Background information of the taxon followed by the Nine steps guidelines for the NDFs assessment provided by CITES.

BSI's deliverance on this NDFs is 'Negative' for wild and 'Positive' for cultivated populations. Hence, the harvest and export are suggested only from the plants in cultivation and no harvest and export of the wild stocks such as plants from the wild population and plants growing in protected areas as well as reserve forests is recommended. The annual export limit has been suggested to be increased from the existing limit of 25,000 kg (chips and powder) and 1,500 kg (oil) to 1,51,080 kg and 7,050 kg respectively. The recommendations based on the outcome of this NDFs will help the Management Authority to frame suitable policies for sustainable utilization of *A. malaccensis* in India.

The present study set an example as it differs from the conventional NDFs assessment by incorporating more interdisciplinary scientific objectives such as morphological, molecular, genetic, and chemical analysis, making it a distinct piece of work. This approach could be adapted for the assessment and management of other CITES-listed species in the future.

धूम्रागरुधूपेन विमलां हंसपाण्डुराम् ।
चित्रां पुष्पोपहारेण कल्माषीमिव सुप्रभाम् ॥

*It was pure and white like a swan with smoke and **agaru** incense.*
She was wonderful and radiant like a blemish with flowers.

Valmiki Ramayana

Like the valleys they have extended a long way, like gardens by the river,
*Like **aloes** that Jehovah has planted, like cedars by the waters.*

Holy Bible (Numbers 24:5-6)

*Spikenard and saffron, cane and cinnamon, with all sorts of trees of frankincense, myrrh, and **aloes**, along with all the finest perfumes.*

Holy Bible (Song of Solomon 4:14)

*Allah's Messenger was quoted (by Abu Huraira) describing Paradise where, among many wondrous things, **agarwood** would be used in their censers (incense burner).*

Imam Muhammad al-Bukhari in 'Sahih al-Bukhari'

*What he smells is utpala, the mixed smell of **agaru,** prkka, tagaraka, tamala-pattra, kunkumam, sandalwood …*

Mahayana Mahaparinirvana Sutra

*The good **aloe** is heavy, smooth, of pleasant long lasting smell, burning slowly without a thick smoke, of uniform fragrance and not friable (i.e. not easily removed by rubbing).*

Kautilya in 'Arthashastra'

गात्राणि कालीयकचर्चितानि सपत्रलेखानि मुखाम्बुजानि ।
शिरांसि कालागुरुधूपितानि कुर्वन्ति नार्यः सुरतोत्सवाय ॥

*And the incense of the **kalaguru***
Lends a finishing touch to the hair
As they prepare to meet their men
The feast of love to share

Kalidasa in 'Ritusamhara'

पूजार्थं कुङ्कुम-कर्पूर-कस्तूरिका-चन्दनाऽगुरुप्रभृ-तौनि सुगन्धिद्रव्याणि, पुष्पाणि जाती-यूथिका मल्लिका-कुन्द -शतपत्र-मदनचम्पक-केतकीप्रभृतीनि च समानीतानि ।

*Perfumes like kukum, copper, musk, sandalwood, **aggur** etc. and flowers like jati, yuthi, mallika, kunda, shatadal, madan, champak, ketaki etc. were collected for worship.*

Kalidasa in 'Dwatrimshat Puttalika'

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The Authors

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Introduction

A showcase-piece of infected heart-wood of *A. malaccensis*

INTRODUCTION

Ensuring trade within sustainable limits is at the core of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). According to the Convention, Parties shall allow trade in specimens of species included in Appendix II only if the Scientific Authority of the State of export has advised that "such export will not be detrimental to the survival of that species" (Article IV).

Further, a Scientific Authority in each Party shall monitor both the export permits granted by that State for specimens of species included in Appendix II and their actual exports. Whenever a Scientific Authority determines that the export of specimens of any such species should be limited to maintain that species throughout its range at a level consistent with its role in the ecosystems in which it occurs and well above the level at which that species might become eligible for inclusion in Appendix I, the Scientific Authority will advise the appropriate Management Authority of suitable measures to be taken to limit the grant of export permits for specimens of that species (Article IV). Collectively, these requirements are referred to as 'Non-detriment Findings' (NDFs).

'Agarwood' or 'Gaharu' is the trade name of a resinous product obtained from infected trees, particularly the genus *Aquilaria* Lam. and *Gyrinops* Gaertn. Though a few more genera under the family Thymelaeaceae produce 'Gaharu', the quality of 'Gaharu' from these genera is not good and not very marketable.

Agarwood production

In India, 2 species of *Aquilaria*, *viz. Aquilaria khasiana* Hallier f. (Assam and Meghalaya) and *Aquilaria malaccensis* Lam. (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and West Bengal) are known to occur in the wild. Whereas, *Gyrinops* is represented by one species, *i.e., Gyrinops walla* Gaertn. (Kerala and Tamil Nadu). The National Biodiversity Authority (NBA) notified *Aquilaria malaccensis* as a species on the verge of extinction in Mizoram [S.O. 2524(E), dated 30th September 2009] and *A. khasiana* as a species on the verge of extinction in Meghalaya [S.O. 2526(E), dated 30th September 2009] under the provisions of Biological Diversity Act, 2002.

Aquilaria malaccensis is listed as a Critically Endangered (CR) species in the IUCN Red List of Threatened Species (Harvey-Brown, 2018) mainly due to over-exploitation. The species is listed under CITES Appendix II (w.e.f. 16 February 1995) based on India's proposal to CITES CoP9 held in Fort Lauderdale in USA in 1994, and therefore, its international trade is under the regulation

of CITES. International trade of specimens in Appendix II species may be authorized by the granting of an export permit or re-export certificate. Permits or certificates should only be granted if the relevant authorities are satisfied that certain conditions are met and the trade will not be detrimental to the species' survival in the wild.

In this context, the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India commissioned a study through the Botanical Survey of India (BSI) to conduct the Non-detriment Findings (NDFs) of *Aquilaria malaccensis* Lam. (Agarwood) in India. The study was executed by a team of scientific staff and researchers of BSI on a priority basis.

Established in 1890, the Botanical Survey of India (BSI) (https://bsi.gov.in) is a premier plant taxonomic research organization under the Ministry of Environment, Forest & Climate Change, Government of India, which serves as the custodian of the country's floral wealth. The organization has been engaged in systematic surveys and documentation of the country's plant resources since its inception. At present, there are 4 units and 11 regional centres of BSI situated in different parts of the country, with the Headquarters in Kolkata. As a National Repository of Plant Resources, this organisation maintains more than four million herbarium specimens preserved in 13 herbaria maintained by the respective units and regional centres. Towards fulfilling the Global Strategy for Plant Conservation, the department also has 12 gardens (including Botanic Gardens and Experimental Gardens) located in different biogeographical zones of the country.

Title of the project: Non-detriment Findings (NDFs) of *Aquilaria malaccensis* Lam. (Agarwood) in India

Executing/ Implementing Agency: Botanical Survey of India, CGO Complex, 3rd MSO Building, Block F (5th & 6th floor), DF Block, Sector I, Salt Lake City, Kolkata 700064, West Bengal, India

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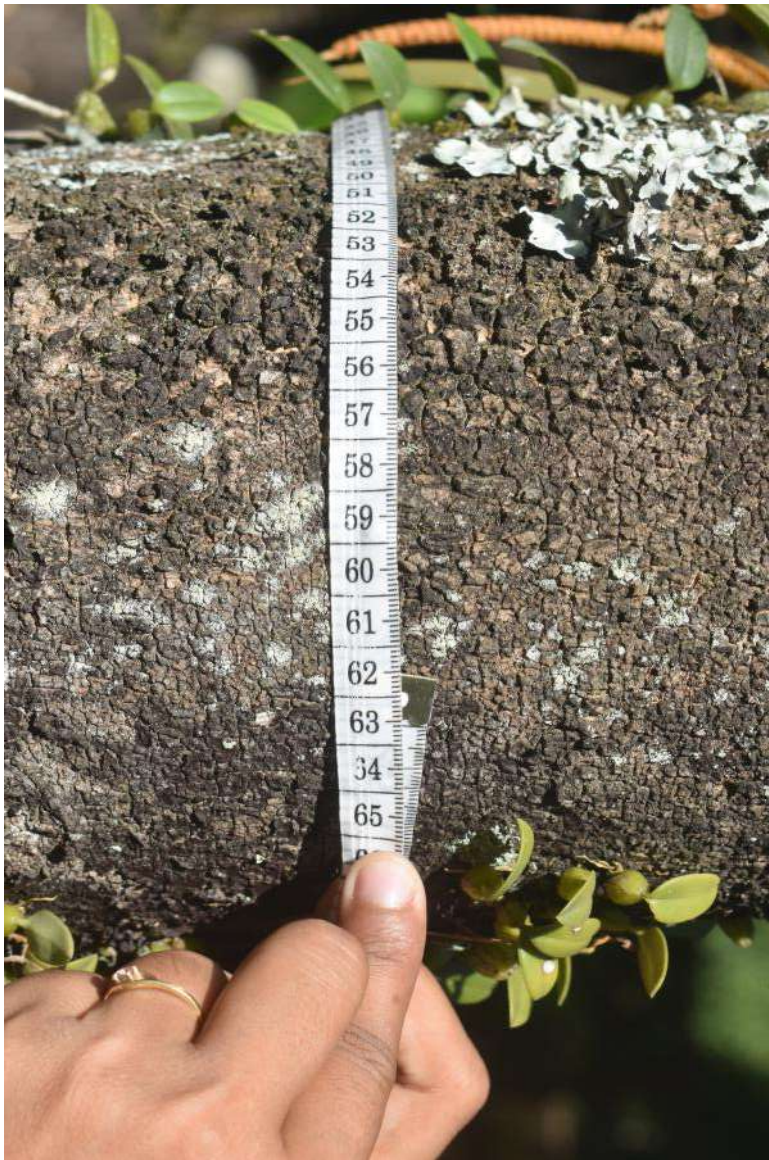
Flowers and fruits of *A. malaccensis*

Methodology



Infected heart-wood of *A. malaccensis*

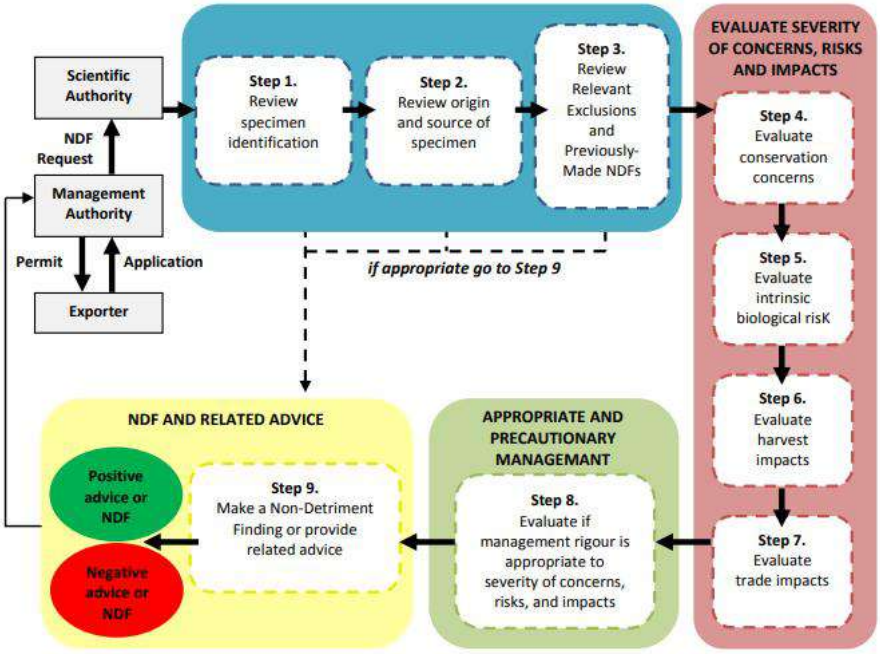
METHODOLOGY

The CITES is updating the NDFs guidance by implementing the 'CITES NDF Project'. During the second 'International Expert Workshop on Non-detriment Findings (NDFs)' (4–8 December 2023 in Nairobi, Kenya), a new module (Module 2) was proposed and reviewed by the experts and representatives of the Parties. However, it was generally agreed that the module was proposed as guidance, not legally binding on Parties, and was not intended to be prescriptive. Parties might already be using other approaches to make Non-detriment Findings, and nothing in this guidance suggests ceasing the continued use of those. However, there might be additional approaches within the module that Parties might wish to use. Furthermore, this guidance is intended to be flexible, and Parties may adopt it according to their circumstances.

However, the Rapid Assessment method by applying the scoring criteria proposed in the Module 2 is not appropriate enough for the present study.

Earlier, the Secretariat published a 'proposed guidance' for making Non-detriment Findings for agarwood-producing species in 2013, as agreed at the 20th meeting of the Plants Committee held in Dublin in March, 2012. However, this guidance needs updates; therefore, the same is not followed in the present study.

The present work has been carried out basically by following the 'CITES Non-detriment Findings Guidance for Perennial Plants' (Wolf & al., 2016) with some **modifications in Step 1, 5, 6 and by the inclusion of some additional parameters like harvest to products, yield, impact on livelihood in Step 6.**



CITES Non-detriment Findings Guidance for Perennial Plants' (Wolf & al., 2016)

Step 1: Review of Specimen Identification **and Pre-NDF checks** (modified from 'Review of Specimen Identification')

Step 2: Review of Compliance with Artificial Propagation Requirements

Step 3: Review of Relevant Exclusions and Previously-Made NDFs

Step 4: Evaluation of Conservation Concern

Step 5: Evaluation of Potential Intrinsic Biological Risk of **Harvest from Wild and Cultivated Populations** (modified from 'Evaluation of Potential Intrinsic Biological Risk of Wild Harvest')

Step 6: Evaluation of Impacts of **Harvest of Plants in Wild and Cultivation** (modified from 'Evaluation of Impacts of Wild Harvest')

Step 7: Evaluation of Impacts of Trade

Step 8: Evaluation of Effectiveness of Management

Step 9: Non-detriment Finding and Related Advice

The representative specimens of *Aquilaria malaccensis* Lam. housed at two major herbaria (ASSAM and CAL) of the Botanical Survey of India were consulted (before conducting field surveys) to observe and understand the phenotypic variations of the species, localities of wild occurrence, flowering and fruiting period and other pertinent information. The protologues, types/ original materials of *Aquilaria malaccensis*, and *A. agallochum* (Lour.) Roxb. ex Finl. were consulted to confirm the identity. Published literature and reports on the species were also studied to record other relevant information. Field surveys in different parts of India were undertaken to locate the wild and cultivated plants and assess the population status, harvest and management practices, threats, and trade (legal and illegal) of the species. Random surveys were conducted in different districts of Arunachal Pradesh, Assam, Karnataka, Kerala, Manipur, Mizoram, Meghalaya, Nagaland, Sikkim, Telangana, Tripura, and West Bengal to locate and estimate the wild as well as cultivated populations. The location data (latitude-longitude, elevation along with date and time of survey) were recorded either with GPS (Garmin Montana 680, Garmin eTrex 30x) or with mobile (GPS Waypoints App) where carrying GPS was prohibited. The height and Girth at Breast Height (GBH), age, regeneration and reproduction rate, potential biological risk and anthropological threats, the regime of harvest, the impact of harvest, trade-related data, etc., were recorded during the surveys. Some data provided by the Forest Department of Assam, Goa, Mizoram, and Tripura are also considered for preparing the report. The major agarwood markets in Hojai (Assam) and Calicut (Kerala) were surveyed. Several agarwood processing units and other agarwood-based units were visited in Assam, Karnataka, Kerala, Manipur, Nagaland, and Tripura to record relevant information.

Biswanath, Assam

Dima Hasao, Assam

Rowa WLS, North Tripura, Tripura

Tamenglong, Manipur

Ntangki NP, Peren, Nagaland

North Garo Hills, Meghalaya

Namdapha NP & TR, Changlang, Arunachal Pradesh

Aizawl, Mizoram


Trivandrum, Kerala


Jalpaiguri, West Bengal


Kodagu, Karnataka


Mahabubnagar, Telangana

Semi-formal field interviews with villagers/ local people, representatives of agarwood associations, sellers, buyers, stakeholders, and people associated with agar processing centres and agar industries were conducted whenever possible to retrieve relevant information on harvest, trade, management, etc. Information has also been collected from the scientists/ scientific staff/ researchers of different units and regional centres of BSI and scientists/ researchers/ academicians of other academic and research institutes in India.


Kalimpong, West Bengal


Hojai, Assam


Bishnupur, Manipur


Golaghat, Assam


West Tripura, Tripura

The national conservation status of the species is assessed by following the 'Guidelines for Using the IUCN Red List Categories and Criteria, Version 15.1' (IUCN SPC, 2022).

The data provided by the Wildlife Crime Control Bureau (WCCB) on re-export, import and illegal trade and the CITES Annual Reports published by the Ministry of Environment, Forest and Climate Change, Government of India are consulted to record the levels of illicit trade. The CITES Trade Database is also consulted to check the trade-related data.

The previously-made NDFs of *A. malaccensis* in India prepared by the Rain Forest Research Institute, Jorhat, Assam, is also referred and reviewed.

Considering the present distribution pattern of *Aquilaria malaccensis*, it is challenging to use GIS techniques because the data captured by remote sensing should be directly related to the properties of the canopy. The species under consideration should either form a homogeneous vegetation or a characteristically distinct species in a mixed population. But, *A. malaccensis* does not have that kind of distribution in India. It is often grown with trees having similar morphological characteristics. Also, they are not always significantly infected by any microorganism. The mapping of *A. malaccensis* in Bukit Nanas F.R., Malaysia, was done using the Airborne Hyperspectral Sensor for Individual Species Counting method, which could not be used during the present study due to limitations. It is also impossible to differentiate infected (which can be harvested for agarwood chips and oil production) and non-infected trees and their infection pattern (natural vs artificial) with this method.

Production of agarwood chips and oil is highly variable, unpredictable and not only dependent on the volume of wood/ timber. It also largely depends on the location, type and intensity of infection, age, harvesting time, resin/oil content, fermentation process in distilleries, etc. In India, agarwood plants grow in mono-specific or mixed plantations. The volume/ biomass equation, regression model equation, forest cover conversion factors etc., are not practical for fixing the export quota for agarwood. For fixing the annual export quota, the estimation of infected trees (both naturally

and artificially induced) of different GBH ranges has been made based on extensive and random surveys in plantations, households, and other growing locations. In some cases, information provided by the farmers/ growers, forest officials, local experts, representatives of different agarwood associations, etc., was also considered. The average yield (location-specific) is estimated based on visits to several agarwood chip processing units, distillation units, and local markets in different parts of the country. During the second 'International Expert Workshop on Non-detriment Findings (NDFs)' held in Nairobi, Kenya, from 4–8 December 2023, the Working Group 10 (Module 11) on the NDFs of Plants recognised that the NDFs should be based on the best available data, including data from field work (which does not necessarily need to be conducted by Scientific Authorities), information available from the applicant, Management Authorities, scientific expertise, local rangers, and other data sources if available. However, it is observed during the present study that in case of low data availability and quality/ low-capacity situations, the Scientific Authority should conduct field work, especially if the SA will make the annual export quota.

A. malaccensis in a tea plantation (Nagaland)

Aquilaria malaccensis Lam.

Dehisced fruit of *A. malaccensis*

A. BACKGROUND INFORMATION ON THE TAXON

Scientific name: *Aquilaria malaccensis* Lam.

Systematic position (APG IV)

Clade: Angiosperms

Clade: Eudicots

Clade: Rosids

Order: Malvales Juss. ex Bercht. & J. Presl

Family: Thymelaeaceae Juss.

Subfamily: Thymelaeoideae Burnett

Tribe: Aquilarieae (R. Br.) Baill.

Genus: *Aquilaria* Lam.

Species: *Aquilaria malaccensis* Lam.

Synonyms: *Agallochum malaccense* (Lam.) Kuntze, *Agallochum officinarum* Lam., *Agallochum praestantissimum* Lam., *Agallochum sylvestre* Lam., *Aloexylum agallochum* Lour., *Aloexylum verum* Lour., *Aquilaria agallochum* (Lour.) Roxb. ex Finl., *Aquilaria agallocha* Roxb. (*nom. illeg.*), *Aquilaria moluccensis* Oken, *Aquilaria ovata* Cav., *Aquilaria secundaria* DC., *Aquilariella malaccensis* (Lam.) Tiegh., *Cynometra agallocha* Spreng.

Common names: Agarwood, Aloeswood, Eaglewood, Lign-aloes, Malayan aloeswood, Malayan eaglewood, Wood of the God.

Vernacular names: *Agar* (Hindi); *Agaru, Sanchi, Sasi, Hasi, Sashi* (Assamese); *Agarchandan, Agarkastha, Agor, Agaru* (Bengali); *Krishna Aguru* (Kannada); *Akil, Outh* (Malayalam); *Ooda, Pharsi* (Punjabi); *Aghil, Agalichandanam* (Tamil); *Aguru* (Sanskrit, Telugu); *Dingagar* (Khasi); *Agor/ Agol* (Garo); Sungya (Ao – Nagaland: Mokokchung); Pu-ou (Phom – Nagaland: Longleng); Pen-o, Shashi, Meihom (Konyak – Nagaland: Mon); Thengrai (Mizo).

Etymology: The generic name is originated from the Latin *aquila, ae* "an eagle" or from the Akkadian *eklu* "dark: said of the day," *ekelu* "to be dark: said of the sun, the day" (Quattrocchi, 2012). The specific epithet is after its probable type locality, *i.e.*, "Malacca".

Description: Trees up to 40 m tall, usually with elongated crown, often fluted with thick buttresses up to 2 m high, bole up to 60 cm in diam. with whitish to greyish, thin, smooth bark. Branchlets pale brown, slender, terete, sericeous, wood light soft, and porous. Leaves ramal, alternate, spirally arranged; exstipulate, with 1 or 2 sericeous scale-like appendages found covering the axillary/

Figure 1. ***Aquilaria malaccensis*** Lam.: **a.** A twig with inflorescence; **b.** adaxial surface of leaf; **c.** abaxial surface of leaf; **c'.** close view of abaxial surface; **d.** single flower (lateral view); **e.** single flower (top view); **f.** L.S. of flower; **g.** different stages of development - bud to fruit; **h.** L.S. of fruit; **i.** a dehisced fruit; **j.** a twig with dehisced fruits.

Figure 2. ***Aquilaria malaccensis*** Lam.: Roxburgh's drawing no. 1970 (as *Aquilaria agallocha*) preserved at CAL. (@Central National Herbarium, Botanical Survey of India)

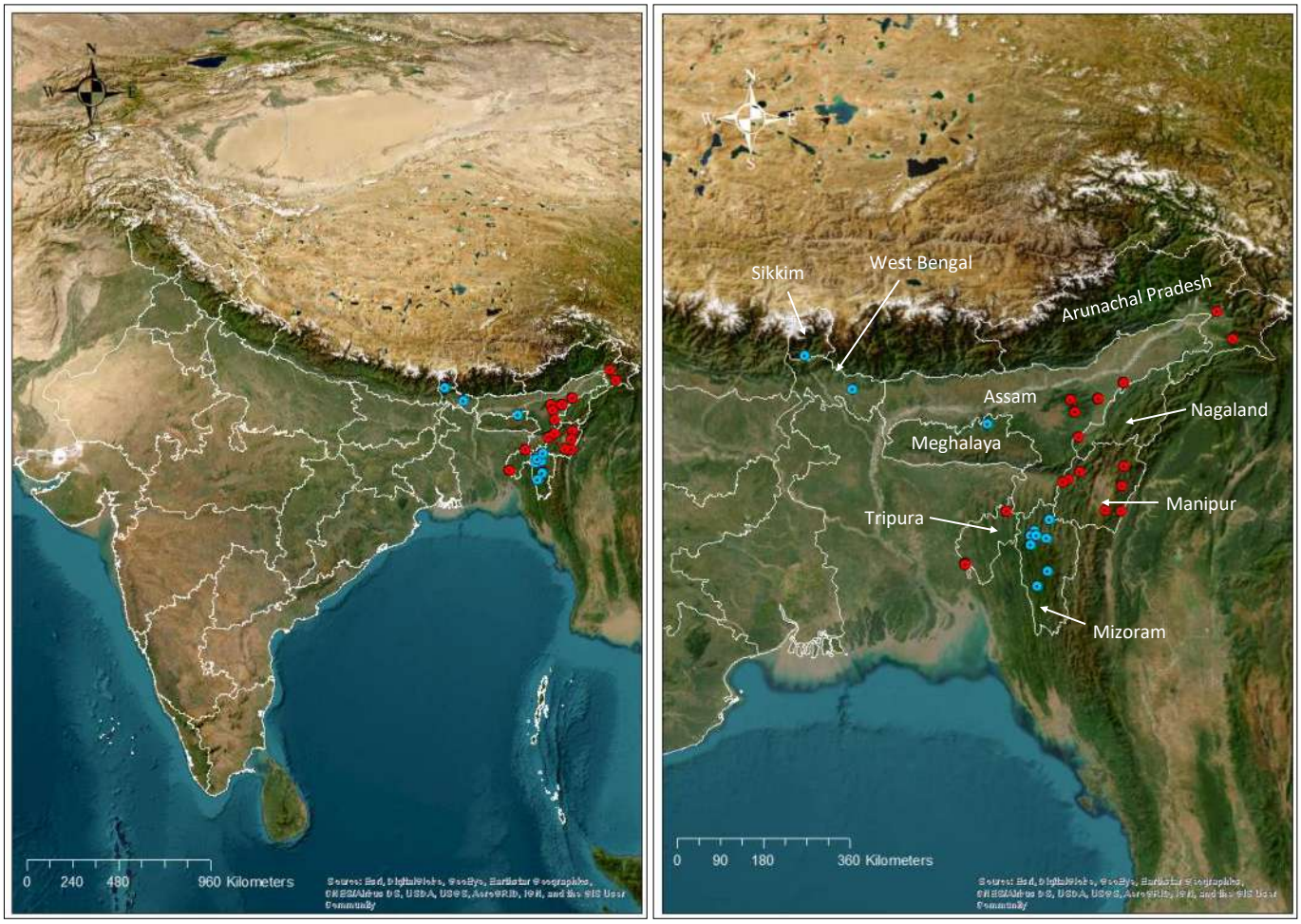
vegetative bud, scales lanceolate, white, petiolate; petiole sericeous, 4–5 mm; lamina simple, obovate to oblanceolate, sometimes elliptic, 8–9.8 × 2.8–3.8 cm, cuneate at base, apiculate at apex, margins undulate, pubescent on midrib and margins of abaxial surface of lamina, unicostate, reticulate, pinnately veined. Inflorescence terminal or axillary, sometimes internodal umbel, usually branched into 2–3 subsessile umbels, each with 8–15 flowers, 20–40 flowers in total, centripetal. Flowers ebracteate, ebracteolate, complete, bisexual, dichlamydeous, actinomorphic, hypogynous, yellowish green, 1.2–1.5 cm long, pedicellate; pedicel terete, sericeous, 6–7 mm long. Sepals 5, gamosepalous, forming calyx tube, persistent, lanceolate to oblong-lanceolate, 7–8 × 1.4–1.6 mm, spreading, densely pubescent, obtuse at apex, valvate, yellowish green. Petals 10, modified into scale-like appendages, attached with the calyx tube, persistent, 1–2 mm long, slightly incurved, densely pubescent, obtuse at apex, valvate, yellowish green. Stamens 10, free, epipetalous, exerted; filament thick, *c.* 2 mm long, pubescent, orange to brown; anther-lobes 2, dorsifixed, lobes *c.* 1 mm, dehiscence longitudinal, yellow; carpel 1, ovoid, 1–2 mm long, densely pubescent; ovary superior, 2-chambered, with single bitegmic ovule per locule; style inconspicuous; stigma capitate or globose, 1 mm thick, 5 ridged and covered with unicellular papillate outgrowths; ovules 2, anatropous; embryo sac monosporic. Fruits loculicidal capsules, obovoid-cylindrical or obovoid-oblong, 2.5–4 × 1.5–2.5 cm, compressed, green, pubescent, bilocular, 1 seed per locule, cuneate at base, rounded at apex; pericarp coriaceous, sericeous; seeds ovoid, *c.* 10 × 6 mm, with *c.* 4 mm long beak, red-pubescent, attached with placental wall by a filiform appendage, developing from fleshy funicular outgrowths at base of seed; appendage twisted, pubescent, as long as seed. (Figure 1, 2)

Flowering and fruiting in India: March–November.

Habitat: The species is usually found in the lowland dipterocarp, mixed dipterocarp forests and tea plantations at altitudes up to 1,675 m. In some places monoculture of the species is practiced. Clay soil with good water and nutrient retention and 70% to 85% humidity are the key factors for well-established plantations.

Distribution: Bangladesh, Borneo, Bhutan, India, Indonesia, Malaysia, Myanmar, Philippines, Singapore, and Thailand.

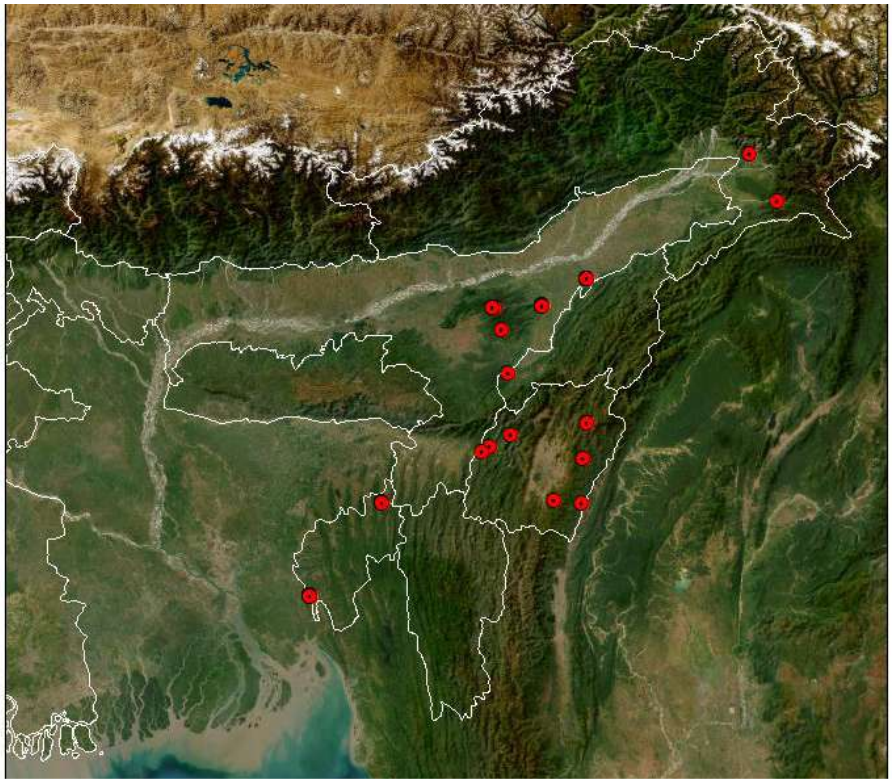
INDIA – *Wild*: Arunachal Pradesh, Assam, Manipur, Nagaland, and Tripura at elevation ranging from 90–1,675 m. However, the species was also reported from Meghalaya, Mizoram, Sikkim, and West Bengal as per some published literature [Saikia & Khan, 2012; Barden & al., 2000; RFRI, 2021 (publ. 2023)], but it could not be located in the wild in these states during the present study. *Cultivation:* Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Jharkhand?, Karnataka, Kerala, Maharashtra, Manipur, Mizoram, Meghalaya, Nagaland, Odisha, Punjab, Rajasthan?, Tamil Nadu, Telangana, Tripura, Uttarakhand, Uttar Pradesh, and West Bengal at elevation ranging from 15–1,200 m.



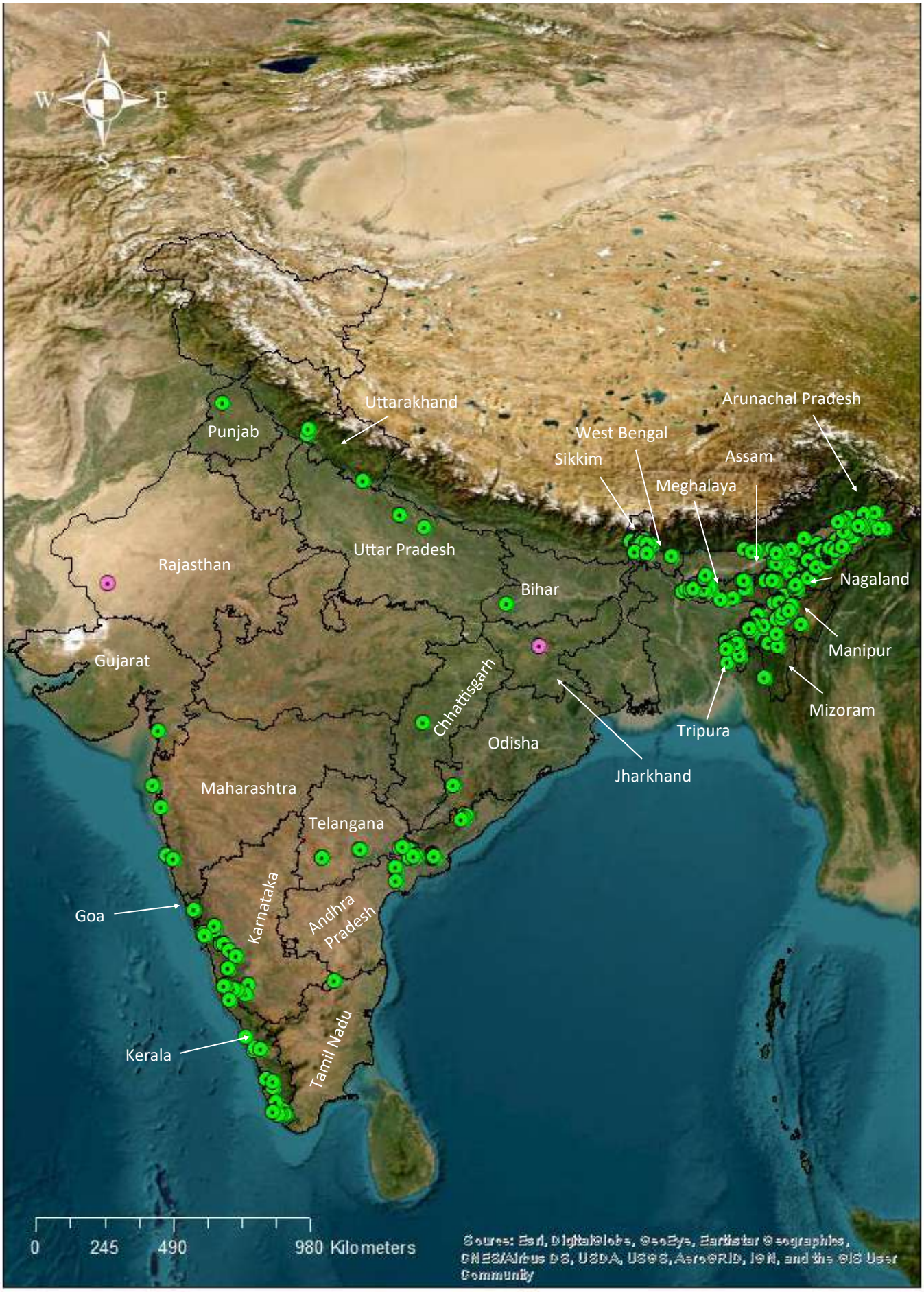
Distribution maps showing occurrence of *A. malaccensis* plants in wild and/ or Protected Areas in India

Locations based on field surveys during the present study

Locations based on published literature



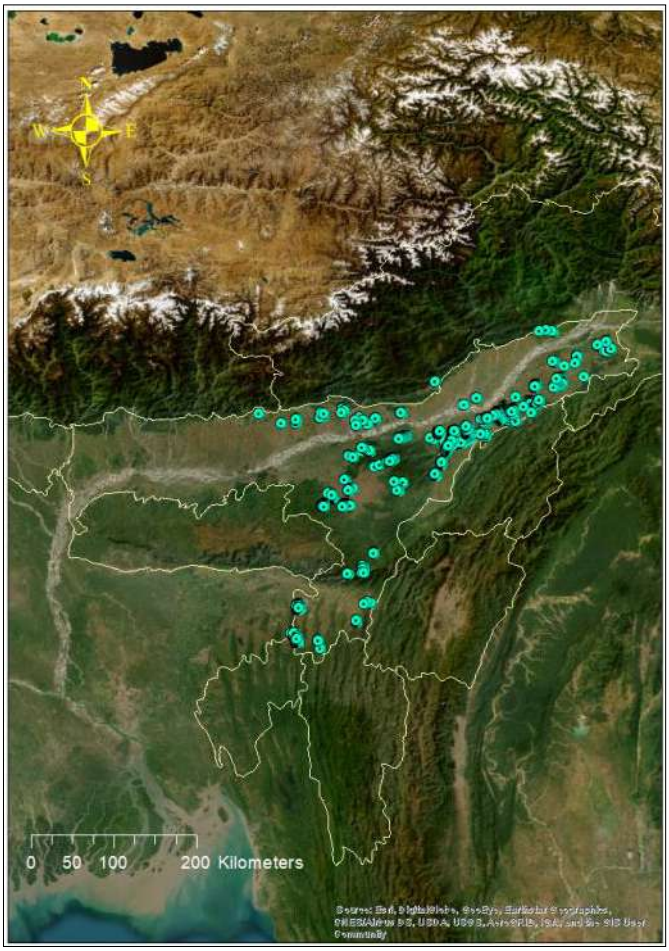
Enlarged map showing current occurrence of *A. malaccensis* plants in wild and/ or Protected Areas in India based on field surveys during the present study



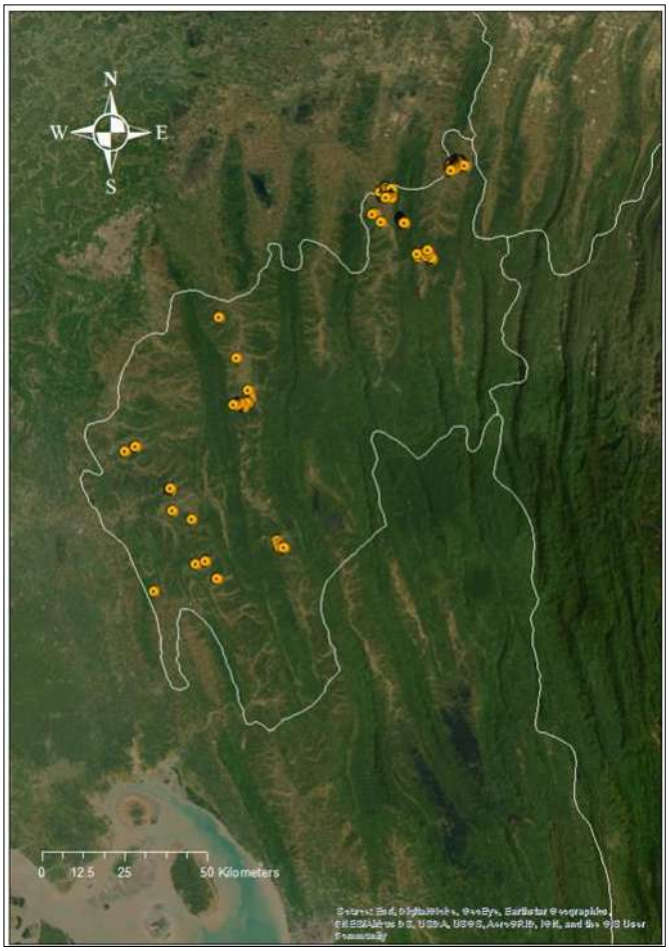
Distribution maps showing occurrence of *A. malaccensis* plants in cultivation in India

Locations based on field surveys during the present study and authentic sources

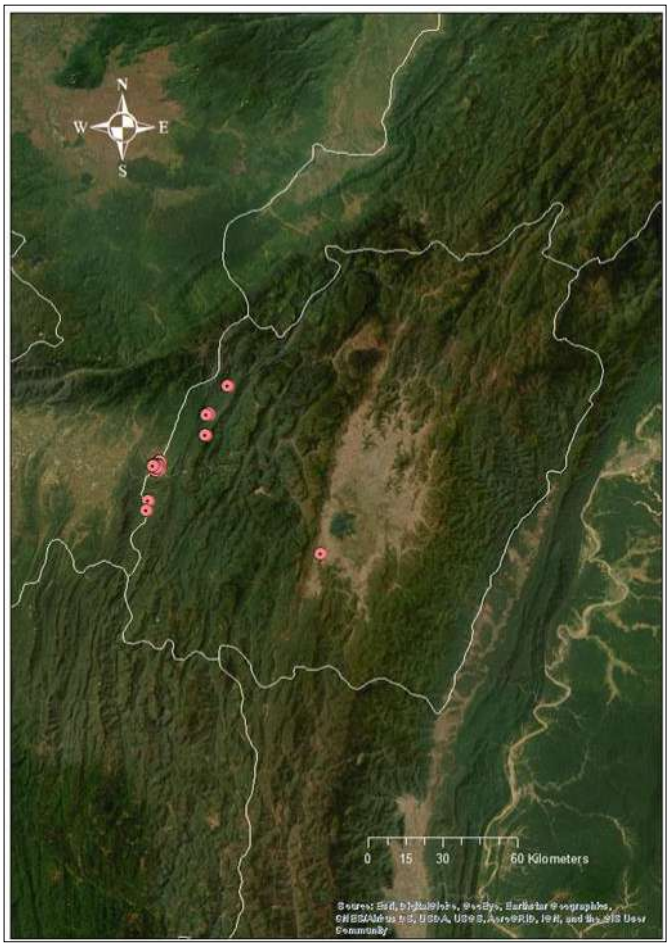
Locations based on non-verified sources



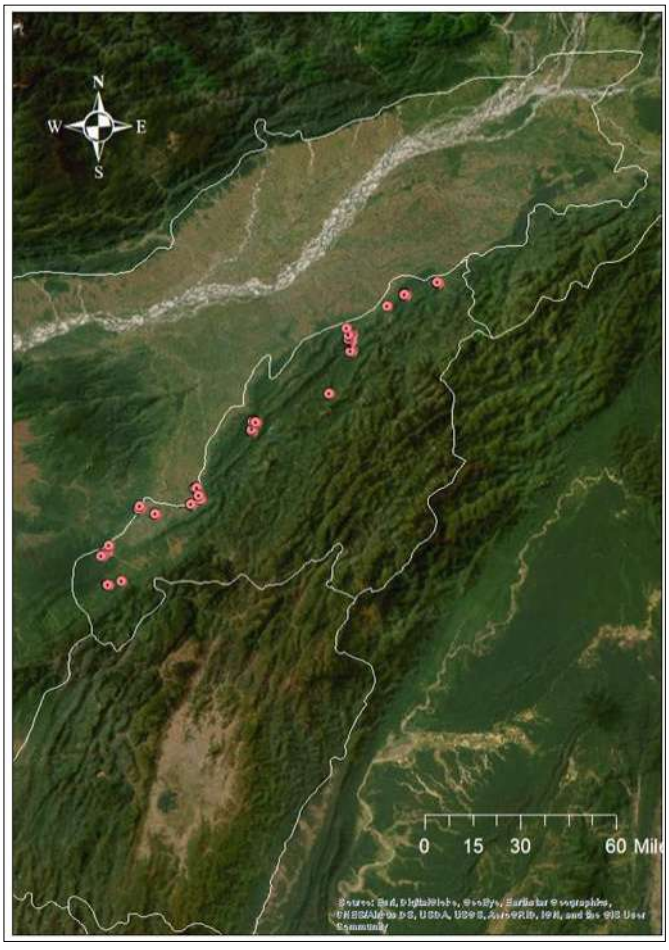
Locations of cultivated plants of *A. malaccensis* in Assam



Locations of cultivated plants of *A. malaccensis* in Tripura



Locations of cultivated plants of *A. malaccensis* in Manipur



Locations of cultivated plants of *A. malaccensis* in Nagaland

Uses: Agarwood is highly valued for its traditional uses as incense in different cultural and religious ceremonies. 'Attar' and 'Aguru' are water-based perfumes containing agarwood oil traditionally used by various communities. It is also utilised in the aroma industry, in medicine preparations, as air freshener and purifier. The essential oil extracted from agarwood has anti-inflammatory, anti-rheumatic, analgesic, anti-oxidant, carminative and stomachic properties. It can also help detoxify the body, clean out excess salt and uric acid, and repair damaged skin cells. Indians and Chinese also use agarwood oil in their traditional medicine as a liniment for treating various skin diseases. Agarwood also helps to cure asthma, abdominal pain, chest congestion, diarrhoea, relieve delivery pain, and treat attention deficit disorder. The oil is also used as a fragrance in producing cosmetics, soaps and shampoos (Chakrabarty & al., 1994). It is also highly used in aromatherapy. The dried leaves of *A. malaccensis* is also used as a tea. In India, the bark and wood of *A. malaccensis* are used to make rope, cloth and fuel for fumigation, respectively (TRAFFIC, 2005). The uses of agarwood are not restricted to incense and perfumery. It is also used in making ornaments, *viz.* bracelets, boxes, bead strings, and sculptures out of solid pieces (Barden & al., 2000; Persoon, 2008). Agarwood powder is known to be used as an insect repellent effective against fleas and lice (Heuveling van Beek & Phillips, 1999). In the Middle East, agarwood oil symbolises wealth and is widely used during wedding ceremonies. In UAE, burning agarwood chips is an essential prevailing practice to honour guests' visits (Antonopoulou & al., 2010). Agarwood is used as an aromatic ingredient in wine in Taiwan. In India, the 'Boya' obtained from agar plants is widely used in making smokeless tobacco products ('Gutka') to produce aromatic flavour. Agarwood is also used in funeral pyres by different communities (Chakrabarty & al., 1994; Yaacob, 1999). Apart from these, agarwood and agar-based products have various other uses.

Some agar-based products available in Indian markets

Agar formation: In natural conditions, the agar is formed due to fungus-host interaction, which usually occurs after boring by the larvae of a stem borer, *Neurozerra conferta* Walker (= *Zeuzera conferta* Walker). The natural infection by certain fungi and bacteria starts in the wood of *A. malaccensis* after the boring by the stem borer. Naturally, agarwood formation is often linked to the physical wounding or damage of the trees caused by thunder strikes, animal grazing, pest and disease infestations (Rasool & Mohamed, 2016; Wu & al., 2017). These events expose the inner part of the trees toward pathogenic microbes, which elicit the defence mechanism of *Aquilaria* to initiate resin production (Tan & al., 2019).

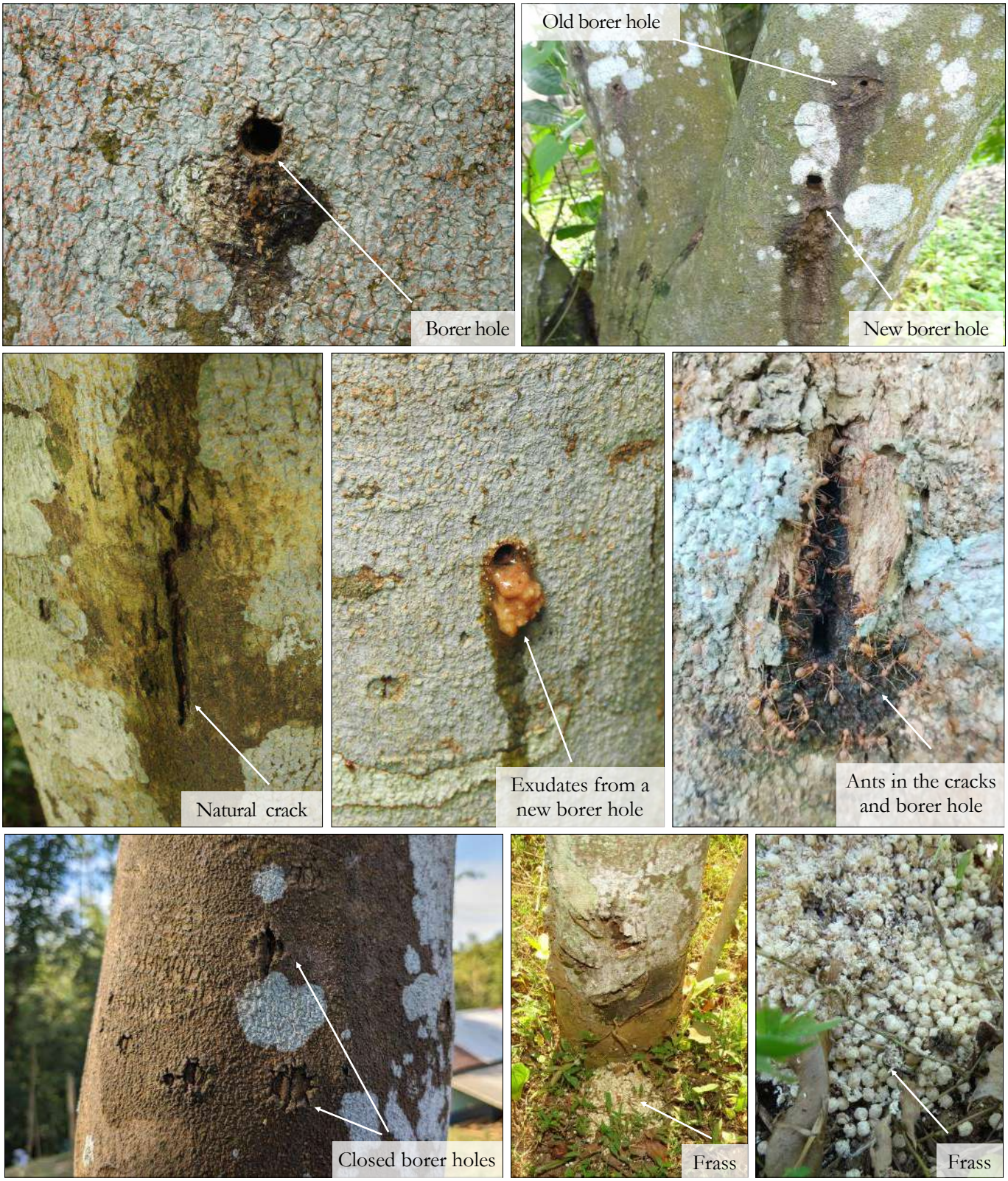
In Dibrugarh district, agar chips formed specifically by infection arising from woodpecker's strike are locally known as 'Soraikhuli' ('*Sorai*' = bird, '*-khuli*' = opening). This occurs when the woodpecker strikes and creates an opening in the agar trees, looking for the borer worm or for laying eggs. This often leads to a significant amount of infection building up there.

'Soraikhuli'

Usually, plants above the age of seven years are vulnerable to infection by the fungus. However, the initiation of natural infection is observed in several plants with an age of less than two years in certain parts of Assam, Manipur, and Tripura. The natural infection is usually established after a few to several years of initiation of infection for producing a significant quantity of agarwood.

The resin is secreted by the trees as a defence reaction and deposited around the wounds over the years following the injury, where the accumulation of the volatile compounds eventually forms agarwood (Subasinghe & Hettiarachchi, 2013). The Rain Forest Research Institute, Jorhat, identified three fungi responsible for agarwood formation (Borah, 2015). The fungus *Phialophora parasitica* Ajello, Georg & C.J.K. Wang is reported to be responsible for the formation of agarwood in the plantations of West Bengal. A few fungal isolates, like *Fusarium* sp., *Rhizophora* sp., *Aspergillus* sp., and *Mucor* sp. were also isolated from the infected host tissue. Four endophytic fungi (*Alternaria sp*., *Curvularia sp*., *Rhizopus sp*. and *Sterilia sp*.) are isolated from juvenile (1-year-old) *A. malaccensis* plant and three fungal colonies (*Penicillium sp*., *Fusarium sp.,* and one putative *Cladosporium sp*.) were isolated from agarwood chips by Mochahari & al. (2020) from the samples collected in Assam.

The naturally infected agar-forming trees can be identified by the presence of borer holes, oozing of liquids from the new borer holes, closed borer holes having some typical marks, accumulation of frass at the base of the tree, presence of longitudinal cracks, presence of ants in the cracks and borer holes etc. Often the infected trees have stunted growth, poor crown, and hollow sounds on sticking or hammering.



Some identifying features of natural infection in plants

Agar production can also be induced artificially by several techniques, which may be broadly classified into physical, chemical, and biological methods or combinations. The ideal age for artificial inoculation is 6–8 years. In Northeast India, where the natural infection is less or absent, the trees are artificially induced to produce agar. Natural infection is found only in some regions of Northeast Indian states. Therefore, artificial induction/ inoculation is the only way to obtain the agar in other parts of the country.

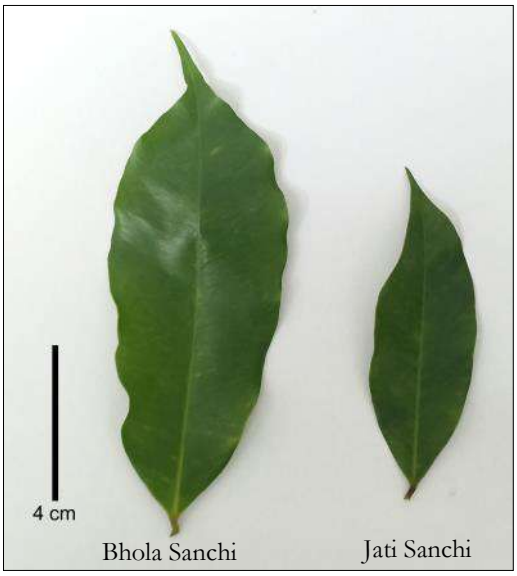
B. NON-DETRIMENT FINDINGS (NDFs) OF *AQUILARIA MALACCENSIS* LAM. IN INDIA

STEP 1: REVIEW OF SPECIMEN IDENTIFICATION AND PRE-NDF CHECKS

1.1 Has the plant/specimen been correctly identified, and, is the scientific name used compliant with the appropriate CITES standard?

The plants/specimens are correctly identified at the species level, *i.e.*, the plant/specimens under trade and export belong to *Aquilaria malaccensis*.

Aquilaria malaccensis is a common species cultivated in Northeast India and other parts of the country. High morphological variations are found in the cultivars of agarwood in India. Two common types of agarwood trees are found in India: plants with broad leaves (considered as *A. crassna* Pierre ex Lecomte in some regions) and small leaves. Often, these two major types of plants are locally known as 'Bhola Sanchi' and 'Jati Sanchi' in Assam based on their different leaf sizes. The 'Bhola Sanchi' has a faster-growth rate than 'Jati Sanchi', but 'Jati Sanchi' are more prone to infection at a young age and produce more yield than 'Bhola Sanchi'. In India, seedlings are grown mostly from the seeds of existing mature plants. Rarely, seedlings/seeds are also brought from outside the country for high yield and quality of wood. Therefore, there is a chance that other species of *Aquilaria* can also be found in India. Apart from *A. malaccensis*, *A. khasiana* Hallier. f. is also reported from India, which is known to be an endemic to the Khasi hills of Meghalaya. Hence, it is mandatory to confirm the species identity of agarwood growing in India for effective management.



Since the morpho-taxonomic status of the members of *Aquilaria* is very complex, along with morpho-taxonomic identification, we have used molecular methods to ensure the identity of agarwood-producing species in India.

Molecular identification: Two accessions of *A. malaccensis* are randomly collected from each state surveyed for the phylogenetic analysis. Additionally, related wild and introduced plants are also used for the study. The sequencing of the total 26 accessions is done for one nuclear (ITS2) and two chloroplast (*rbcl* and *matK*) DNA regions. To construct a comprehensive phylogenetic tree, sequences of agarwood-producing trees (*Aquilaria* and *Gyrinops*) available on the NCBI are also used. The phylogenetic tree has been constructed using the software IQ-TREE v.1.6.12 with 10,000

ultrafast bootstrap replicates and automatic substitution model selection. All other parameters are set as default. The output tree file is visualized in FigTree V.1.4.4, and appropriate modifications are made (Figure 3).

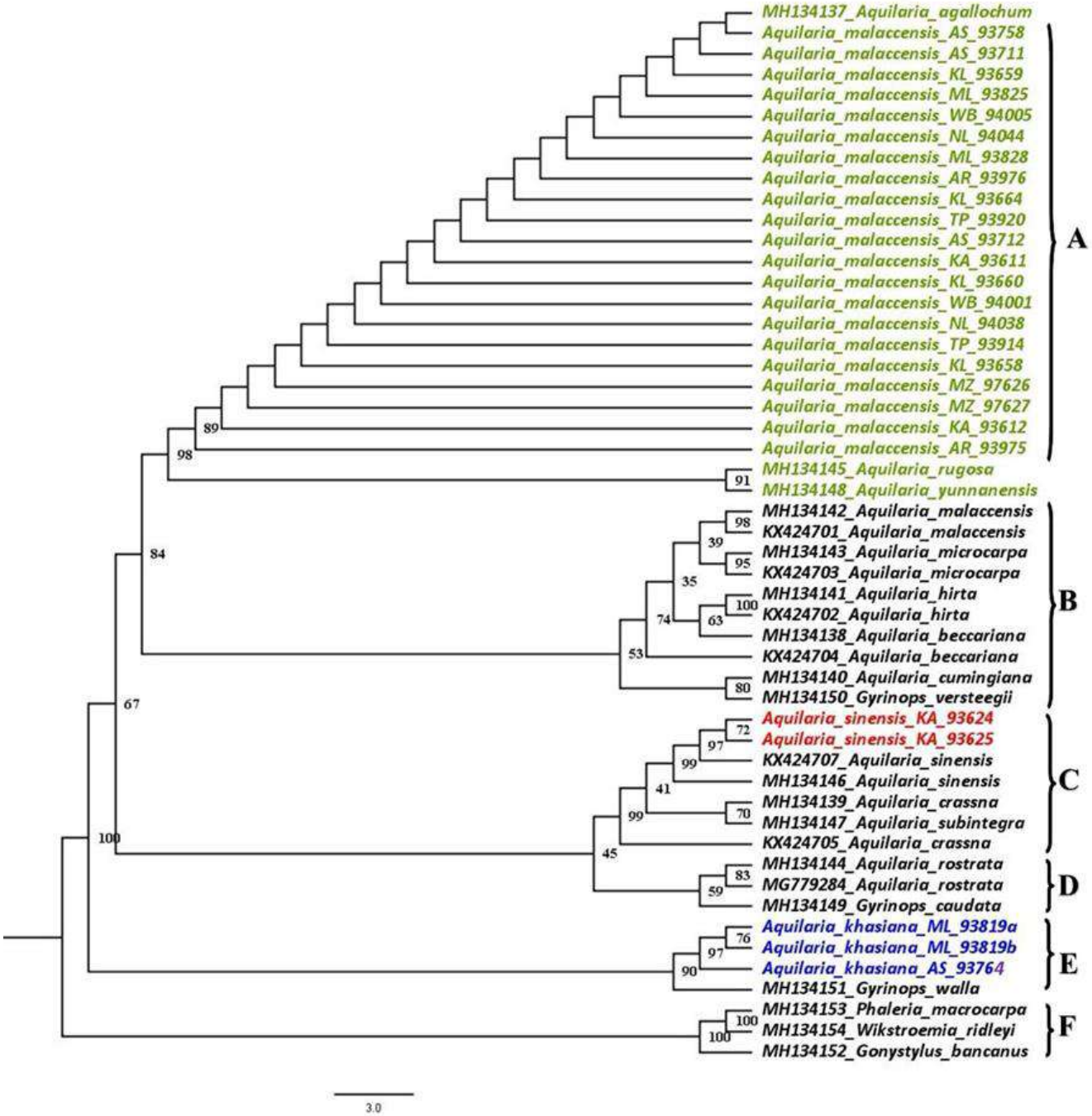


Figure 3. Phylogenetic analysis of the genus *Aquilaria* and *Gyrinops*. The maximum likelihood tree was generated using concatenated sequences of ITS2 (nuclear), *rbcl*, and *matK* (chloroplast) markers in IQ-TREE v.1.6.12. The clades A, C, and E samples belong to upper Southeast Asia. Samples in clades B and D belong to the Malayan peninsular region. Bootstrap values are provided in the respective nodes.

Major inferences

- All the *A. malaccensis* accessions collected from India nested within a single clade A along with *Aquilaria agallochum, A. rugosa* Kiet & Kessler, and *A. yunnanensis* S.C. Huang of upper Southeast Asian origin. Meanwhile, the *A. malaccensis* accessions obtained from the NCBI database nested within the clade B along with other *Aquilaria* species of Malayan Peninsular

origin. Therefore, different genotypes are present in *A. malaccensis* formed due to geographical isolation. The Indian genotype (clade A) is morphologically and genetically similar to that of *Aquilaria agallochum* (presently treated as a synonym of *A. malaccensis* in literature), whereas the Malayan genotype (clade B) constitutes the 'typical' *A. malaccensis*. Hence, from the taxonomic point of view, the Indian genotype, *i.e., A. agallochum* can be treated as a new subspecies of *A. malaccensis*, *viz. A. malaccensis subsp. agallochum* (under publication). It should be noted that according to Article I of the Convention, "Species" means any species, subspecies, or geographyically separated population thereof, and hence, by treating the Indian population as *A. malaccensis subsp. agallochum* will not affect the present trade, export, and other management measures.

- *Aquilaria crassna* is not found in the current sampling from India, and the plant with broad leaves belongs to *A. malaccensis* (= *A. malaccensis subsp. agallochum*) only.
- Two accessions/ gatherings collected from Karnataka state (which are brought from China) belong to the *A. sinensis* (Lour.) Spreng. Both samples are nested within the clade C along with other *A. sinensis, A. crassna,* etc. The introduced plants are 4 years old and well adapted to the climate in the Western Ghats region of Karnataka state. Hence, *A. sinensis* can be cultivated on a large scale in India for commercial purposes.
- Two sets of samples of an agarwood species (not under trade/ export) are collected from the East Khasi Hills district of Meghalaya and Dibrugarh district of Assam, which are morphologically (vegetative) quite different from *A. malaccensis* but very close to *A. khasiana* (endemic to India). However, the DNA sequences of the samples did not show affinity with any other species of *Aquilaria,* instead, it grouped with the only *Gyrinops sp.* present in India (*G. walla* Gaertn. in Western Ghats). Therefore, it could be a *Gyrinops sp.* rather than *Aquilaria sp.*, which is not reported from India yet. However, the species is tentatively identified here as *A. khasiana* due to similar vegetative morphology, and occurrence in the same location in Meghalaya. Further taxonomic examinations in its flowering and fruiting conditions are to be done in due course of study to confirm the identity.

Genetic diversity analysis using microsatellite markers: The assessment of genetic diversity and population structure of plants is useful for finding genetic variability, conservation, and understanding the evolutionary history of a species. Thus, it will contribute to the sustainable management and utilization of plant genetic resources. Genetically diverse plant lines hold different desirable traits such as disease resistance, yield potential, and adaptability to different environmental conditions. In the case of wild plant populations, especially endangered and threatened plants, assessing the genetic diversity is useful to identify genetically distinct populations and prioritize conservation efforts.

As part of the current NDFs study, an intraspecific genetic diversity study is conducted using simple sequence repeat (SSR) markers. The plant samples are collected from 10 agarwood growing states of India. A total of 195 accessions of *A. malaccensis* are used for the study, which represents 39 assumed populations. Four to eight accessions are considered per population. In addition, 2 accessions of *Aquilaria khasiana* are added to compare its genotype structure with that of *A. malaccensis*. Four to eight accessions are considered per population. In addition, 2 accessions of *Aquilaria khasiana* are added to compare its genotype structure with that of *A. malaccensis*.

The SSRs are codominant markers and are highly polymorphic to assess the genetic variability within the species. A total of 60 SSR markers obtained from the published literature are considered for the analysis out of which 15 markers are found highly polymorphic with proper amplification. These markers were then used for genotyping all the accessions and the PCR-amplified products were analysed using fragment analysis. Further, the allele size calling from the fragment analysis data is done in GeneMarker v.2.6.3. The frequency-based (number of alleles, heterozygosity, Shannon index, genetic differentiation, and gene flow) and genetic distance-based (AMOVA) statistical analysis are conducted using GenALEx v.6.5. Bayesian model-based STRUCTURE analysis is used to determine genetic admixture and clustering among different genotypes.

The genetic diversity analysis in Indian *Aquilaria malaccensis* resulted in high average values of Observed Heterozygosity (Ho= 0.56 ± 0.012) and Shannon Index (I= 0.904 ± 0.02), which shows high genetic variability within individuals. The average inbreeding coefficient (F_{IS}) value is −0.116 ± 0.038, which suggests no loss of heterozygosity. Apart from that, low genetic differentiation (F_{ST} = 0.158 ± 0.006) and high geneflow (1.369 ± 0.081) are also observed in the analysis. The analysis of molecular variance (AMOVA) revealed that most of the genetic variance is partitioned within the population (89%) and comparatively less (11%) among the population. The Bayesian model-based STRUCTURE analysis roughly divided all accessions into 6 clusters with high admixture (Figure 4; under publication).

Major inferences

- The current study showed the presence of high genetic variability in the Indian germplasm of *Aquilaria malaccensis*. It has also been observed that genotypes from different populations were grouped into six genetic clusters. Cluster I includes the two accessions of *A. khasiana*, while II to VI includes all the accessions of *A. malaccensis* which were grouped irrespective of their geographical distribution. This is due to a large spread of plant material in the form of seeds and saplings for cultivation purposes. It is also evident from the present survey that the planting materials of agarwood are majorly brought from Assam in most of the states.

- High genetic admixture is observed in all the clusters of *A. malaccensis* except Cluster II. The accessions with the least admixture in Cluster II are mostly from the plantations in the Darjeeling and Jalpaiguri districts of West Bengal and the Shivamogga and Uttara Kannada districts of Karnataka. Since their admixture is very less, low genetic variability is also expected in these genotypes. One of the probable reasons for this observed low genetic variability might be the dependency of the nurseries and plantations on a limited number of sources for seeds/ saplings which caused reduction in genetic diversity of the progeny population due to inbreeding depression. Therefore, using its progenies for future cultivation and breeding is not advisable.

- The genotypic comparison of *A. khasiana* with *A. malaccensis* showed the presence of a unique genotype in both the *A. khasiana* accessions (Cluster I) collected from the forest regions of Assam (Joypur Reserve Forest, Dibrugarh) and Meghalaya (Mawsynram, East Khasi Hills). It is reported to be very rare, with restricted and fragmented distribution in Meghalaya (Mir & al., 2017). Unfortunately, the plants are exploited in these regions as they also produce agar by natural infection. Therefore, strict monitoring and protection of these wild stands in their native habitats is a must to prevent their extinction. Further, a comprehensive survey is required to estimate its true geographical range and actual population size for setting up conservation priorities.

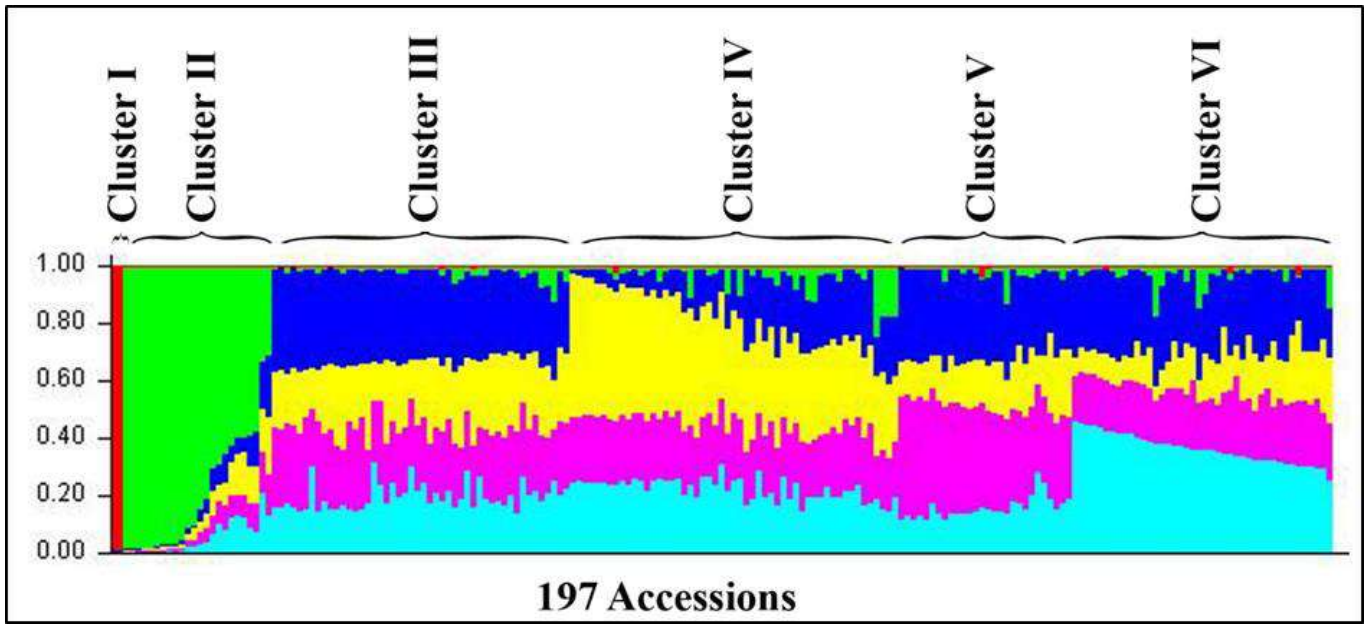


Figure 4. The bar plot shows the clustering and genetic admixture of *Aquilaria* accessions based on Bayesian model STRUCTURE analysis. Six clusters resulted, in which Cluster I and Cluster II showed low admixture.

Phytochemical profiling of *Aquilaria spp.* found in India (wild/cultivated): The exploration of the chemical composition of plant species is pivotal for unlocking their potential applications in various industries, ranging from pharmaceuticals to nutraceuticals. Chemical profiling can also help to identify and classify plant species based on their unique chemical fingerprints. Certain compounds or classes of compounds can indicate a particular group of plant families or genera, aiding in taxonomic studies. Furthermore, it can also be used to identify powdered plant material to the degree that uniquely identifying features are no longer present, as well as extracts that lack any cellular elements where alternative testing is required. More than 150 compounds were identified from *Aquilaria spp.*, mostly sesquiterpenoids, chromones and volatile aromatic compounds (Naef, 2011). In this context, High-Performance Liquid Chromatography (HPLC) analyses of different *Aquilaria spp.*, collected from various locations, have been carried out to understand their phenolic profiles. Identifying and quantifying specific phenolic compounds and their retention times (RT) have enabled the construction of characteristic chromatographic profiles for *Aquilaria spp.*

This study focused on the chemical analysis of multiple accessions of *A. malaccensis*, along with *A. sinensis* (introduced for cultivation) and *A. khasiana* (wild), gathered from distinct regions, including Karnataka, Tripura, Assam, and Meghalaya. Chemical assays (HPTLC and HPLC) and spectrophotometric methods (UV, IR) provide qualitative and quantitative information in a single assay. Leaves of *Aquilaria spp.* contain a variety of phenolic and polyphenolic compounds. Here, the targeted *Aquilaria spp.* were authenticated by identifying several marker compounds, like chlorogenic acid, caffeic acid, ferulic acid, mangiferin, myricetin, and quercetin, in the tested leaves by HPLC (Figure 5–16). The data were meticulously presented in triplicate, accompanied by a convergence limit to enhance the robustness of the analysis.

This study delves into the specific phenolic composition of *A. malaccensis* (along with two other species for understanding the differences), highlighting chemotaxonomic relationships and the unique compounds present in particular samples. The establishment of characteristic chromatographic profiles serves as a valuable tool for evaluating chemical similarities among diverse extract forms, ultimately aiding in the development of standardized protocols for the bioprospecting evaluation of the species under study.

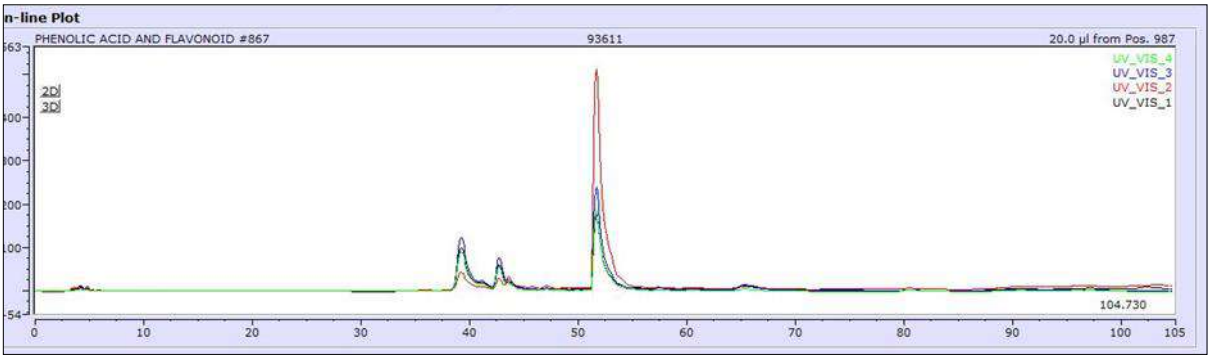


Figure 5. *Aquilaria malaccensis:* Collection number – 93611, locality – Vanasiri farm, Shivamogga, Karnataka.

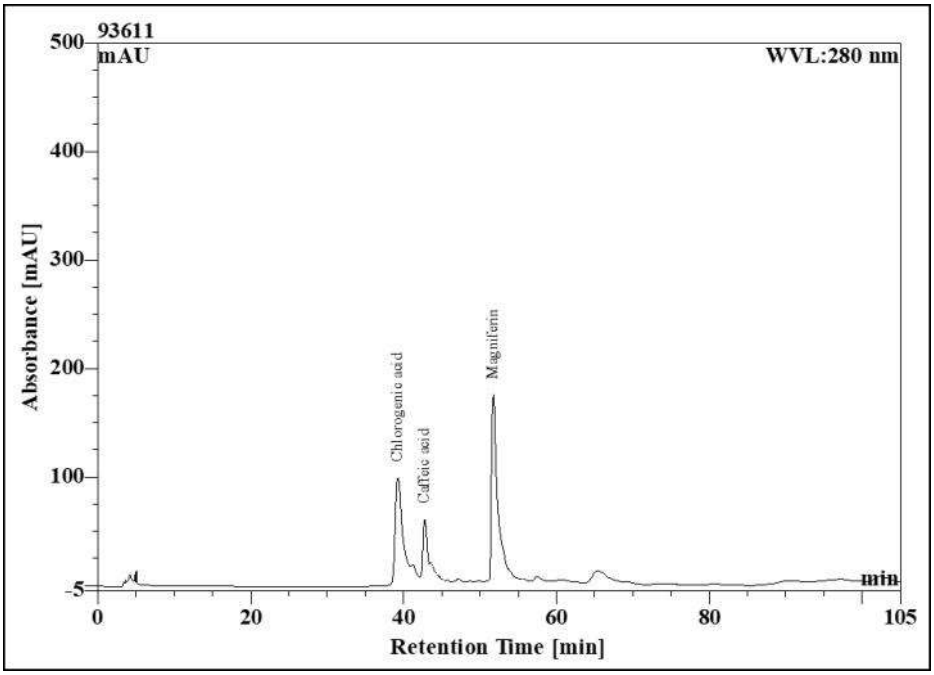


Figure 6. The results of HPLC analysis of *Aquilaria malaccensis* (Collection number – 93611): Location – Vanasiri farm, Shivamogga, Karnataka. Major compounds present: chlorogenic acid (RT 39.25 min.), caffeic acid (RT 42.75 min.), and magniferin (RT 51.79 min.).

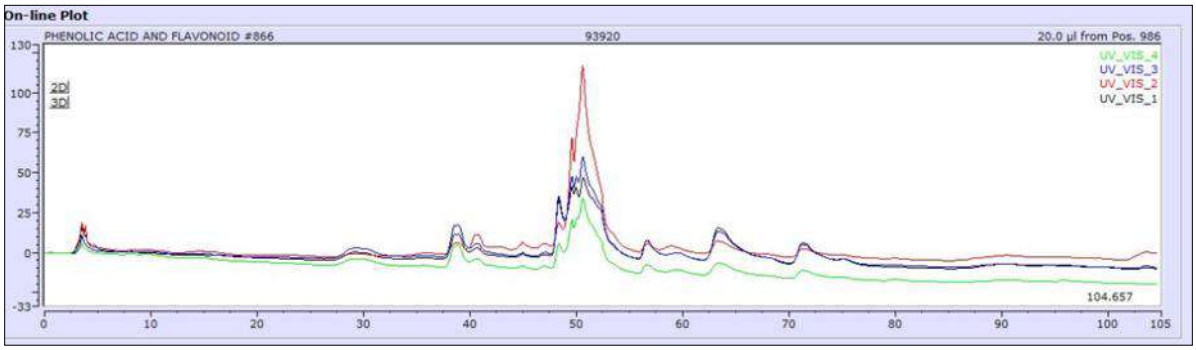


Figure 7. *Aquilaria malaccensis*: Collection number – 93920, Locality – Rowa Wildlife Sanctuary, North Tripura.

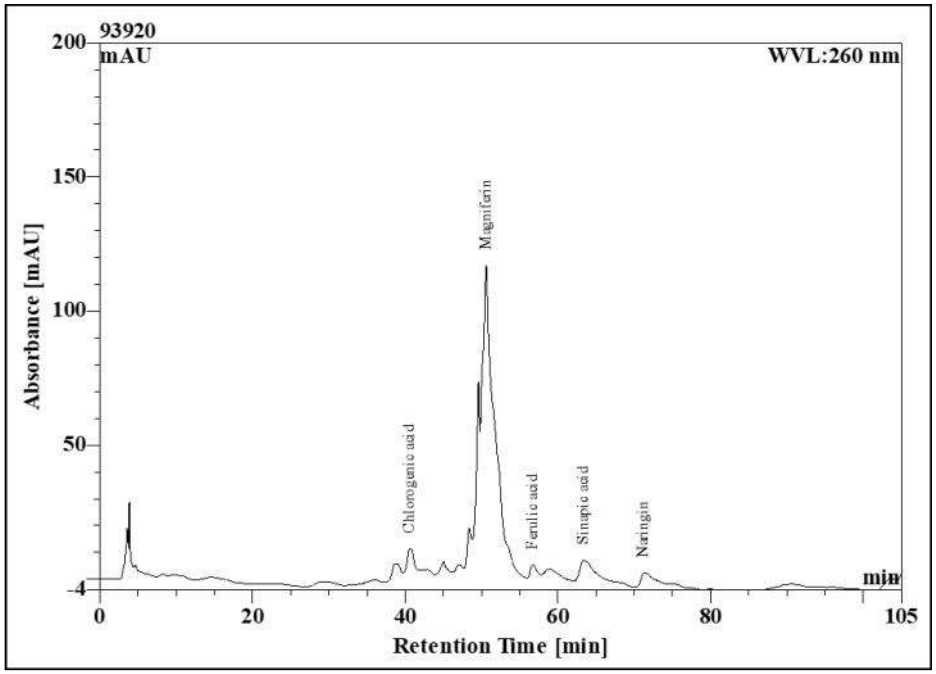


Figure 8. The results of HPLC analysis of *Aquilaria malaccensis* (Collection number – 93920): Location – Rowa Wildlife Sanctuary, North Tripura. Major compounds present: chlorogenic acid (RT 40.61 min.), magniferin (RT 50.61 min.), ferulic acid (RT 56.77 min.), sinapic acid (RT 63.36 min.) and naringin (RT 71.29 min.).

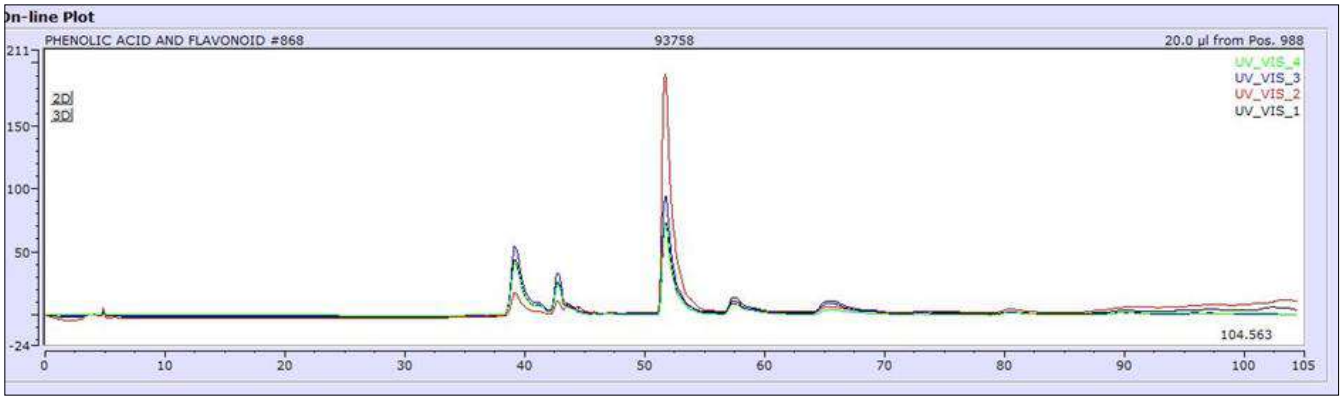


Figure 9. *Aquilaria malaccensis*: Collection number – 93758, Location – Retzol, Dima Hasao, Assam.

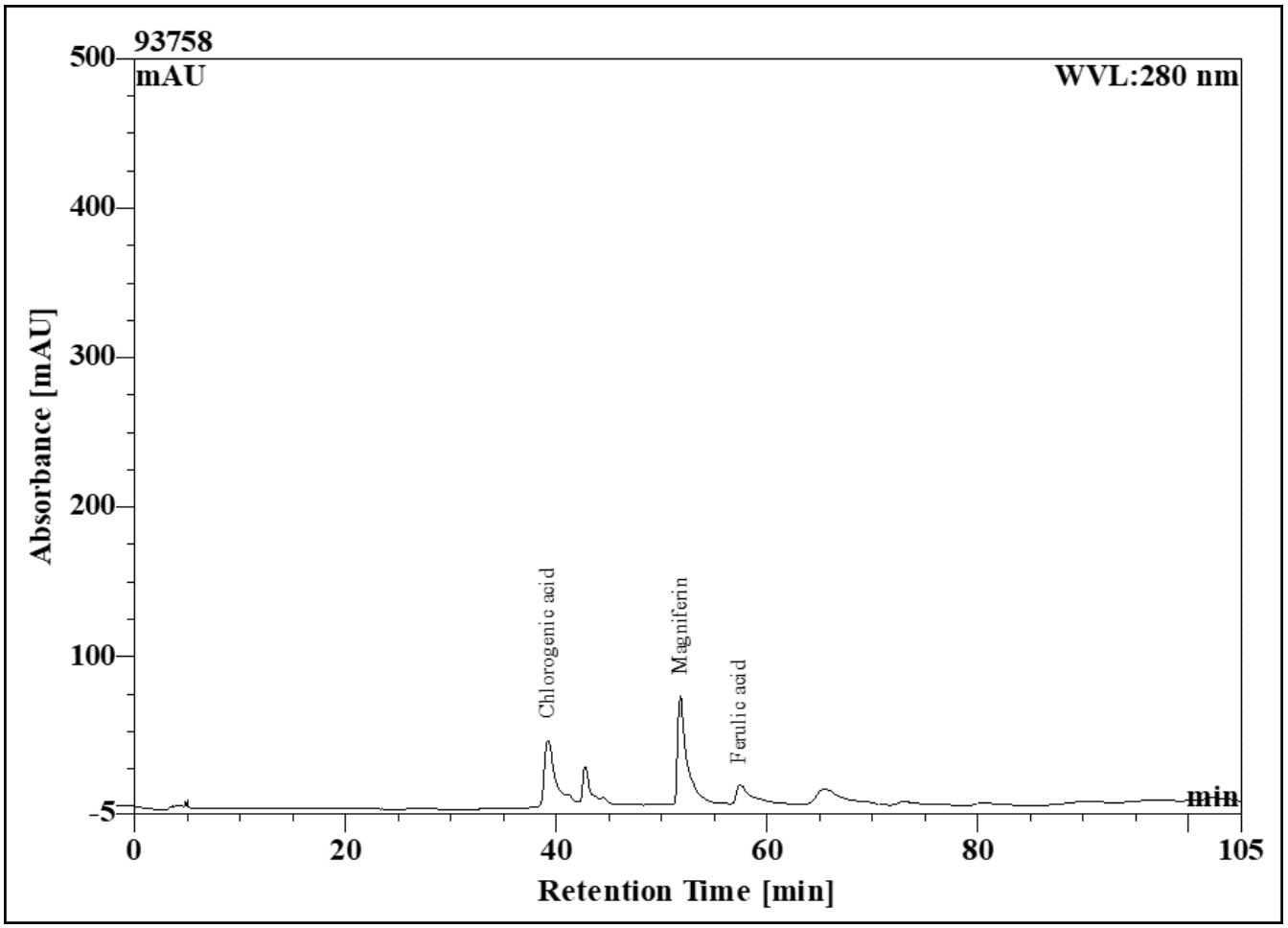


Figure 10. The results of HPLC analysis of *Aquilaria malaccensis* (Collection number – 93758): Location – Retzol, Dima Hasao, Assam. Major compounds present: chlorogenic acid (RT 39.22 min.), magniferin (RT 51.81 min.), and ferulic acid (RT 57.45 min.).

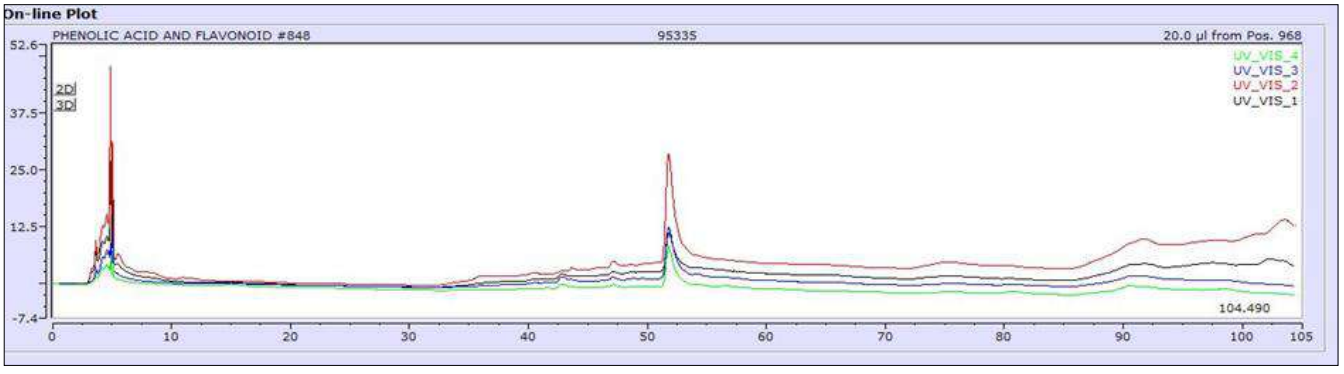


Figure 11. *Aquilaria malaccensis*: Collection number – 95335, Location – Modartoli, Hojai, Assam.

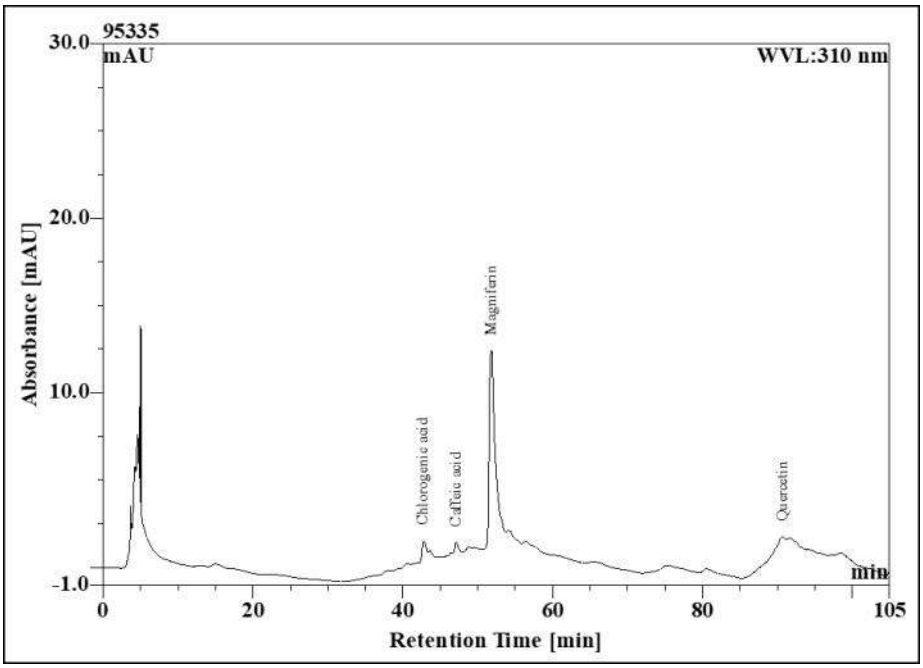


Figure 12. The results of HPLC analysis of *Aquilaria malaccensis* (Collection number – 95335): Location – Modartoli, Hojai, Assam. Major compounds present: chlorogenic acid (RT 42.79 min.), caffeic acid (RT 47.13 min.), magniferin (RT 51.85 min.), and quercetin (RT 90.75 min.).

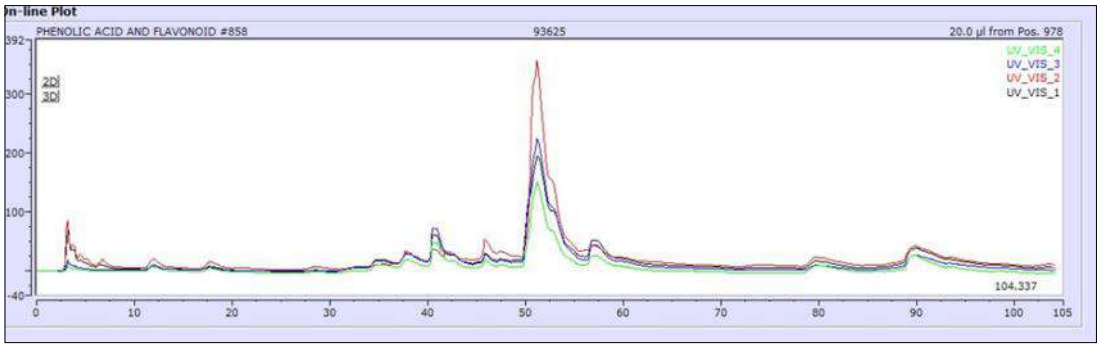


Figure 13. *Aquilaria sinensis*: Collection number – 93625: Location – Vanadurgi farm, Sringeri, Chikkamagaluru, Karnataka.

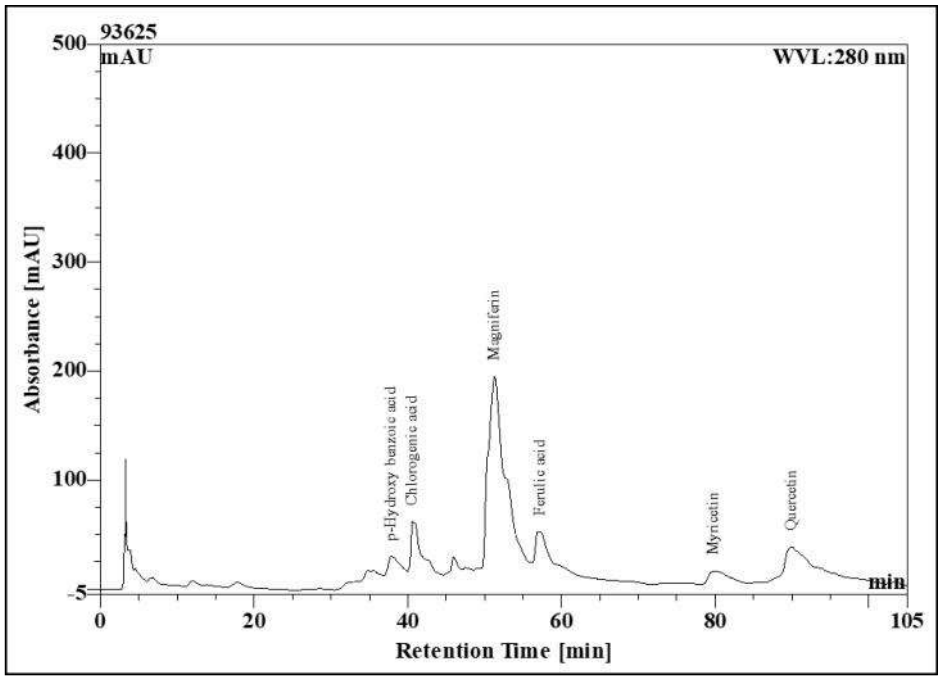


Figure 14. The results of HPLC analysis of *Aquilaria sinensis* (Collection number – 93625): Location – Vanadurgi farm, Sringeri, Chikkamagaluru, Karnataka. Major compounds present: p-hydroxy benzoic acid (RT 37.83 min.), chlorogenic acid (RT 40.65 min.), magniferin (RT 51.30 min.), ferulic acid (RT 57.32 min.), myricetin (RT 79.78 min.) and quercetin (89.97 min.).

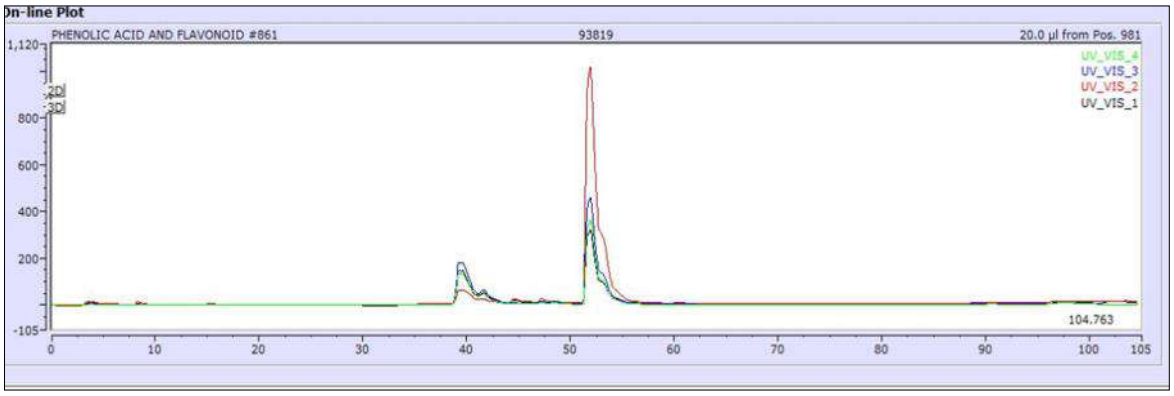


Figure 15. Sample number 93819: *Aquilaria khasiana* collected from Mawkasin, Mawsynaram, East Khasi Hills, Meghalaya.

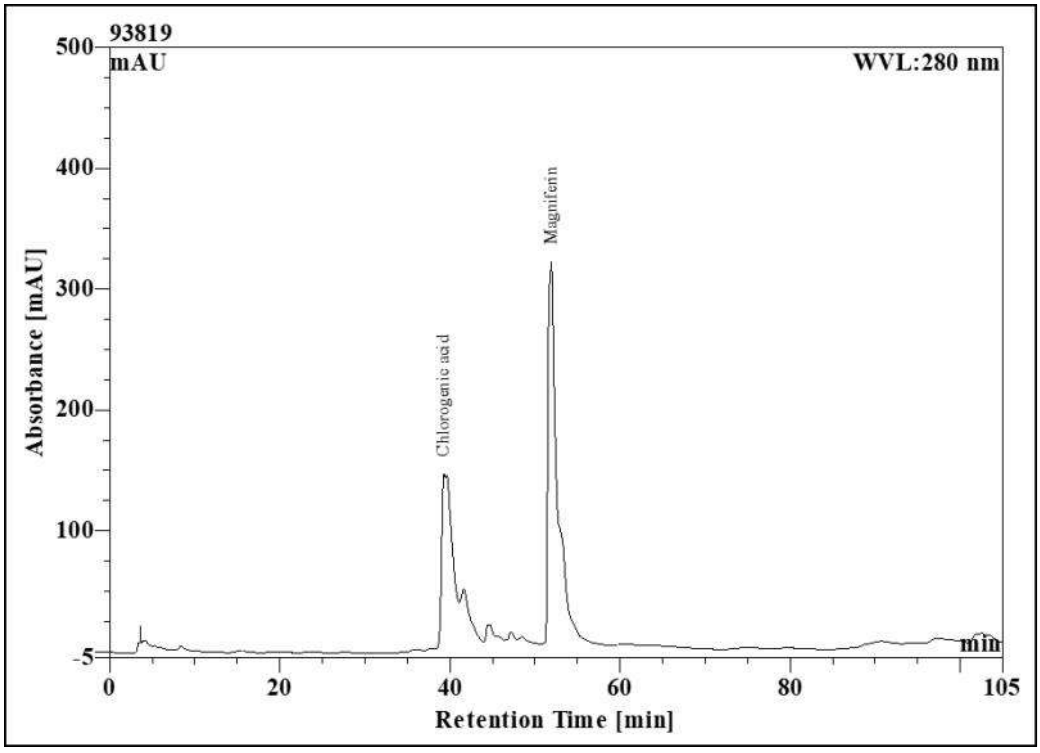


Figure 16. The results of HPLC analysis of *Aquilaria khasiana* (Collection number – 93819): Location – Mawkasin, Mawsynaram, East Khasi Hills, Meghalaya. Major compounds present: chlorogenic acid (RT 39.33 min.) and magniferin (RT 51.93 min.).

Major Inferences

- Compounds such as chlorogenic acid and magniferin are found across all the tested samples, suggesting potential chemotaxonomic relationships among *Aquilaria spp.*
- Unique compounds like sinapic acid and naringin in *A. malaccensis* and myricetin and quercetin in *A. sinensis* add to the chemical diversity observed within the genus. All compounds besides chlorogenic acid and magniferin were absent in *A. khasiana.*
- The established chromatographic profiles serve as a foundation for evaluating the chemical similarities among various extract forms, aiding in developing standardized protocols for the bioprospecting evaluation of *Aquilaria spp.*
- The outcomes of this research contribute to scientific knowledge and the sustainable use and conservation of these valuable plant resources, fostering advancements in medicinal and nutritional applications.

1.2 Is the species listed in Appendix I or Appendix II?

The species is listed in **Appendix II.**

All parts and derivatives of *A. malaccensis* are controlled by CITES except —

- Seeds and pollen;
- Seedling or tissue cultures obtained in vitro transported in sterile containers;
- Fruits;
- Leaves;
- Exhausted agarwood powder, including compressed powder in all shapes; and
- Finished products packaged and ready for retail trade, this exemption does not apply to wood chips, beads, prayer beads and carvings.

However, up to 1 kg of woodchips, 24 ml of oil and two sets of beads or prayer beads (or two necklaces or bracelets) per person are exempted from the CITES regulations as personal effects as per the Res. Conf. 13.7. (Rev. CoP 17).

1.3 Purpose of export?

Trade

1.4 Where were the specimens harvested from?

Home/ community gardens, private or community production plantations, plantations in leased/ 'Patta' lands etc. (not from wild).

STEP 2: REVIEW OF COMPLIANCE WITH ARTIFICIAL PROPAGATION REQUIREMENTS

2.1 Is the permit application for Art. Prop. Specimens?

The permit applications are for either Artificially Propagated specimens (source code A) or the specimens Assisted Production (source code Y).

According to the **Resolution Conf. 16.10** (CoP19) the term 'artificially propagated' is to be interpreted to refer to plant specimens of **Agarwood** as follows:

i) Grown under controlled conditions; and

ii) Grown from seeds, seedlings, saplings, cuttings, grafting, marcotting/ air-layering, divisions, plant

tissues or other propagules that have been derived from **wild or cultivated parental stocks**, according to the definition of 'cultivated parental stock' in Resolution Conf. 11.11 (Rev. CoP18).

As per the Resolution Conf. 16.10 the trees of agarwood-producing taxa grown in cultivation such as:

a) Gardens (home and/ or community garden); and

b) State, private or community production plantation, either monospecific or mixed species; shall be considered as artificially propagated in accordance with the definition above.

At present, the trade of *Aquilaria malaccensis* in India is from the millions of plants harvested from the home/ community gardens, private or community production plantations, plantations in leased/ 'Patta' lands only and not from the wild plants because the wild population of *A. malaccensis* in India is almost extinct due to overharvesting in the past. The wild plants of *A. malaccensis* are confined only in a few Protected Areas of Northeast India and extraction of any plants from these Protected Areas are not permitted. Mostly the seeds for raising the planting stock are collected from the cultivated mother plants, and in very rare cases sustainably from the wild or from the plants conserved in the Protected Areas. The collection of seeds from cultivated plants is not detrimental to the survival of the species in the wild.

Hence, the specimens under trade can be considered to be harvested from 'Artificially Propagated' stock and can be exported by applying the **source code 'A'** (without fixing an annual export quota).

However, the **source code Y** ['Assisted Production'; definition adapted from Res. Conf. 11.11 (Rev. CoP18)] was introduced recently for which NDFs were necessary. But there is no clear guidance on which source code (A or Y) has to be applied for the specimens (harvested/ extracted from cultivation/ plantation) of agarwood-producing species. Further, the Resolution Conf. 16.10 is presently under revision by the PC26 Intersessional Working Group on Agarwood-producing taxa (*Aquilaria spp.* and *Gyrinops spp.*) and the source of 'artificially propagated' specimens of agarwood producing taxa may be limited to 'cultivated parental stocks' (rather than 'wild or cultivated parental stocks') in future with exception to permit limited amount of seeds/ propagules etc. from wild only necessary to maintain the vigour and productivity of the cultivated parental stock.

Therefore, on a precautionary basis, the specimens in export are to be treated under the **source code 'Y' (obtained through 'Assisted Production')**.

*[**Assisted production**: Characteristic of plant specimens that do not fall within the definition of 'artificially propagated', and are considered not to be 'wild' because they are propagated or planted in an environment with some level of human intervention for the purpose of plant production;*

Material used to produce plant specimens from 'assisted production' systems can be derived from plant material that is exempt from the provisions of the Convention, or derived from artificially propagated plants, or derived from plants grown in an environment with some level of human intervention or derived from plant materials collected sustainably from wild populations in accordance with the provisions of CITES and relevant national laws and in a manner not detrimental to the survival of the species in the wild.

Assisted production is represented by source code Y, a source code between 'artificial propagation' and 'wild'. Source: CITES Glossary]

2.2. Is export of the artificially propagated specimens of this species permitted by national or relevant sub-national legislation?

The export of the artificially propagated specimens of this species is legally permitted.

2.3. Do the specimens covered by the export permit application clearly meet all requirements for artificial propagation according to Res. Conf. 11.11 (Rev. CoP18)?

The specimens covered by the export permit application do not clearly meet all requirements for artificial propagation, according to Res. Conf. 11.11 (Rev. CoP18), but meet all requirements for artificial propagation according to **Resolution Conf. 16.10** (CoP19) for agarwood-producing taxa.

2.4. Are there concerns about compliance of the specimens with CITES requirements for artificial propagation that cannot be resolved by the Scientific Authority by undertaking a detailed NDF?

There is no clear guidance by CITES mentioning which source code (A or Y) has to be applied to the specimens (harvested/ extracted from the cultivation/ plantation) of agarwood-producing species, as both source codes can be applied.

However, as a precautionary measure, the specimens in export are treated here under the **source code 'Y' (obtained through 'Assisted Production'),** and an annual export quota (national) is established.

STEP 3: REVIEW OF RELEVANT EXCLUSIONS AND PREVIOUSLY-MADE NDFs

3.1. Is the harvest or the export of wild-harvested specimens of this species permitted by national or relevant sub-national legislation or regulation?

The wild harvest and export of wild-harvested specimens of this species are not legally permitted.

3.2 Is the specimen listed in CITES Appendices (may be excluded by annotation or listing)?

The specimens of the species are listed in CITES Appendix II. However, the following parts and derivatives are excluded according to the #Annotation 14.

- Seeds and pollen;
- Seedling or tissue cultures obtained *in vitro* transported in sterile containers;
- Fruits;
- Leaves;
- Exhausted agarwood powder, including compressed powder in all shapes; and
- Finished products packaged and ready for retail trade, this exemption does not apply to wood chips, beads, prayer beads and carvings.

Further, up to 1 kg of woodchips, 24 ml of oil and two sets of beads or prayer beads (or two necklaces or bracelets) per person are exempted from regulations as personal effects as per the Res. Conf. 13.7. (Rev. CoP 17).

3.3. Has the Scientific Authority previously made a science-based NDF for this species that is still valid and is sufficient to evaluate the specimens for the current export permit application?

The previously-made NDFs of *A. malaccensis* in India was prepared by the Rain Forest Research Institute, Jorhat, Assam in 2021 which has been critically reviewed. It was a preliminary NDFs and was based mainly on the secondary data, without incorporating most of the field survey records due to certain limitations. Only 10 million plants from the north-eastern part of the country in the Eastern Himalayan region and Brahmaputra plains, and about 5 million in the south-western part of the country along the Western ghats were estimated in the previous NDFs. The estimation was extremely low in comparison to reality. The present study estimates at least **139.89 million (13.989 crore)** plants of *A. malaccensis* from India.

STEP 4: EVALUATION OF CONSERVATION CONCERN

4.1. Has the conservation status of the species been assessed at any geographic scope?

The species was assessed as Critically Endangered A2cd (Harvey-Brown, 2018) in wild at global context. During the present study *A. malaccensis* is found growing in wild only in some protected as well as non-protected areas of Northeast India. The assessment by Harvey-Brown (2018) as CR A2cd based on criteria 'A' (population size reduction) is also applicable for India as the wild population of this species had been drastically reduced due to harvesting for trade.

4.2. What is the severity ("Low", "Medium", "High", or "Unknown") of conservation concerns and identified threats relevant to the harvest area?

Severity of conservation concern of wild population: **High**

The wild population of *A. malaccensis* is very less in India due to excessive harvesting in the past, fragmentation, less gene flow, genetic erosion, land use changes, and other anthropogenic activities causing genetic erosion. The species was earlier assessed as Vulnerable (VU) in 1998 but assessed as Critically Endangered (CR) in 2018 in Global context as it was estimated that the population for the last three generations was declined by over 80% due to agarwood exploitation (Harvey-Brown, 2018).

Severity of conservation concern of population under cultivation: **Low**

Aquilaria malaccensis is one of the highest cultivated species in Northeast India, especially in certain districts of Assam, Manipur, Nagaland, and Tripura. It is also in cultivation in other parts of the country. The present study estimates not less than **139.89 million (13.989 crore)** plants of *A. malaccensis* which are in cultivation/ plantation. Due to its extensive cultivation, the species itself does not fall under any threatened categories (*i.e.* CR, EN, VU) in India.

STEP 5: EVALUATION OF POTENTIAL INTRINSIC BIOLOGICAL RISK OF HARVEST FROM WILD AND CULTIVATED POPULATION

5. What is the severity of intrinsic biological risk factors?

1. Plant part harvested versus life form of species

Risk severity: **High**

Primarily, harvest of whole plant is for extracting agarwood chips, dust/ 'churan' and oil; also harvested for agarwood beads, and rarely for carvings; leaves are harvested for preparing agarwood tea.

2. Resilience of the species

Risk severity: **Medium (in India)**

The resilience of the species concerned is dependent on the plant part that is harvested in relation to the ability of the individual plant and the harvested population to recover (Wolf & al., 2016). In case of *A. malaccensis,* tree trunk is felled but not entirely uprooted while harvesting. Hence, it is posing comparatively less risk than to the plants which are harvested by uprooting entirely. Being a perennial tree, this species is observed to be resilient in terms of its regeneration and reproduction potential (discussed in detail in 'Regeneration' and 'Reproduction'). Hence, it is able to overcome the damaging effects of sustainable harvesting.

The natural agarwood is formed as the result of self-defence mechanism in response to fungal infection, which usually occurs due to boring by the stem borer, *Neurozera conferta* (= *Zeuzera conferta*). However, the biotic stress caused by various pests and fungal infection is reported to be one of the factors which adversely affects the resilience of the species. For instance, the larvae of *Heortia vitessoides* Moore are reported to cause the defoliation of the whole tree. The germinating seeds and seedlings sometimes show damping off due to fungal infections. In natural conditions, the seedlings often die due to root infestation by soil-borne pathogens, but the survival rate is higher in nurseries/ cultivation due to proper management. The fungus *Fusarium equiseti* (Corda) Sacc. is known to cause wilt and dieback of *A. malaccensis* in India.

Syazwan & al. (2019) reported 19 insect pest species from Australia, China, India, Indonesia, and Malaysia. A total of six categories of plant disease, consisting 12 different diseases, has been recorded, out of which, the dieback disease is the only one with significant damage, causing about 30% mortality in plantations in China (Syazwan & al., 2019).

Heortia vitessoides larvae feeding on leaf and bark of *A. malaccensis* (in cultivation)

3. Geographic distribution

Risk severity: **High for wild population.**

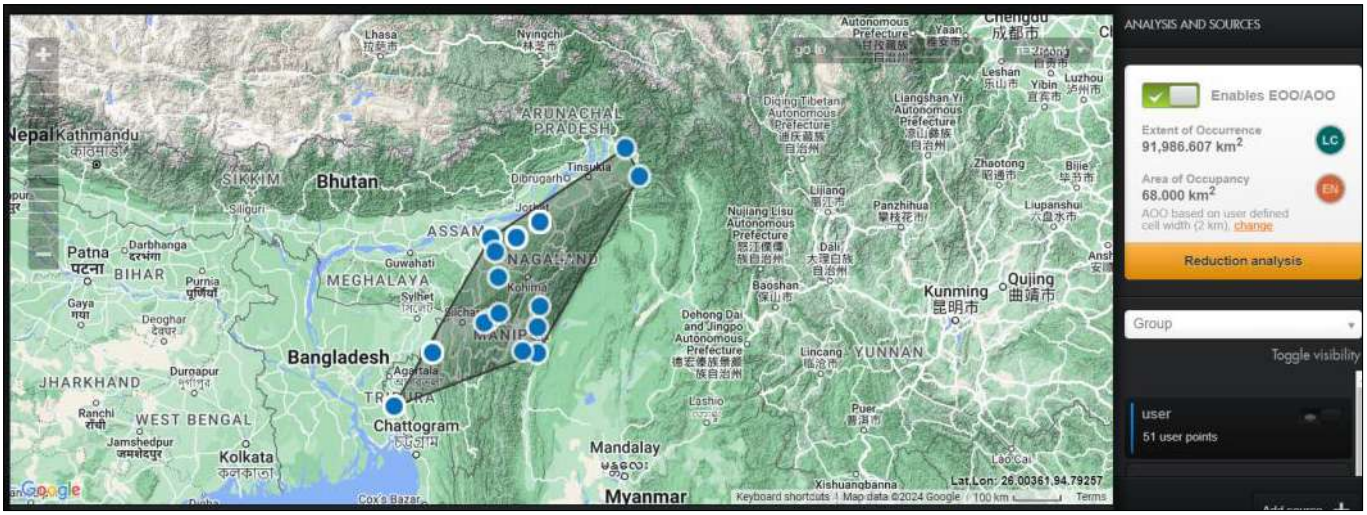
The species is found in wild in Bangladesh, Borneo, Bhutan, India, Indonesia, Malaysia, Myanmar, Philippines, Singapore, and Thailand.

The wild populations of *A. malaccensis* were earlier reported in India from Arunachal Pradesh, Assam, Meghalaya, Nagaland, Mizoram, Manipur, Sikkim, Tripura, and West Bengal at up to an elevation of 1,000 m (Chakrabarty & al., 1994). However, with a long history of illicit felling and overexploitation, even since 1905, the wild populations have been depleted drastically. During the present study, no plant could be located in the wild from Sikkim and West Bengal. Also, no plant has been reported to be present in the wild by the Forest Department of these states. According to Chakrabarty & al. (1994), the Khellong Forest Division, Banderdewa Forest Division, Nampong Forest Division, and the Pasighat Forest Division in Arunachal Pradesh were the significant agarwood custodians. Tabin & Shrivastava (2014) reported wild subpopulations of *A. malaccensis* at Balijan, Bhekuliang, Bhismaknagar, Namdapha, Wakro in Arunachal Pradesh, and at Assam-Nagaland border and Golaghat in Assam. In Mizoram, *A. malaccensis* grows sporadically in some of the catchment areas of main river tributaries such as Tuivawl (Chakrabarty & al., 1994).

During the present study, the species is found growing in Garampani Wildlife Sanctuary, Hollongapar Gibbon Sanctuary, East Karbi Anglong Wildlife Sanctuary, Nambor Wildlife Sanctuary of Assam, Rowa Wildlife Sanctuary, Sephaijala Wildlife Sanctuary (plantation), Trishna Wildlife Sanctuary (plantation) of Tripura, Namdapha National Park & Tiger Reserve of Arunachal Pradesh, Ntangki National Park of Nagaland, and Nongkhyllem Wildlife Sanctuary of Meghalaya. A few trees are found in wild conditions in non-protected forest areas in Khanbamun Hills of East Karbi Anglong district of Assam. According to the local peoples and forest officials, the species can be found in the wild forest regions of Jiribam, Tamenglong, Ukhrul, Tengnoupal, Kamjong, and Chandel districts of Manipur, and Bhekuliang, Lohit district of Arunachal Pradesh. However, these wild locations in Manipur and interior parts of the forest in Bhekuliang (adjoining to Payagam) could not be accessed during the present study due to certain limitations.

The species is also found planted in Patharia Reserve Forest under the Churaibari range, Badshahi Tila Reserve Forest under the Lowairpoa range in Assam, Umsaw Reserve Forest, Rongrenggre Reserve Forest, Darugre Reserve Forest of Meghalaya. However, no natural infection was found in any trees in these locations.

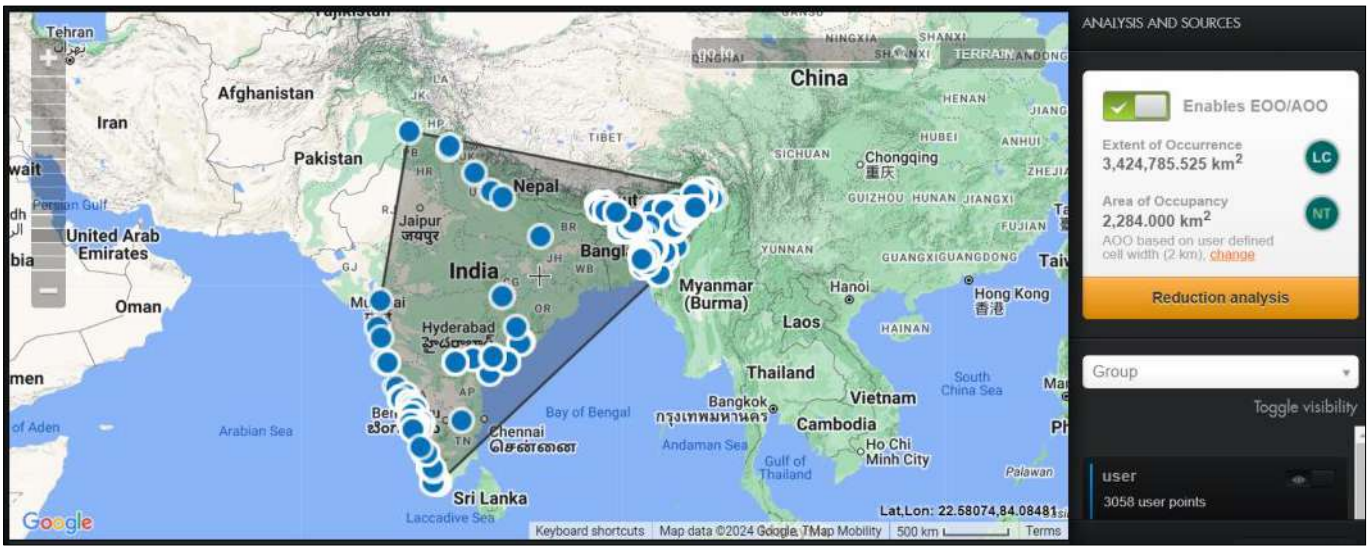
The estimated Extent of Occurrence (EOO) and Area of Occupancy (AOO) of the wild population of *A. malaccensis* in India are 91,986.607 km^2 and 68 km^2 respectively.



EOO and AOO estimated in GeoCAT for the wild population of *A. malaccensis* occurring in India

Risk severity: **Low for cultivated population.**

Aquilaria malaccensis is under extensive cultivation in some parts of Assam (mainly upper Assam), Tripura (especially northern districts), Manipur (Jiribam district) and Nagaland (Mokokchung and Mon). Besides, the species is also found in cultivation in some parts of Andhra Pradesh, Arunachal Pradesh, Bihar, Chhattisgarh, Goa, Gujarat, Jharkhand?, Karnataka, Kerala, Maharashtra, Meghalaya, Mizoram, Odisha, Punjab, Rajasthan?, Tamil Nadu, Telangana, and West Bengal. The estimated Extent of Occurrence (EOO) and Area of Occupancy (AOO) of the cultivated population of *A. malaccensis* in India is 34,24,785.525 km² and 2,284 km² respectively.



EOO and AOO estimated in GeoCAT for the cultivated population of *A. malaccensis* occurring in India

4. National population size and abundance

Risk severity: **High for the wild population.**

During the present study, only a few plants are traced in protected and non-protected forest areas of Assam. In Nambor Wildlife Sanctuary, eight trees with GBH >45 cm, devoid of infection, are observed. In Hollongapar Gibbon Sanctuary, around 1,100 trees are found. About 70% of plants are 10–30 or more years of age with GBH ranging from 40–135 cm. The rest of the trees are below

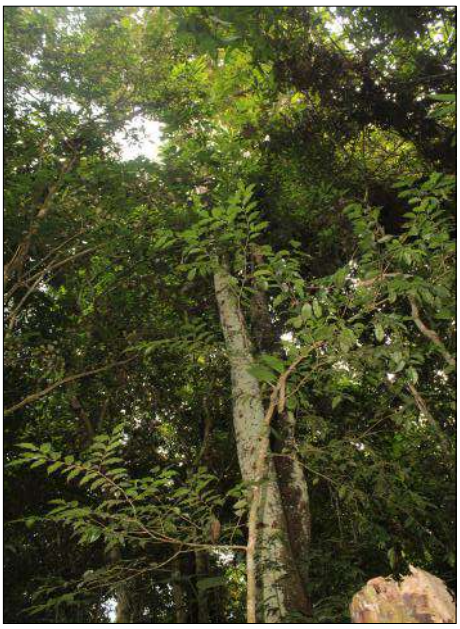
ten years of age with GBH <40 cm. A tree with 15–30 cm GBH and another with GBH 30–45 cm is observed in wild conditions within the East Karbi Anglong Wildlife Sanctuary. Another 3 trees with GBH 15–30 cm, infected by physical injury, are growing in wild conditions within the Garampani Wildlife Sanctuary. In Rowa Wildlife Sanctuary, Tripura, nearly 2,500 plants are located, of which around 40% are naturally infected. Around 35% of plants are with GBH of <15 cm, 64% with 15–30 cm, and 1% with GBH of 30–45 cm. In Trishna Wildlife Sanctuary, *c.* 1,350 agar plants are found in a plantation by the Forest Department. The rate of natural infection is good in this plantation. Wild populations of agarwood are reported in some forest regions of Jiribam, Tamenglong, Ukhrul, Tengnoupal, Kamjong, and Chandel districts, but we could not access them due to certain restrictions. Wild populations of *A. malaccensis* are found in very few numbers in Namdapha National Park and Tiger Reserve, Changlang district, and according to the local people of Bhekuliang, several wild agar plants can be found in the hilly forest areas adjoining the village.

A. malaccensis in Hollongapar Gibbon Sanctuary, Assam (in wild)

A. malaccensis in Hollongapar Gibbon Sanctuary, Assam (in wild)

A. malaccensis in Garampani WLS, Assam (in wild)

A. malaccensis in East Karbi Anglong WLS, Assam (in wild)



A. malaccensis in Khanbamun, Assam (in wild)

A. malaccensis Namdapha NP & TR, Arunachal Pradesh (in wild)

A. malaccensis in Ntangki NP, Nagaland (in wild)

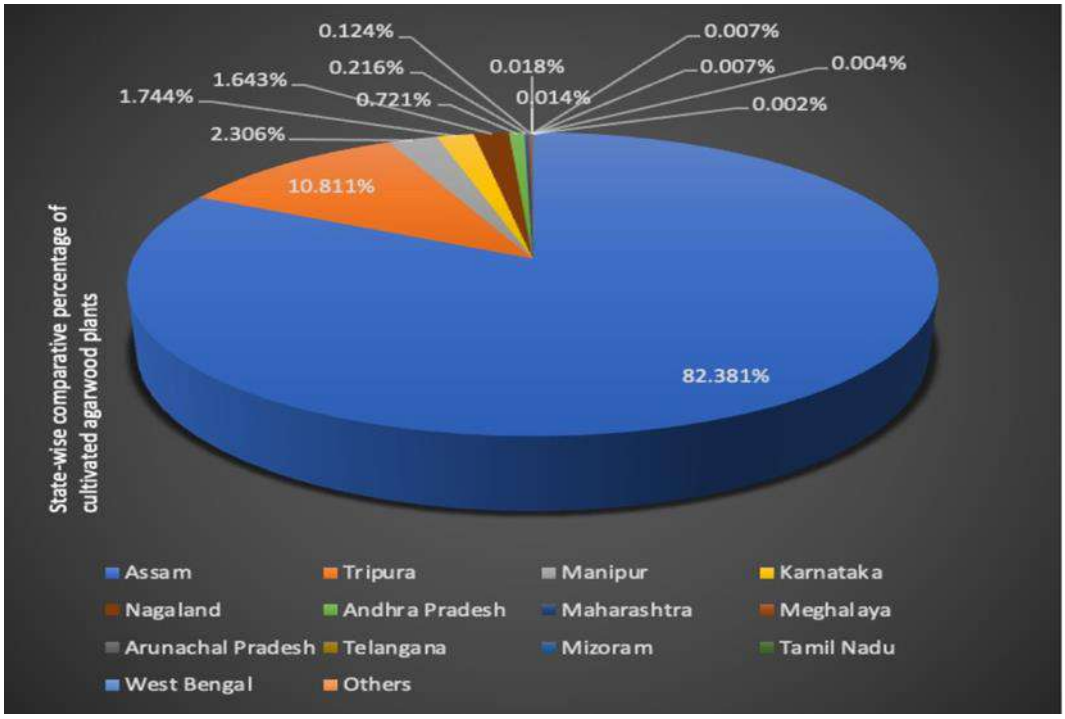
A. malaccensis in Rowa WLS, Tripura (in wild)

Risk severity: **Low for the cultivated population.**

The species is extensively cultivated in home/ community gardens, plantations on leased/ 'patta' lands, private or community plantations. The national population size of cultivated plants of this species has been estimated to at least 139.89 million (13.989 crore) which are >2 years of age or with >10 cm GBH. An overview of the cultivated plants of *A. malaccensis* in India is provided as follows.

Estimated number of plants (>2 years of age/>10 cm GBH) in India: At least 139.89 million (13.989 crore).

Name of the state	Estimated number of agarwood plants
Assam	114.3 million (11.43 crore)
Tripura	15.15 million (1.515 crore)
Manipur	3.2 million (32 lakh)
Karnataka	2.42 (24.2 lakh)
Nagaland	2.28 million (22.8 lakh)
Andhra Pradesh	1 million (10 lakh)
Kerala	1 million (10 lakh)
Maharashtra	0.3 million (3 lakh)
Meghalaya	0.172 million (1.72 lakh)
Arunachal Pradesh	25 thousand
Telangana	20 thousand
Mizoram	10 thousand
Tamil Nadu	10 thousand
West Bengal	5.5 thousand
Others	3 thousand
Total	**139.89 million (13.989 crore)**



Assam: *Aquilaria malaccensis* is extensively cultivated in home gardens of Assam, especially Golaghat, Jorhat, Sivasagar, Karimganj, and Cachar districts. Apart from these districts, cultivated plants are also found sporadically in Charaideo, East Karbi Anglong, Dibrugarh, Hojai, Nagaon, Dima Hasao, Hailakandi, Biswanath, West Karbi Anglong, Goalpara, Udalguri, Tinsukia, Dhemaji, Majuli, Kamrup, Sonitpur, and Dhubri districts.

A vast number of plants *i.e.,* around **45 million** are observed in the **Golaghat district**, especially at Naharani, Pulibor, Padumoni, Dhekial, Ganaphuki, Kuralguri, Dubial, Likson gaon, Burha gaon, Bongaon, Badulipara, Junaki Nagar, Dabidubi, Kamarbandha, Bokolai, Sialekhati, Borjan, Melamora, Khumtai, Numaligarh, Jugibari etc. Almost every household in these areas has agar plants grown as a fence along the boundary and plantation at the backside. This practice is common almost throughout the district. Most of the people in the Golaghat district cultivate agarwood on whatever portion of land is available. Large plantations, along with tea plants, are also quite common. The home gardens have 150–5,000 trees; most of them have their own nursery where they grow seeds to raise seedlings/ saplings. One of the most extensive plantations is observed in Naharani with around 25,000 trees. Around 100 mature trees are found growing in village home gardens within the Kaziranga National Park. However, these trees are devoid of any natural infection, unlike other areas in the Golaghat district. Therefore, artificial inoculation has been done in around 10–15 trees.

The **Jorhat district** also has extensive cultivation **(at least 20 million)**, especially at Kakojan, Meleng, Seleng, Nakachari, Hansara, Tamulchiga, Simaluguri, Titabor, Soraibahi, Shantipur, Tilikiam, Charaibahi, Lehetiya, Dhekelia, Pokamura Charali, Kamargaon, Jalukonibari etc. Agar plants are also found in several tea plantations in Jorhat district; however, excessive pesticide spraying on tea plants causes less infection in the agar trees.

Agarwood plantations in Golaghat district, Assam

Agarwood plantations in Golaghat district, Assam

Agarwood plantations in Golaghat district, Assam

Agarwood plantations in Jorhat district, Assam

Agarwood plantations in Jorhat district, Assam

GBH classes in **Golaghat** and **Jorhat districts**: around 30% are of GBH <15 cm, 35% within 15–30 cm, 20% within 30–45 cm, and 15% >45 cm. Around 60–70% of plants are found to be infected. Commonly, the spacing for plantation used here is 2.5 × 2.5 m for block and 2.5 m distance for boundary plantation. But spacing of 1.5 × 1.5 m for block and 1.5 m for boundary plantation or even less, are also used here.

In the **Sivasagar district**, the central agarwood harvesting regions are Aamguri, Borsila, Chamaguri, Dhupdhar, Jhanji, Namti and Simaluguri, where almost every household has agar plants in their private lands or gardens. Around 10,000 trees are located in Namti Chariali Kabarsthan (Graveyard). **At least 17.5 million agarwood plants** have been estimated in the Sivasagar district.

Agarwood plantations in Sivasagar district, Assam

Agarwood plantations in Sivasagar district, Assam

GBH classes: 36% of the total plants are found to be with GBH of <15 cm, 28% with 15–30 cm, around 24% are with 30–45 cm and about 12% with >45 cm. The spacing between the plants of the private plantations are about 1.5 × 1.5 m, though in some plantations, spacing between the trees is less than 1 m to accommodate more trees and to facilitate easy infection. Almost every plantation has natural infection, and in some cases the trees are found to be infected artificially. The Assam Forest Department has a plantation at Athkhel R.F., Kamlabari of Sivasagar district, which was done in 2008 in two parts, each of 1 ha area. It consists of around 1,550 and 714 of mature trees respectively grown in 2 × 2 m spacing. GBH classes: 23% of the total plants are with GBH of <15 cm, whereas about 27% with 15–30 cm, 39% with 30–45 cm and around 11% with GBH of >45 cm. However, the percentage of naturally infected plants (around 15%) is less in this plantation compared to other parts of the Sivasagar district. According to the local people, establishing a large unit by the Oil and Natural Gas Corporation Limited (ONGC) in the nearby area is responsible for environmental pollution, which causes a decrease in the agar borer *Neurozerra conferta*.

Around **15 million plants** are estimated in our survey within **Karimganj district**. In Kathaltali and adjoining areas, several small, medium and large-scale plantations are visited. In the plantation at Maa Durga Agarwood Industries, around 68,000 agar trees are currently surviving. The maximum number of plants are infected naturally from 2–3 years of age, and few are tried for artificial infection. GBH classes: 30% of the total plants are found to be with GBH of <15 cm, 45% with 15 –30 cm, 12% with 30–45 cm and 13% with >45 cm. In Marugaon, Balicherra, Balurbond, Kurti gaon, and Tilbhum villages, agar plants are found in almost every household. Together, these villages hold 2 million plants. GBH classes: 25% of the total plants are found to be with GBH of <15 cm, 55% with 15–30 cm, 12% with 30–45 cm and 8% with >45 cm. In almost every plantation, *c.* 60% of the plants are naturally infected, and the rest are being experimented with artificial infection. Around 35–40 oil distillation units are located here. In Patharia Reserve Forest under the Churaibari range, 10,000 agarwood trees are present in a scattered manner as well as in patch plantation. GBH classes: 10% of the total plants are with GBH of 15–30 cm, 70% with 30–

45 cm and 20% with >45 cm. Also, a home garden in Khoirong Khasi Punji village is visited where approximately 1,000 trees are found, among which 35% of the total trees are in GBH <15 cm and the rest of the trees are with GBH class 15–30 cm. In Khabol, Dolgram and Dhubri areas, several village plantations are visited, and agar plants are found in almost every household in their home gardens. Together, these villages hold around 1 crore agar plants. GBH classes: 20% of the total plants are found to be with GBH of <15 cm, 53% with GBH 15–30 cm, 15% with GBH 30–45 cm and 12% with >45 cm. Almost in every plantation, 60–65% are naturally infected, while the rest are tested for artificial infection. Several chipping units are present in those areas, and they finally sell them to Hojai. The Bilbari Dhubri Punji village has approximately 500 trees, in which tribal people are mainly growing betel plants on agarwood trees. GBH classes: 5% trees are with GBH of <15 cm, 15% with 15–30cm, 70% with30–45cm and 10% with>45 cm. In Lathirghat, Chandbari, and adjoining villages, several village plantations are visited, and the agar plants are found in almost every household in their home gardens. Together, these villages hold about 0.6 million trees. GBH classes: 21% of the total plants are found to be with GBH of <15 cm, 57% with 15–30 cm, 13% with 30–45 cm and 9% with GBH >45 cm. Almost in every plantation, 70% are naturally infected; the rest of them are tried for artificial infection. In Nayagram, under the Lowairpoa range, one large plantation is visited, and approximately 0.1 million plants are present there. The maximum number of plants are infected naturally from 2–3 years, and 30% of total plants are in harvestable age. Some trees are also artificially inoculated. GBH classes: 15% of the total plants are found to be with GBH of <15 cm, 40% with 15–30 cm, 40% with 30–45 cm and 5% with >45 cm. Seedlings are found growing naturally in abundance in the forest bed. Several small, medium, and large plantations are visited in Zerjheri, Solamona, Patiala, Dosdewa, Balia, Karimganj Bill and adjoining areas where around 1.7 million plants are present. 60–70% of plants are naturally infected here. GBH classes: 10% of the total plants are found to be with GBH class <15 cm, 40% with GBH 15–30 cm, 45% with GBH of 30–45 cm and 5% with GBH of >45 cm.

Agarwood plantations in Karimganj district, Assam

Agarwood plantations in Karimganj district, Assam

In Badshahi Tilla Reserve Forest 0.2 million plants are present in several small, medium, and large plantations. One large plantation in the same area with 50,000 trees is observed, among which more than 55% are in GBH class of >45 cm, and the rest are falls in GBH of 30–45 cm.

In Cachar district, at least 10 million plants have been estimated from different parts during the survey. Plantations are found mostly in Fulertal, Harinagar, Hmarkhawlien, Jirighat, Joypur, New Khairabad, Lalpani, Sachinpur in which Jirighat Harinagar, Hmarkhawlien, Fulertal and Joypur have maximum number of agar plants. These plants are found in almost every home-gardens with approximately 30% of the plants having natural infection. In Hazrat Peer Langar Shah Babar

Mukam in Fulertal, 20 agar trees (10–15 years old) are recorded with natural infections, among which two mature trees (30–35 years old) are observed to have GBH of 117 cm and 132 cm. All these trees are protected by the Langar authorities. In Jirighat, 10–12 large scale plantations (~ 20,000 plants) are found. Most of the plantations are 6–10 years old having natural as well as artificial infections. Only 2–3 plantations are found to be 3–5 years old. In New Khairabad and Lalpani regions, several small scale plantations (500–1,000 plants) are found. Majority of the plants (~70%) are having GBH of >45 cm and are artificially infected via physical injuries. In Sachinpur, a mixed plantation is visited where about 11,000 plants are estimated, among which around 750 trees are harvestable. GBH classes: 46% of the total plants are with GBH of <15 cm, 27% with 15 –30 cm, 23% with 30–45 cm and only 4% with >45 cm. As informed by the owner, very few trees (~11%) in this mixed plantation are recorded with natural infection. Apart from the mature trees, numerous seedlings, saplings and several 2–3 years old plants are also found to be growing naturally in this particular plantation. In the other surveyed regions of Cachar district *i.e.,* Kumachara, Labankhal, Chandrapur, Banskhandi and Sonai some small scale scattered plantations with 50–500 plants are found. Average age of these plantations is 10–12 years. Most of the plants are artificially infected with comparatively very less instances of natural infection are recorded GBH classes: 21% of the total trees in these small-scale plantations are found to be with GBH of <15 cm, 22% with 15–30 cm, 46% with 30–45 cm and 11% with >45 cm.

Agarwood plantations in Cachar district, Assam

At least 5 million plants are estimated during the entire field survey including home-gardens and tea estates of **Charaideo district**. Maximum plants are found in Mathurapur village and its adjoining area. Some plantations are also observed in Borbam, Charimuthia, Goriapothar, Lakhua, Pothaligarh, Neemnagar and Sonari. Large agarwood plantations are not observed in this district due to very low rates of natural infection. According to local people, one of the probable reasons behind this is the dry nature of the soils which is unsuitable for borer instects. However, in some areas of Mathurapur like Mathurapur Primary School the soil is black and wet. Therefore, some instances of natural infection is being recorded in this area. The spacing between the trees in the private plantations is about 1.5 × 1.5 m in these areas. However, in some plantations the spacing between the trees are less than 1 m, whereas in the tea estates, the trees are with spacing of about 10 m. GBH classes: 27% of the total plants are found to be with GBH of <15 cm, 27% with 15–30 cm, 32% with 30–45 cm and around 14% with >45 cm. Most of the trees are artificially infected. Although, in some plantations, some mature trees are also found to be infected naturally. The largest tree is about 35 years old with GBH of 131 cm.

In **Dibrugarh district,** around **4 million plants** are estimated from plantations located in Ouguri, Agunesua, Ketengibor, Tingkhong, Latuguri, Dillibari, Ratanpur, Tipomia, Borbam, Rongabam, Kenduguri, Ophulia, and Moran regions. In Jokai Reserve Forest, a 21 year old plantation of agar done by the Forest Department was found, from which around 120 mature trees are recorded. Several seedlings/ saplings are observed on the forest bed. GBH classes: 3% of total plants are with GBH of <15 cm, 15% with 15–30 cm, 75% with 30–45 cm and 7% with >45 cm. In Dibrugarh district, 35% of trees are artificially infected. Artificial infection methods are quite popular in this district which include physical injury such as 'Ghaap mara' (deep cuts by a 'dao'), 'Kil mara' (hammering nails in a definite pattern), 'Botali mara' (inserting wooden cylinders after creating holes on the trunk) and inoculation with fungal strains/chemicals.

Agarwood plantations in Charaideo district, Assam

Agarwood plantations in Charaideo district, Assam

Agarwood plantations in East Karbi Anglong district, Assam

Agarwood plantations in Dibrugarh district, Assam

About **0.2 million plants** are estimated in **Hojai district** including a few others grown in some of the households. There are 3 large plantations in Hojai which comes under the Ajmal group in Madartoli, Kurkut Basti and Jabrakhowa areas. GBH classes: 5% of the total plants are with GBH of <15 cm , 15% with 15–30 cm, 70% with 30–45 cm, and 10% with >45 cm. Natural infection in these plantations is found to be very less. In total *c.* 20% infected plants (natural + artificial) are observed in the district.

In **Nagaon district**, the main agarwood harvesting regions are Salbari, Haspani, Anjukpani and adjacent areas where the natural infection rate is about 35% among the mature plants. There are two big and few small scale plantations in the Salbari area. A good instance of an integrated model of cultivation and processing is seen in a 30-year-old plantation owned by Baksh Agrotech LLP which runs its own agarwood chips processing unit and distillation unit. In Anjukpani area agar plants are found in most of the home gardens. **At least 0.12 million** agarwood plants have been estimated in Nagaon district. GBH classes: 10% plants are with GBH of <15 cm, 35% with 15–30 cm, 40% with 30–45 cm and 15% with >45 cm.

The **Dima Hasao district** has large plantations along the hill slopes of Harangajaoin Buol Muol, Bara Mulkoi, Chota Mulkoi, Retzol which adds up to an estimation of around **0.1 million plants** from the district. GBH classes: 10% of the total plants are with GBH of <15 cm , 45% with 15–30 cm, 40% with 30–45 cm, and 5% with >45 cm. Natural infection is also seen to be persist which together forms 37% of the total population.


Agarwood plantations in Hojai district, Assam


Agarwood plantations in Nagaon district, Assam

Agarwood plantations in Nagaon district, Assam

At least 17,000 plants are found in **Hailakandi district**. Durgapur alone contributes in having more than 15,000 agar plants. This large scale plantation was done by the Ajmal Group in 700 bigha along with mahogany, rubber, sandal and teak trees. The spacing between the plants used here is about 1.5 × 1.5 m. However, in tea plantations the spacing between the plants is about 5 × 5 m where agar plants are used as shade trees. More than 65% plants are found with natural as well artificial infection and can be harvested after 1–1.5 years. GBH classes: 29% of the total plants are found to be with GBH of <15 cm, 28% with 15–30 cm, 24% with 30–45 cm, 12% with 45–60 cm, and 7% with >60 cm. Several trees are found with GBH of >100 cm. Plants with very high GBH *i.e.,* 172 cm tree is also found in Durgapur. Furthermore, the plantation has its own nursery which consists of around 2,000 agar saplings. In the Jalnacherra Grant Village, a total of 250 trees are found in home-plantations with approximately 15–20 years of age and GBH >45 cm. No natural infection is observed here and artificial inoculation is done before 5 years in 20 trees.

In Biswanath district, around **10,000 plants** are estimated growing mainly in the Borgang, Pabhoi, Sootea area. Scattered plantations are seen in households and tea gardens. Plantations with natural infections are rarely recorded in this district. Three small plantations are seen in Pabhoi as mixed cultivation with tea. GBH classes: 10% of the total plants are with GBH of <15 cm, 30% with 15–30 cm, 40% with 30–45 cm and 20% GBH >45 cm.

Agarwood plantations in Hailakandi district, Assam

Agarwood plantations in Biswanath district, Assam

At least 10,000 plants in total are estimated from **West Karbi Anglong district**. Few individual plants or very small groups are found in Hamren, Donkamukam and Kheroni area. Natural infection is rare in this district. No big plantation is observed in the district. Only one plantation is found with 500 plants in Kheroni area. Another comparatively small plantation is present in the DFO office campus at Hamren. Some small home-gardens of agar plants can be seen in this district. All the mature trees are found to be artificially inoculated. GBH classes: 5% of the total plants are with GBH of <15 cm, 20% with 15–30 cm, 45% with 30–45 cm and 30% with >45 cm. Here, some plants are also found with GBH of >100 cm.

In **Goalpara district**, **at least 6,000 agarwood plants** are found growing mainly in mixed plantations at Manikganj, Khamari, Salpara, Krishnai, Hathimura, Mehendipathar and adjoining villages. GBH classes: 15% plants are with GBH of <15 cm, 17% with 15–30 cm, 22% with 30–45 cm, 13% with 45–60 cm, 25% trees with 60–90 cm and 8% trees with 90–150 cm.

Around 5,000 agarwood plants are estimated from the **Udalguri district**, present mainly in Mazbat Rowta and adjoining area. Cultivators entirely depend on artificial inoculation, mainly done by the Z Black Diamond LLP in these areas. Further, instances of few medium sized plantations done by locals on an experimental basis are also recorded. GBH classes: 40% of the total plants are with GBH <15 cm, 30% with 15–30 cm, 20% with 30–45 cm and 10% with >45 cm. Around 40% of total plants are artificially infected.

Only about **3,000 plants** are recorded in **Tinsukia district,** with almost no instances of natural infection in them. These plants are mainly grown in home-gardens and small scale plantations located in Philobari, Rupai Siding, Kakojan (Dumduma) and Gondhoguri (Kakopather). GBH classes: 15% trees with GBH of 15–30 cm and 85% with 30–45 cm. Only around 5% of the trees have been experimented with artificial infection in the above regions.

Agarwood plantation (with tea) in Udalguri district, Assam

Agarwood plants in Majuli district, Assam

In **Dhemaji district, only around 1,000 plants** are estimated in total, growing mainly in the home gardens of Laimekuri, Jamjing and Dekapam areas. GBH classes: 33% are with GBH of <15 cm, 20% with 15–30 cm, 45% with 30–45 cm and 2% with >45 cm. As the instances of natural infection is rare in this district, the agarwood plantations are also very few in Dhemaji.

Situated quite close to Jorhat is the island district of **Majuli**. A very small number of about **200 plants** are found to be distributed in Garamur and Jengraimukh areas of this district. Only around 5% of total plants have GBH of 15–30 cm, while the remaining 95% has GBH of 30–45 cm. The plants in Majuli are devoid of any infection.

The total estimated number of cultivated agarwood plants in Assam during the present study is at least **114.37 million (highest in India),** which is much higher than the estimation (1.433 million) given in the report on 'Agarwood Resource in Non-Forest Areas of Assam and its Industry' by the Forest Department, Govt. of Assam and GICIA India Pvt. Ltd., Noida based on their study conducted from April 2017 to March 2018.

Name of the district	Estimated number of agarwood plants (>2 years of age/ >10 cm GBH)
Golaghat	45 million (4.5 crore)
Jorhat	20 million (2 crore)
Sivasagar	17.5 million (1.75 crore)
Karimganj	15 million (1.5 crore)
Cachar	10 million (1 crore)
Charaideo	5 million (50 lakh)
East Karbi Anglong	1 million (10 lakh)
Dibrugarh	0.4 million (4 lakh)
Hojai	0.2 million (2 lakh)
Nagaon	0. 12 million (1.2 lakh)
Dima Hasao	0.1 million (1 lakh)
Hailakandi	17 thousand
Biswanath	10 thousand
West Karbi Anglong	10 thousand
Goalpara	6 thousand
Udalguri	5 thousand
Tinsukia	3 thousand
Dhemaji	1 thousand
Majuli	2 hundred
Kamrup	2 hundred
Sonitpur	2 hundred
Total	**114.37 million (11.437 crore)**

Tripura: This state has the second highest number of cultivated agar plants in India. According to the data provided by the Tripura Forest Department, the state had 138,45,934 (~ 13.84 million) cultivated/planted agar plants, of which 82,05,567 (~ 8.2 million) plants are with age less than 3 years, and 56,40,367 (~ 5.64 million) plants are with age more than 3 years. Our field surveys in different districts of Tripura, almost supports the estimation provided by the Tripura Forest Department.

At least 10.6 million plants are estimated in **North Tripura** district. Almost every household has the agar plants in their private and home-gardens, especially in Kadamtala, Premtala, Alinagar, Palpara, Borgul, Lalcherra, Churaibari, Jayanand Dham, Uttar Fulbari, Madhya Fulbari, Paschim Fulbari, Julaibasa, Rowa, Panisagar, Ramnagar, Uttar Padmabil, Nabincherra and adjoining areas. On an average, 60% plants are found to be infected of which 50% of them are naturally infected. GBH classes: 30% of the total plants are with GBH of <15 cm, 50% with 15–30 cm, 12% with 30 –45 cm and 8% with >45 cm.

Around **4.5 million plants** are reported from **Unakoti district**, distributed in Kailashahar, Dhaliarkandi, Ejekhaora, Tilagaon, Rangauti, Khowrabil, Irani, Arabindanagar, Srinathpur, Pecharthal areas. Almost every household has agar plant in their private plantations and home-gardens in these areas. Apart from the above mentioned areas, several plants are also found in Kumarghat (~ 423 plants), East Raitwisa village (~ 50 plants), Kanchanbari, including Dudpur and Saidabari (~ 510 plants). The percentage of infection is almost same as that of North Tripura district. GBH classes: 28% plants are with GBH of <15 cm, 66% with 15–30 cm, 5% with 30–45 cm and 1% with GBH >45 cm.

Agarwood plantation in North Tripura district, Tripura

Agarwood plantations in North Tripura district, Tripura

Agarwood plantations in Unakoti district, Tripura

In **Khowai** district **at least 32,200 plants** are found during the field survey. Plants are mainly found in Birchandra, Thakurpara, Chhankhala, Purba Belchara, Biswanath Sippai Para, Ram Thakur Para, Jumia Bari, Gobinda Chow Para, Gagan Chow Para, Dafadhar bari, Ramkumar Chow Para, Tong Bari, and Hazaribari areas. About 17% plants are found to be infected and having GBH of 30–45 cm and the remaining trees are non-infected having GBH >45 cm. In Khasia Mongal Central Nursery, Teliamura subdivision, around 6,000 plants are found in a plantation. GBH classes: 19% of the total plants in this plantation are found to be with GBH of <15 cm, 4% with 15–30 cm, 15% with 30–45 cm and 62% with >45 cm. Numerous seedlings and saplings are also found growing naturally in the plantation. The percentage of infected plants is very less (~10%). In Rupachora area 150 trees are found having GBH of >45 cm. In Zion hills area c. 25,500 plants are found. GBH classes: 5% of the total plants are found to be with GBH of <15 cm, 30% with 15–30 cm, 20% with 30–45 cm and 45% with >45 cm. Numerous seedlings, saplings and young plants are also found growing naturally in the forest bed. Artificial infection is done in most of the mature plants. In Teliamura Range office, Gamaibari, around 55 trees are observed with GBH of >45 cm.

In **Dhalai district**, around **4,100 plants** are observed in cultivation during the survey in Manu, Chawmanu, Dhumachera, Karamcherra, Jambisora, Dhulocherra, Laldinga, Notunbajar, Kamalpur villages and nearby areas. In Dhulocherra and Laldinga areas, approximately 2,310 young plants of 2 –4 years of age are found. In Manu and Chowmanu around 300 trees are found with GBH of >45 cm. The natural infection rate is zero in this area. In Jambisora, one private plantation is found to have around 1,500 trees with GBH of >45 cm. The artificial infection was done about 2 years ago in that plantation. In Soronmonipara of Kamalpur, Durgachowmuhani, 4 mature trees are found with GBH of >45 cm.

Agarwood plantation in Khowai district, Tripura

An agarwood tree
in Dhalai district, Tripura

In **Sepahijala** district, **around 900** plants are found during the survey. In Sepahijala WLS, a forest plantation with *c.* 250 trees (GBH >45 cm) is also found. Several seedlings and young plants are also observed in the forest bed. In Sepahijala Zoological Park, one plantation consisting of around 380 plants are observed. GBH classes: 21% plants of that plantation are with GBH of <15 cm, 53% with 15–30 cm and 26% with >45 cm. In 'Agar Bon' (a plantation by the forest department), Sepahijala, total of 269 mature trees are found having GBH of >45 cm and with several naturally grown seedlings and young plants.

A total of **2,650 plants** are estimated from **West Tripura** district based on the present survey. In a research plot of Tripura Forest Department near Prakriti Bhawan, Agartala, West Tripura district, around 2,400 agar trees with >45, even several trees with GBH of >90 cm are found. Some of these trees are artificially infected by different inoculation agencies on trial basis. Experimental intercropping with 'Sugandhmantri' plants [*Homalomena aromatica* (Spreng.) Schott, Araceae] is also observed in the research plot. Another plantation at Biodiversity Park, Agartala, consisting of around 250 plants is also recorded.

'Agar Bon' - a plantation of *A. malaccensis* inside Sepahijala WLS, Tripura

A plantation of *A. malaccensis* inside the Sepahijala Zoological Park (under Sepahijala WLS), Tripura

A plantation of *A. malaccensis* near 'Prakriti Bhavan', Agartala, West Tripura district, Tripura

In **Gomati district, at least 14,553 plants** are found. In the experimental plot of Bagma Forest Beat office under Udaipur Range of Gomati district, around 2,500 agar plants are observed during the survey, among which 1,200 trees were artificially infected in 2022. GBH classes: about 30 plants (2%) are with GBH of 15–30 cm, 570 (21%) with 30–45 cm, 1900 (70%) with >45 cm, and 200 (7%) with >120 cm. In the adjoining villages approximately 500 plants are present in home-gardens along with rubber plantations. In Tepania Ecopark and adjoining area 15 trees are found with age 20 –25 years having GBH of >90 cm. The natural infection rate is very low. In a plantation of Forest Department around 10,000 agarwood plants are found. GBH classes: 3% plants are with GBH of <15 cm, 7% with 15–30 cm, 60% with 30–45 cm and 30% with>45 cm. Seedlings and young plants are found growing abundantly on the forest bed. Natural infection rate is low in this area. In Jatanbari area under Amarpur Range, one home-garden was visited where 52 plants, 7–8 years old, are found with GBH of 15–30 cm. Artificial inoculation was done in these plants just one year ago. In the adjoining area very few agar plants are observed due to the dominance of rubber plantation. One tree with GBH of 162 cm is found in Rangachara area. In 2022, a new plantation is established in Rangachara area with *c.* 4,000 plants. Under Ampi Range (Toidu area), around 1,500 mature trees 20–25 years old age are observed in a departmental plantation. Almost 90% trees in the plantation are with GBH of >45 cm and the rest are with 30–45 cm. Natural infection rate is observed to be low in this area.

In **South Tripura district, a total 4,450 plants** are estimated during the survey. In Sacchindragarupara under Rajapur area of South Tripura district, a home plantation was visited with about 100 agar trees of almost 25 years age. All the trees were artificially infected in 2021. In Birchandranagar, Birchandramanu and Rajapur villages around 1,000 agar plants are estimated, among which 100 trees are of 30 years age and with GBH of >45 cm; the largest GBH recorded in this area is 172 cm. Artificial inoculation is recorded in 60 trees which was done in 2021. In the Bagafa Ecopark (Santibazar area) around 100 trees with GBH of >90 cm are observed. Natural infection rate is low. In Trishna Wildlife sanctuary, under Joychandrapur range, a plantation done by the Forest Department is recorded to have about 1,350 agar trees of 30 years age with GBH of >100 cm. The rate of natural infection is good in this plantation. Another experimental plot of 2 ha area in Rajnagar Wildlife Range is visited where 2,000 agar plants of 5–6 years of age are found with GBH of 15–30 cm. As per the present estimation, Tripura has at least **15 million agar** plants in plantation.

Agarwood plantation in Gomati district, Tripura

Agarwood plantation in South Tripura district, Tripura

Name of district	Estimated number of agarwood plants (>2 years of age/ >10 cm GBH)
North Tripura	10.6 million (1.06 crore)
Unakoti	4.5 million (45 lakh)
Khowai	32,200
Dhalai	4,144
West Tripura	2,650
Sepahijala	900
Gomati	14,553
South Tripura	4,450
Total	**15.15 million (1.515 crore)**

Manipur: Manipur is one of the most agarwood-cultivating states of Northeast India after Assam and Tripura. The tropical climate in the districts situated on the western sides of the state (Barak basin) is suitable for agarwood cultivation compared to the subtropical climate in the eastern districts. The agarwood plantations are mostly found in the Jiribam district of Manipur, which is the bordering district of Assam. Both large-scale (>5,000 trees) and small-scale (50–500) plantations are found throughout the villages of the Jiribam district, such as Kashimpur, Sonapur, Lalpani, Jairalpokpi, Mullargao, Uchathol, Babupara, Islamabad, Mongbung, etc. Small-scale agarwood cultivations are also found in Bishnupur, Churachandpur, Pherzawl, and Tamenglong districts. One advantage of agarwood cultivation in Manipur is the high natural infection rate. The natural infection rate is about 50% in Jiribam, Bishnupur, and Churachandpur, 40% in Pherzawl, and 15–20% in Tamenglong district. Natural infections is seen to start in young plants (2–3 years old) with GBH of 15 cm. Apart from natural infection, some artificial inoculation methods are also practiced.

A total of **32,20,000 (3.2 million)** plants are estimated from the state. GBH classes: ~7,90,000 (24.53%) plants are below 15 cm GBH, 4,25,000 (13.19%) plants are with GBH of 15–30 cm, 4,40,000 (13.66%) are with GBH of 30–45 cm, and 15,65,000 (48.60%) plants are above 45 cm GBH. Out of 32,20,000, about 15,60,000 (48.44%) plants could be infected, and 16,60,000 (51.55%) are non-infected. However, the infected harvestable trees are around 10–20% of the total infected trees.

A large plantation of *A. malaccensis* in Jiribam district, Manipur

Agarwood plantations in Jiribam district, Manipur

Agarwood plantations in Tamenglong district, Manipur

Nagaland: According to the survey, the plantations of *A. malaccensis* are found in Dimapur, Longleng, Mokokchung, Mon, Peren, and Wokha districts. **Around 1.2 million** plants are estimated from **Mokokchung district**. Large scale (>5,000 plants) and small scale (50–500 plants) plantations are found throughout the villages of Mokokchung district such as Tulikong, Longkong, Aitlanten, Merangkong, Luyong under Tuli range, Longtho range, Longchem, Mangkolemba beat, Changtongya beat, Changchang beat under Longchem range, Longti, Medemyim, Chungtiayimsen, Longphayimsem and adjoining villages. In Merangkong village, one household plantation is recorded to have about 5,000 plants. GBH classes: 24% are with GBH of <15 cm, 36% with 15–30 cm, 40% with 30–45 cm. The infection rate is good, and it starts from 3–4 years old plants. Several such small-scale plantations are observed in the entire village and approximately in all household agar plants are grown in their backyards. Approximately 0.4 million plants are estimated in Luyong village. GBH classes: 20% of are with GBH of <15 cm, 10% with 15–30 cm, 65% with 30–45 cm and 5% with >45 cm. The infection rate is very high starting from 3–4 years. In total, around 0.4 million plants are estimated from medium to large sized household plantations in Tulikong, Longkong, Aitlanten and adjoining areas under Tuli ward. GBH classes: 18% of the plants are with GBH of <15 cm, 12% with 15–30 cm, 69% with 30–45 cm and the remaining 1% are with GBH of >45 cm. The rate of infection is observed to be approximately 60%. Massive plantations have been started since 2010 to 2012 in this area. According to the locals, due to the close spacing of the plants, the average height of the plants is higher in comparison to other regions of the state.

Around **30,000 plants** are found in **Longleng district**. One plantation is found in Tamlu village with *c.* 5,500 plants. GBH classes: 36% of these are with GBH of <15 cm, 27% with 15–30 cm, 22% with GBH 30–45 cm and 15% with >45 cm. The mortality rate is about 30% due to leaf wilting.

Around **0.3 million agarwood plants** are estimated from the **Dimapur district,** mainly in Aoyimkum, Indisen, Chekiya, Hovukhu, Niuland and adjoining areas. In one home plantations at Aoyimkum village. Around 300 mature trees with 72–95 cm GBH are found. All these trees are reported to be artificially inoculated 7–8 months ago using the techniques adopted from Indonesia. Total 5,000 plants are present in Auyinkom and Indisen but artificial infection has hardly been done here. In another home plantation at Chekiye, around 250 mature agarwood trees have been observed which was reported to be planted in 1996 and 50 trees are artificially inoculated 8 months ago. Most of the plants are with GBH of >45 cm, whereas only about15 plants are with GBH ranging from 15–30 cm. In Hovukhu village, around 500 non-infected mature agar trees are found along with tea plantation which are of GBH of >45 cm. In Niuland and adjoining areas around 7000 plants are present in home-gardens. Natural infection is not observed here. In Nikhukhu,

about 5,000 non-infected agar plants are observed in a single plantation. GBH classes: 40 plants are with GBH ranging from 15–30 cm, 260 trees with 30–45 cm and 4,700 trees with >45 cm.

A total **0.15 million** agar plants are estimated from New Beisumpui, Ikiesingram, Nsenlwa villages and adjoining areas of **Peren** district. GBH classes: 15% of the total plants are with GBH of <15 cm, 10% with 15–30 cm, 20% a with 30–45 cm, 55% with >45 cm. The natural infection rate is 30% and rest of the trees are under trial for artificial infection. It is reported that prior to the establishment of these villages in 1971, naturally growing agar plants were present in huge numbers. In 1990s the traders from Assam started coming here in search of agarwood and that is when villagers started to know about the economic value of the plant and started plantation. In the adjoining villages of Ntangki National Park around 2,500 plants are found. GBH classes: 5% of the total plants are with GBH of <15 cm, 25% with 15–30 cm, 65% with 30–45 cm and 5% with >45 cm.

Agarwood plantations in Mokokchung district, Nagaland

Agarwood plantations in Dimapur district, Nagaland

Agarwood plantations in Peren district, Nagaland

Around **0.2 million plants** are documented in cultivation during random survey in Upper Baghty, Lower Baghty villages and nearby areas of **Wokha district**. In Lower Baghty area total 50,000 plants are found in a scattered manner in almost every household. As per local sources the plantations were started vigorously around 5 to 7 years ago. Around, 25% of existing agar plants are 20–23 years of age and having GBH of 30–45 cm. The remaining plants are 7–8 years of age with GBH of 15–30 cm. The infection rate is moderate here. A private plantation in Upper Baghty area is recorded to have around 40,000 plants present in pure as well as mixed plantation with rubber and tea. GBH classes: 10% of plants are with GBH of <15 cm, 20% with 15–30 cm, 55% are with 30–45 cm and 15% are with GBH of >45 cm. Natural infection rate is moderate and artificial inoculation is being done using drilling and dripping injection method by the farmer himself. Another plantation in this area found to have about 300 agar plants and are with GBH of <15 cm.

A total **0.4 million** agar plants are estimated from **Mon district** distributed in Oting, Hothati, Upper Tiru, Lower Tiru, Kongan, Namthai, Wapnyo village in Nagini Mora range, Lapa Lampong villages in Tizit range and Namsa range and adjoining areas. Total of 4,050 plants are recorded I road-side plantations and home gardens at Lower Tiru village. GBH classes: 62% of the total plants are with GBH of <15 cm, 25% with 15–30 cm, 10% with 30–45 cm and 3% with GBH of >45 cm. In Nagini Mora range, around 2 lakh agar plants are found with GBH classes: 15% are with GBH of <15 cm, 35% with 15–30 cm, 45% with 30–45 cm and 5% plants with >45cm. Natural infection rate is low and, in many cases artificial inoculation is being done. Several medium sized mixed plantations (~ 1 lakh) with rubber and tea are seen in Lapa Lampong village under Tizit range are GBH classes: 10% plants are with GBH of <15 cm, 35% with GBH 15–30 cm, 50% with 30–45 cm GBH and 5% with GBH of >45 cm.

In total at least 2.28 million cultivated plants are estimated during the present study . The number may even raise if a thorough survey in all the districts would be conducted.

Agarwood plantations in Wokha district, Nagaland

Agarwood plantations in Mon district, Nagaland

Karnataka: Agarwood plantations in Karnataka state were reported to be initiated by Vanadurgi Agarwood India Limited in 2006. It is a private sector agriculture-based corporate company that researched the prerequisites of agarwood cultivation and introduced the plants to Karnataka. Since 2007, the Vanadurgi have planted 2.4 million saplings in their estates and other agricultural lands by coordinating around 8,376 farmers. The plantations are found mainly in 7 districts *viz.* Chikkmagaluru, Kodagu, Dakshina Kannada, Hassan, Uttara Kannada, Shivamogga, and Udupi. All these lies in the Western Ghats and nearby areas. Out of the 24,88,275 plants, 10,69,253 (42.97%) are grown-up plants with a GBH of >45 cm. The plants are usually infected at this stage by Vanadurgi. However, inoculation has been done only in 67,030 plants (2.69% of total plants and 6.26% of mature trees) in the last three years.

Mixed plantation of Agarwood (with *Coffea arabica*) in Chikkmagaluru, district, Karnataka

Mixed plantation of Agarwood (with *Areca catechu*) in Chikkmagaluru, district, Karnataka

Mixed plantation of Agarwood (with *Hevea brasiliensis*) in Shivamogga district, Karnataka

Mixed plantation of Agarwood (with *Piper nigrum*) in Hassan, district, Karnataka

Mixed plantation of Agarwood (with *Cocos nucifera*) in Uttara Kannada district, Karnataka

District	No. of farmers	Area (hectare)	No. of plants	Trees with GBH>45cm	No. of trees inoculated
Chikkmagaluru	2,057	996	6,44,926	2,77,266	13,635
Kodagu	826	444	2,87,874	97,117	4,690
Dakshina Kannada	899	382	2,47,896	1,17,973	11,945
Hassan	889	545	3,53,444	1,69,663	6,740
Uttara Kannada	1,232	518	2,96,810	1,44,681	10,040
Shivamogga	2,096	845	5,49,028	2,18,385	15,715
Udupi	184	98	53,628	25,339	3,825
Other districts	193	82	54,669	18,829	2,200
Total	**8,376**	**3,910**	**24,88,275**	**10,69,253**	**67,030**

Andhra Pradesh: Agarwood plantations are mainly found in the districts of East Godavari, West Godavari, and Krishna. Several large-scale (>5,000 plants) and small-scale (50–500) plantations are present in Rajahmundry, Kadiam, Kolamuru and adjoining areas of East Godavari district, Makkinavarigudem, Nimmalagudem, Asannagudem and adjoining area of West Godavari district,

Vijayawada and adjoining area of Krishna district, Dwaraka Tirumala of Eluru district, Kuchipudi of Guntur district, Dwarapudi, Vermulapalle, Seetayyapalem of Konaseema district and Araku Valley of Visakhapatnam district. The average age of the cultivated plants is 6–8 years. Natural infection is not reported, but in some of the plantations, artificial inoculation has been done very recently on a trial basis. Inoculation is done only in 0.2% plants (~ 2,000) of total plants in the last two years. Most of the plantations are mixed *i.e.*, agar plants are cultivated along with the *Areca catechu* L. and *Cocos nucifera* L. A total of **around 1 million** plants of *A. malaccensis* are estimated from the state. GBH classes: 48% (~ 4,80,000 plants) are with GBH of <15 cm, 43% (~ 4,30,000) with 15–30 cm GBH and 9% (~ 90,000) with 30–45 cm.

Maharashtra: *A. malaccensis* is cultivated in various parts of the state, including Ratnagiri, Konkan, Raigad, Zapade, and Lanja. The Trupti Herbal Agro & Biotechnology Pvt. Ltd., Pune started plantation of agarwood in 2021. The company planted around **0.3 million** saplings of agarwood in Maharashtra.

Kerala: Agarwood was introduced in Kerala 40–50 years ago. It is reported that Christian priests or people who worked in Northeast India brought the plants from Assam and planted in their home gardens. Large plants (>30 years of age) are found in the home-gardens of many persons in Kannur, Idukki, Kottayam, Trivandrum districts, etc. The large-scale plantations in Kerala were reported to be started in 2007 by AWK Research India Pvt. Ltd., Kuttipuram. Currently, the agarwood plantations, inoculation, and harvesting in Kerala are done by different associations/ organizations such as KAFAI (Kerala Agarwood Farmers Association of India and Producer Company), KAFA (Kairali Agarwood Farmers Association), and APRC (Aquilaria Plantations and Research Centre) India. Presently, agarwood is cultivated in all the districts of Kerala except Alappuzha. However, the cultivation is scattered and detailed data on agarwood farmers and plantations are not available in Kerala as in the case of Karnataka.

During the present study, four districts, *viz.* Trivandrum, Palakkad, Kollam and Kottayam are visited. A total of around **93,450 plants** of *A. malaccensis* (Trivandrum: 77,400; Palakkad: 12,080; Kollam: 2,030; Kottayam: 1,940) are recorded during random survey, out of which 5.92% (*c.* 5,540) are grown-up plants with a GBH of >45 cm. Inoculation has been done only in 19 trees (0.02% of total plants and 0.34% of mature trees) in the last three years. The survey shows that most of the plantations have been built over the previous 2–3 years. The percentage of mature trees and inoculated trees is meagre compared to the Karnataka state.

The agarwood plantation data are also collected from officials of the major associations. The data showed that there are about **1 million (10 lakh)** plants present in Kerala, out of which around 10,000 (1%) are grown-up plants with a GBH of >45 cm. Inoculation is done only in 250 trees (0.025% of total plants and 2.5% of mature/ harvestable trees) in the last three years.


Agarwood plantations in Trivandrum district, Kerala

Agarwood plantation in Palakkad district, Kerala

Agarwood plantation in Kottyam district, Kerala

Meghalaya: At least **0.172 million** cultivated plants are located in different districts (Ri Bhoi, East Khasi Hills, South-west Khasi Hills, East Garo Hills, West Garo Hills, South Garo Hills, South-west Garo Hills, and North Garo Hills) of Meghalaya. The highest number of plants is found in Ranikor and adjoining villages of south-west Khasi Hills (~85,500); GBH classes: 6% with GBH of <15 cm, 35% with 15–30 cm, 41% with 30–45 cm and 18% with >45 cm), followed by Baghmara of South Garo Hills (~70,000; GBH classes: 10% with GBH of <15 cm, 30% with 15–30 cm, 40% with 30–45 cm and 20% with >45 cm), Ampati of south-west Garo Hills (~ 8,900; GBH classes: 9% with GBH of <15 cm, 25% with 15–30 cm, 30% with 30–45 cm and 36% with >45 cm), Resubelpara of North Garo Hills (~ 6,150; GBH classes: 8% with GBH of <15 cm, 24% with 15–30 cm, 33% with 30–45 cm and 35% with >45 cm) and William Nagar of East Garo Hills (~1,300; GBH classes: 15% with GBH of <15 cm, 23% with 15–30 cm , 24% with 30–45 cm and 38% with >45 cm). About 60% of the total estimated plants are infected (naturally plus artificially). Overall, the natural infection rate is very low in Meghalaya and about 15% of total infected plants are found with natural infection, the rest are artificially infected.

Mizoram: Several small-scale (50–500 plants) plantations are found in the Sairang range, Shiphir (Aizawl district) and some large-scale (>4,000 plants) plantations are found in Borapansury (Zeuzera Aloe International Company) in Lawngtlai district and Ratu village (private plantations) in Aizawl district. In Dilkhan Ram near Tamdil Lake, three mature trees are found with natural infection. The natural infection is about 23% in Lawngtlai and 12% in Aizawl district. A total of

around **10,000** plants are estimated. GBH classes: 27% plants are with GBH of <15 cm, 33% with 15–30 cm, 28% with 30–45 cm and 12% with >45 cm. Mizoram may have more plants, but the survey could not be done extensively in this state due to some limitations.

Agarwood plants in
South-west Khasi Hills district, Meghalaya

Agarwood plants in
East Garo Hills district, Meghalaya

Agarwood plants in Mizoram

Arunachal Pradesh: Both large-scale (>5,000 plants) and small-scale (50–500 plants) plantations are reported from Pioing circle, Mounglang and Lathao of Namsai District, Bolik near Roing, Lower Dibang valley district, Ngorlung near Ruksin, Borguli and adjoining areas of East Siang district. The natural infection is found to be around 12% in Bolik (near Roing) and 7% in Ngorlung. Natural infection is observed from plants of 3–4 years onwards. Apart from the natural infection, artificial inoculation methods are also applied to some trees. In Payagam, only four large trees are found in a home garden. Around **25,000 plants** are estimated from the state. GBH classes: around 17% of plants are with GBH of <15 cm, 32% with 15–30 cm, 45% e with 30–45 cm, and 6% with >45 cm. In Bolik, a single tree with a GBH of 132 cm was found in a home plantation.

Telangana: The agarwood plantations are mainly found in the districts of Mahabubnagar and Suryapeta. In Mahabubnagar, several private plantations are reported, but only one large agarwood plantation is found at Chinnadarpally. The plantation in Chinnadarpally is reported to be done in 2018 with *c.* 10,000 saplings; presently, *c.* 8,000 non-infected plants are found surviving here. In the

Suryapeta District, large and some small-scale plantations are found in the Kethipally area, having *c.* 10,000 plants. In Khammam District, some small-scale plantations are found in Sathupalli, Nagupalli, and adjoining areas with *c.* 2,000 plants. The average age of the cultivated plants is recorded to be 5–7 years. Most of the plantations face high mortality rates due to dry soil, moist weather, and high temperatures. In some plantations in Suryapeta and Khammam, artificial inoculation is done in about 7% of plants in 2022. A total of *c.* **20,000 plants** is estimated in the state. In which 65% (~13,000) plants are with GBH of <15 cm and remaining 35% (~7,000) with GBH of 15–30 cm and only 7% (~1,400) plants are found infected by artificial methods. Saplings/ seedlings of these plantations are mostly imported from Assam by some private companies.

Agarwood plantations in Lower Dibang Valley district, Arunachal Pradesh

Agarwood plantation in East Siang district, Arunachal Pradesh

Telangana: The agarwood plantations are mainly found in the districts of Mahabubnagar and Suryapeta. In Mahabubnagar, several private plantations are reported, but only one large agarwood plantation is found at Chinnadarpally. The plantation in Chinnadarpally is reported to be done in 2018 with *c.* 10,000 saplings; presently, *c.* 8,000 non-infected plants are found surviving here. In the Suryapeta District, large and some small-scale plantations are found in the Kethipally area, having *c.* 10,000 plants. In Khammam District, some small-scale plantations are found in Sathupalli, Nagupalli, and adjoining areas with *c.* 2,000 plants. The average age of the cultivated plants is recorded to be 5–7 years. Most of the plantations face high mortality rates due to dry soil, moist weather, and high temperatures. In some plantations in Suryapeta and Khammam, artificial inoculation is done in about 7% of plants in 2022. A total of *c.* **20,000 plants** is estimated in the state. In which 65% (~13,000) plants are with GBH of <15 cm and remaining 35% (~7,000) with GBH of 15–30 cm and only 7% (~1,400) plants are found infected by artificial methods. Saplings/ seedlings of these plantations are mostly imported from Assam by some private companies.

Agarwood plantation in Mahabubnagar district, Telangana

Tamil Nadu: It has been reported that the Agarwood Neyveli plantation started cultivating *A. malaccensis* in Tamil Nadu during 2009–2010. About **10,000** plants are planted in nearby places of Neyveli by involving many farmers. Around 800 trees are artificially inoculated after 9–10 years of planting. The SMARD foundation, Coonoor, also initiated agarwood cultivation in Tamil Nadu. They have funded a research grant to the Forest College and Research Institute (FC & RI), Mettupalayam for initiating research on the topic entitled 'Screening and Evaluation of Agarwood (*Aquilaria* spp.) in Tamil Nadu for Agar Production' in 2011. At present, the foundation is inactive due to challenges in agarwood plantations. The total number of estimated plants in Tamil Nadu will increase since some small-scale plantations are reported to be present.

West Bengal: Based on the survey, the state has *c.* **5,500** plants (>3–4 years of age) mainly in the northern districts, *viz.* Alipurduar, Darjeeling, Jalpaiguri and Kalimpong. The Forest Department of West Bengal has three plantations in North Bengal: one under the Silviculture (Hills) Division at Chhota Adalpur, Sukna Range, Kurseong subdivision of Darjeeling district, and two under the Silviculture (North) Division at Jalpaiguri Research Range, Lataguri, Lataguri (L1) Block, Jalpaiguri district and at Rajabhatkhawa, Buxa, Coochbehar Research Range, Alipurduar district. The plantation at Chhota Adalpur consists of 1 ha area with around 800 non-infected plants of *A. malaccensis*. The plantation is reported to be done in 2009 with a spacing of 2.5 × 2.5 m. GBH classes: 14% of plants are with GBH of up to 45 cm, 80% with 45–95 cm and 6% of 96–145 cm. The plantation at Lataguri was also done in 2009 with a spacing of 2.5 × 2.5 m in 1 ha of 1,600 seedlings. The seedlings are sourced from Jorhat, Assam and the plantation is divided into Patch A (0.75 ha for artificial infection/ inoculation) and Patch B (0.25 ha for normal growing). At present there are 556 and 111 trees at Patch A and B respectively. The infected plants show stunted growth compared to the non-infected ones. GBH classes: 15% plants are with GBH of 45–95 cm, 55% with 95–145 cm and 30% with >145 cm. In the Patch A, artificial infection was done in 103 trees in 2020 and then again 250 trees in 2022. Another plantation at Rajabhatkhawa was done by the Forest Department in 2011 in 1 ha area with 1,100 seedlings having a spacing of 3 × 3 m. Around 320 plants are currently surviving. The infection was done in 50 trees in 2020 and in 270 trees in 2022. GBH classes: 30% of plants have a GBH of 45–95 cm, 54% have 95–145 cm, and 16% have a GBH of >145 cm. Under the Directorate of Cinchona and other Medicinal Plants (DCOMP), a total of 1,150 (468+500+182) saplings are reported to be planted in 2019, 2022, and 2023 at Raniban Khasmal, Naya Kaman, Rangpo Forest, Kalimpong and surrounding regions. During 2020 and 2022, seedlings of *A. malaccensis* were planted along the roadside in the land of DCOMP, from Kumai Forest to Bindu. Six plants are found along the roadside in Kumai Forest from Kumai to Gairibas. During the 2020–2021, 202 seedlings are planted by DCOMP near the Gairibas viewpoint. DCOMP planted 300 saplings in 2019 at Rowneydara Ribong Nursery in Mungpoo, Kalimpong. Apart from these, 4 mature, naturally infected trees with GBH ranging from 60–90 cm are also found in this nursery. About 135 saplings are found growing (intercropping with orange and cinchona trees) in Latpanchar of Darjeeling district in the land of DCOMP. One mature, naturally infected tree with 57 cm GBH is also located in a private land in Latpanchar. In the Git Dubbling Khasmahal, Kalimpong II CD block, 500 mature, non-infected trees with GBH ranging from 50–70 cm are also found. At Dabaipani village in Lingsay, Kalimpong, *c.* 500 mature, artificially inoculated trees of GBH range of 45–90 cm are found. The farmer planted the agar plants in 2003, 2004, 2007, and 2010 after purchasing seedlings from local merchants. In the Devithan area of Darjeeling district, *c.* 650 saplings were planted in 2019, and *c.* 782 saplings were grown in the 18 Block area of Reshep in the same year.

Agarwood plantation in Alipurduar district, West Bengal

Agarwood plantation in Jalpaiguri district, West Bengal

Agarwood plantation in Darjeeling district, West Bengal

Agarwood plantation in Darjeeling district, West Bengal

Agarwood plantation in Kalimpong district, West Bengal

Agarwood plantation in Kalimpong district, West Bengal

Odisha: As per the reports the Agarwood Agro Company has recently started agarwood cultivation in the Nabarangpur district of Odisha. There were 4,000 to 5,000 saplings on their plantation in 2022.

Goa: The Valkini Nursery is reported to have a plantation in Sanguem with 481 non-infected trees (479 plants with GBH of up to 45 cm and two plants with GBH of 46–95 cm).

Sikkim: The state is represented by a minimal number of agarwood plants. In Toribari village of East district, 8 mature, naturally infected plants are located with a GBH range of 45–90 cm. Plants of *A. malaccensis* are also found growing in the campus of Bagey Salingay Social Forestry Nursery (8 trees), Bagey Khola Territorial Nursery (10 plants) in East district, Bhari Khola Social Forestry Nursery (5 plants), Mamring NTFP Nursery (5 plants) in South district, and Sipsu Nursery (5 plants) in West district.

Uttarakhand: The Lalkuan nursery area of Nainital district has 155 agarwood trees with GBH of 30–45 cm. The other plantation is in Kalsi (Reevar Range, Chakrata Forest Division), Dehradun district having 48 non-infected plants with GBH class 30–45 cm. This data is provided by the Haldwani Forest Circle (Research) of Uttarakhand State Forest Department.

Uttar Pradesh: According to the report provided from the Indian Council of Forestry Research and Education-Eco-Rehabilitation Centre (ICFRE-ERC), Prayagraj, has recently started experimental plantation trials in the Lakhimpur Kheri and Bahraich districts under a research project entitled 'Introduction of *Aquilaria malaccensis (*Agar) in the Terai Region of Uttar Pradesh' which is funded by ICFRE.

The remaining states with instances of initial and experimental phases of agarwood cultivation have been mentioned here based on the data collected from different direct/ indirect authentic sources and reports.

Mr Girendra Sharma of Dihri Village (Patna district) in **Bihar** has started agarwood cultivation on his private land in May 2023. He procured 100 seedlings from Tripura through Z Black Diamond's Faridabad Office. Currently, 50–60 small plants are surviving in his farm. Agarwood plants are also growing in Ras farm of Raipur city in **Chhattisgarh**. Here, agarwood is planted with calendula, rosemary, aloe vera, moringa, peppermint, patchouli, chrysanthemum, mango, banana, lemon, sandalwood, and pomegranate trees. In the Navasari district in **Gujarat**, the Awk Research India Pvt. Ltd. successfully planted agarwood from 2016 to 2017. The **Punjab** Forest Department is presently conducting scientific trials to evaluate the durability of agarwood trees in the soil.

In 2016, the estimated number of agarwood trees in plantations in India was 10 million (UNODC, 2016). The estimated number of trees was about 15 million in the previous NDFs on *A. malaccensis,* which is very low. It was also mentioned that the Scientific Authority (RFRI) could do the physical surveys only in limited areas of Assam and Tripura to estimate the growing stock and regeneration

status due to travel restrictions imposed during the COVID-19 pandemic. For all the other cultivation areas, data were collected with the assistance of the various associations of planters and traders, Forest Departments, and research organizations (RFRI, 2021). It was also mentioned that the major areas of cultivation could be covered by the collection of statistics. However, particular areas with limited cultivation were not included due to poor response from the concerned departments and associations (RFRI, 2021).

The present study estimates not less than **139.89 million (13.989 crore)** plants of *A. malaccensis* in India, which is primarily based on field surveys in almost all the states (Andhra Pradesh, Arunachal Pradesh, Assam, Karnataka, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Telangana, Tripura, and West Bengal) from where the species is known to occur either in wild or in cultivation. As there are very few reported representations of this species in Bihar, Chhattisgarh, Goa, Gujarat, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, and Uttar Pradesh, and the plantations are new without any harvestable trees), no field surveys are conducted in these non-harvesting states. However, the relevant data have been incorporated in the report either according to the data provided by the State Forest Departments of the respective states or based on some other authentic sources.

5. Habitat specificity and vulnerability

Risk severity: **Medium**

The species grows naturally in locations having elevation ranging from 90–1,675 m with an average daily temperature of 20–22°C, a mean annual minimum temperature of 14–21°C and a mean annual rainfall of 1,500–6,500 mm. However, it is adaptable to growing in high rainfall areas, *i.e.,* outside its natural range of occurrence. Hence, the habitat of the species is not very specific, and the species is not vulnerable.

6. Regeneration

Risk severity: **Low**

The species show good resilience in terms of its regeneration *i.e.* the (re-) sprouting capability in form of coppice after harvesting. Profuse regeneration through coppice is frequently seen in cultivated population of *A. malaccensis* even outside the natural range which indicates the adaptive potential of this species. According to a recent study carried out in Northeast India by Nath & al. (2023), the monoculture stands aged more than 20 years with stem girth (1.37 m above ground) of 60–70 cm had the highest growth increment of 3.73 cm yr^{-1}. Further, the monoculture stands (>10 years old) were also recorded with higher number of coppicing stocks than polyculture stands. The highest coppice growth increment (4.07 cm yr^{-1}) was recorded in the 70–80 cm stem girth in monoculture stands. Therefore, coppicing has been suggested as the promising method to conserve the species while also meeting the economic needs.

Regeneration through coppice

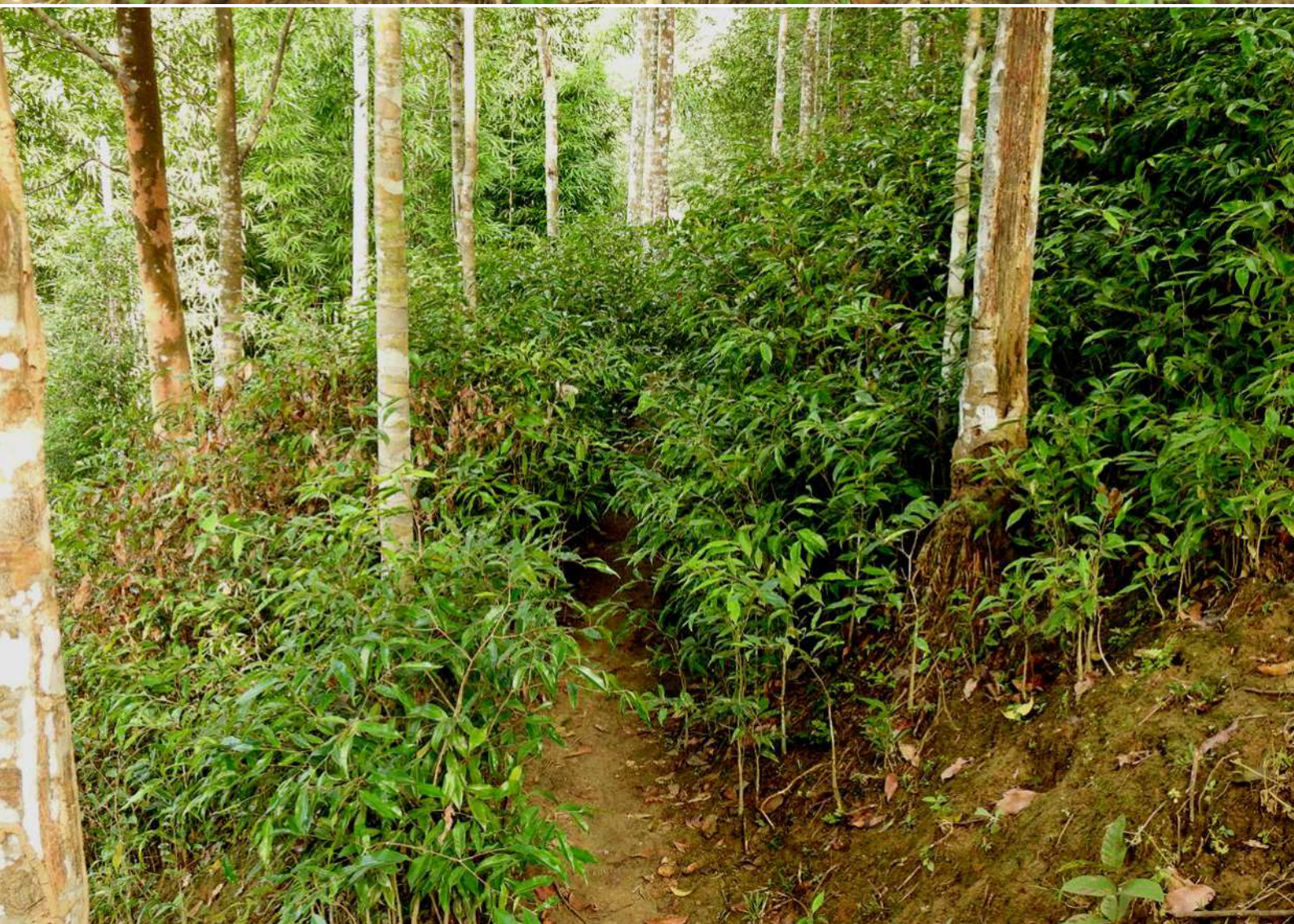
Utilization of regenerated coppice

7. Reproduction

Risk severity: **Medium**

This factor addresses the recovery capacity of the harvested population *i.e.*, the ability of the remaining plants to rebuild the population or to repopulate areas where individuals or sub-populations have been removed (Wolf & al., 2016). Since, *A. malaccensis* reproduces sexually (monoecious) and it has common pollinators, seed production is quite good (up to 19,000 seeds/ tree per season) (RFRI, 2021).

Widespread seed dispersal in not observed in *A. malaccensis* and majority of the seeds germinate in close proximity to the mother plant, as it does not involve any kind of abiotic and biotic agents. However, case of specialized seed dispersal mechanism through yellow banded wasp (*Vespa affinis* L.) has also been reported in the species (Manohara, 2013). Viability of the seeds is short (6-10 days) and the germination rate is very slow. Less tolerance to high irradiance, root competition due to overcrowding and susceptibility to pest, and fungal diseases have been reported in seedlings. All these biological risk factors result in low to moderate seedling growth and survival in natural condition. However, the survival rate of seedlings in nurseries/ plantations is higher due to the application of various preventive measures and practices against these potential risks.



8. Role of the species in its ecosystem

Risk severity: **Low**

Aquilaria malaccensis is not a keystone species. However, it is one of the host species of the insect pest *Neurozerra conferta* which completes the larval and pupal stages of its life-cycle in plants of this species. Since the insect is not exclusively dependent on *A. malaccensis*, and has alternative hosts (polyphagous) (Chi & al., 2022), this insect has a low survival risk due to the sustainable harvest of *A. malaccensis* from cultivation. The role of *A. malaccensis* in any other ecological functions of its ecosystem is still unknown.

STEP 6: EVALUATION OF IMPACTS OF HARVEST OF PLANTS IN WILD AND CULTIVATION

6. Considering the impacts of harvest, is the severity of harvest impact on individual plants, target populations, the national population, and on other species "Low", "Medium", "High", or "Unknown"?

1. Impact of harvest on individual plants for the exports requested

Harvest impact severity: **High**

The impact of harvest on individual plants is high as the entire plant is removed for the purpose of trade, and therefore, the harvest is fatal for the individual plants.

2. Impact of harvest on target populations for the exports requested

Harvest impact severity: **Low**

Harvesting and exporting are banned from the wild populations.

The harvesting and exporting are being done at present only from the cultivated population. As the species is under extensive cultivation in the major harvesting states (target populations) in India, the harvest impact severity on target populations for the exports requested is low.

3. Impact of harvest on national population for the exports requested

Harvest impact severity: **High for wild populations.**

The harvesting and exporting are presently not done from the wild populations in India due to the unavailability of plants in the wild except in some Protected Areas, Reserve Forests and in a few remote locations of non-forest areas. However, the wild populations of the species were highly depleted in past due to over-harvesting from its wild occurrence. Strict surveillance is necessary to protect the remaining wild plants from harvesting.

Harvest impact severity: **Low on cultivated populations.**

In India, the harvest of *A. malaccensis* is being done at present from the trees under cultivation/ plantation occurring outside the Protected Areas, *i.e.,* from home-gardens, private lands, leased lands etc. Practically, in Northeast India, the harvest is not only dependent on the age and GBH/ DBH of the trees, but also on the intensity of infection in trees, monetary needs of the growers, etc. In several areas of Assam and Tripura, harvesting is done from naturally infected trees, even <30 cm of GBH, as well as from well-grown artificially infected trees. However, due to presence of very high number of plants in cultivation and frequent plantation activities in the harvesting states, the present volume of harvest has low impact on the national population of this species.

Harvest to products: Harvesting of agarwood trees can be done throughout the year. However, the best harvesting period is from January to May due to the presence of maximum concentration of oil and lesser amount of waxy substances in the wood during that time. After felling, the lateral branches and leaves are removed, and main trunks of the trees are cut into logs. In the process of bringing out the infected part in the form of 'Chips', the logs ('Kunda') of agar trees must be chiselled through a series of stages with different market value. Hence, various agarwood forms are available in the market depending on the cutting stages, locally (Assam, Tripura) known as 'Buta', 'Bangtang', 'Chap Bangtang', 'Chips', 'Churan' etc. The first stage after removal of bark and some of the non-infected parts is called 'Buta'. The further chiselled stages are called 'Bangtang', 'Chap Bangtang' and finally the 'Chips'. During this entire process, some parts of wood get dusted out, which also bears infected parts of agarwood. This is locally known as 'Churan'/ 'Churen' (saw dust/ powder) which is used in 'Malor oil' (high-grade oil) production. Similarly, several kinds of chips are available depending on their finishing, like 'Zora' or 'Jura', 'Chhalla', 'Mori' or 'Muri', 'Khudi Mori/ Muri', 'Sishor muri', 'Kone', 'Ghap' etc. Several grades of Agar-oil are available in the market ('Khara', 'Batali mal', ' Kolagachi', 'Dum', 'Boha', 'Boya', '1st Jaal', '2nd Jaal', '3rd Jaal', AAA, AA, A+, A1, A, Super Deluxe, Super Double, Super etc.). Still, there is no commonly accepted set standard.

Agar formed in an artificially inoculated tree

Buta

Buta

Bangtang

Chap Bangtang

Chips

Chipping

Churan/ powder/ saw dust

Zora/ Jura

Chhalla

Mori/ Muri

Khudi Mori/ Muri

Sishor muri

Sishor muri

Ghap

The highest quality of agarwood produce is locally known as 'Sem' in Assam, which ranges from Rs. 2,00,000/- to several crores depending on the infection and size. Sem is formed where agar formation in a part of the tree concentrates to such an extent that it hardens up. It becomes so hard that it is impossible to further process this wood with 'dao' or 'botali' (chisel). The structure has uniform colour tone which might be creamy white (muga coloured), reddish or dark brown. The term 'Sem' is known to be derived from 'same' or even tone of colour and texture. The 'Sem' sinks into water because of its density. When burnt, it doesn't give any 'Boya' fragrance which confirms that it is devoid of any non-infected part and has pure resin. It can be formed both by artificial as well as natural infection. However, in the present day, the availability of 'Sem' is quite rare.


Sem


Sem

Small pieces of agarwood, sometimes along with 'Churan'/ 'Dust' (saw dust/ powder) are soaked into water for about a month or more for fermentation and then put into the boiler(s) and boiled for 20 to 30 days. Oil collected from day 1 to day 3 is of the best quality, followed by the oil extracted in 4 to 7 days. The quality and price decrease with time in the later days of the distillation process. The quality and price also depend on the percentage of infected parts in the agarwood pieces/ 'Churan'/ 'Dust'.


Agarwood pieces for oil production


Fermentation of agarwood pieces

Fermentation of agarwood pieces

Production of oil in distillation chambers

Distillation chambers

Freshly produced oil in collection drum of a distillation chamber

Pure agarwood oil (Malor)

Different types and grades of agarwood oil

The 'Boya' or 'Boya oil' is a hydrophobic viscous or semi-liquid by-product with fragrance, obtained after extracting the pure oil/high-grade oil from raw plant material, usually by hydro-distillation (generally on second or third distillation) or any other distillation methods to extract the remaining resinoids which is light yellow to brown in colour and later forms waxy substance when solidified in cool temperature. Sometimes, the 'Boya' is also extracted from the non-infected portions of infected trees or even from the non-infected trees. It is widely used in making perfumes and smokeless tobacco products to produce aromatic flavour. The residual wood waste obtained after the oil extraction is used in the production of incense sticks and 'Bakhoor'.

Boya

Residual wood waste (exhausted) obtained after oil extraction

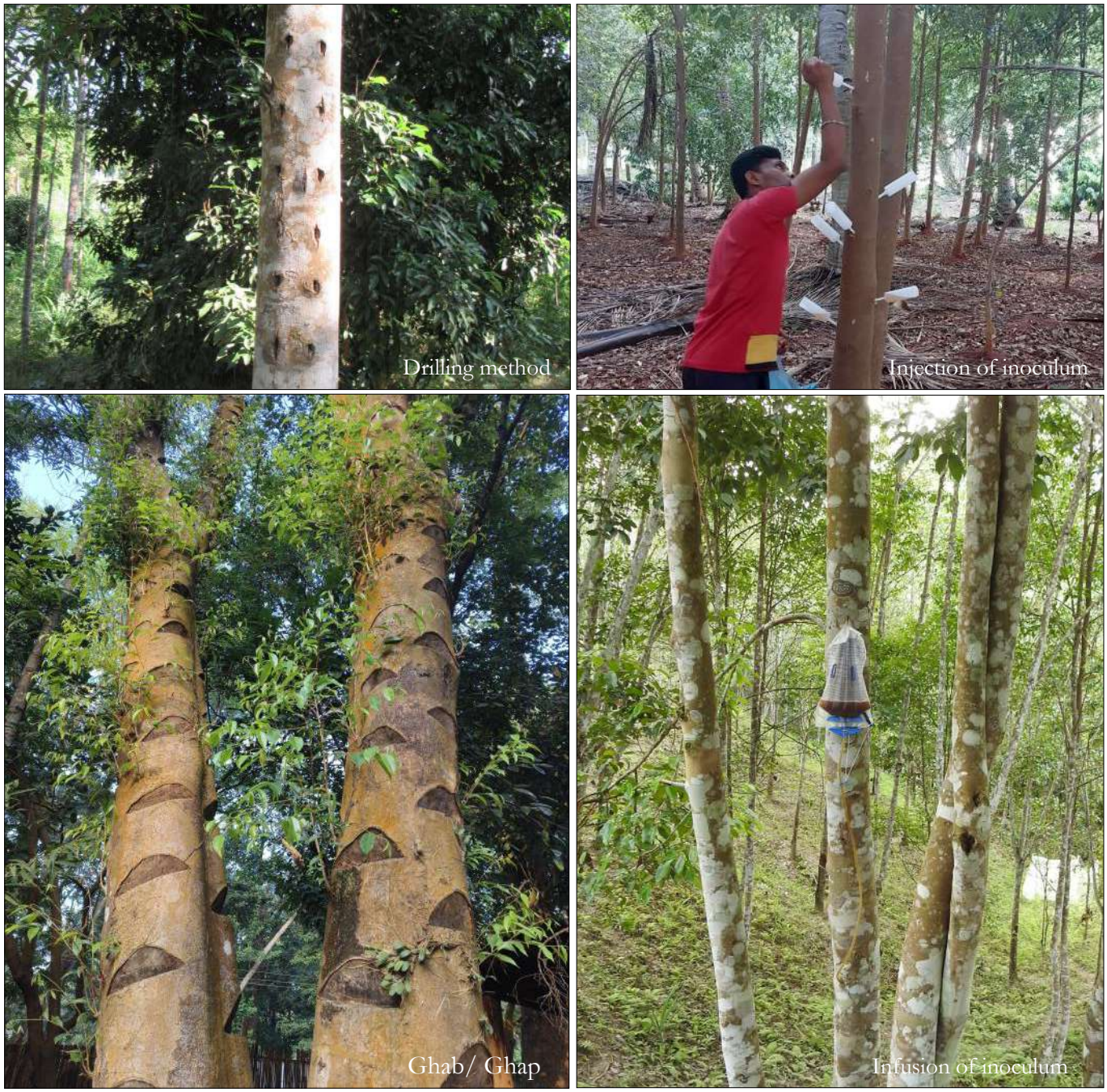
Bakhoor

The distillation units or 'Dag' come in a variety of sizes. 'Malor oil' is processed in Dags of sizes: 5 kg, 10 kg and 60 kg. Boya oil is processed in 500 kg and 1,000 kg Dags. The fuels used for the oil distillation process are usually rice husk or firewood. Though the use of firewood is so expensive, it is still used, because the fragrance of oil distilled using firewood is preferred by some buyers.

In some parts of Assam, especially in Dibrugarh district, artificial infection methods are quite popular which include physical injury such as 'Ghaap mara' (deep cuts by a 'dao'), 'Kil mara' (hammering nails in a definite pattern), 'Botali mara' (inserting wooden cylinders after creating holes on the trunk) and inoculation with fungal strains/chemicals. In Meghalaya, artificial induction is done using the 'Ghab'/ 'Ghap' method from April to October. Growers/ dealers cut a portion of a tree trunk through a sharp object commonly known as 'Kowat' in the local language. The gap is *c.* 1 foot between each cut, and after 2 years, the resinous wood is cut from the main trunk and is sent for further processing to Siju and Hojai vendors. After cutting the trunk, the remaining part, locally called 'Deckmal' or 'Moramal', is used in making oil. Different types of artificial infection methods are also observed in other parts of the country where natural infection is less or absent.

Different types of artificial infection methods

Artificial inoculation method: 'Botali mara'



Different types of artificial infection methods

Inoculation trials by different companies

Artificial inoculation in agarwood trees

Artificial inoculation in agarwood trees

The 'Z Black Diamond Agarwood LLP' (Hojai, Assam), 'Vanadurgi Agarwood India Limited' (Bengaluru, Karnataka), 'MJI Agarwood Research and Development LLP (Guwahati, Assam), and several other private companies are providing paid services for artificial induction of agar formation by using different techniques. The 'Z Black Diamond Agarwood LLP' has developed 3 types of techniques for artificial induction of agar formation. According to them, these techniques have been recognised and proven to be the best inoculation techniques to date and have a 100% success rate. The techniques are:

1. DTII (Direct Trunk Injection of Inoculum),
2. TIIC (Trunk Injection of Inoculum through Cannula), and
3. PIBR (Pasting of Inoculum through Bark Removal)

In DTII, their inoculation experts do the injury through drill machines with proper precision. After this process, the inoculum is injected in the tree trunk through the drill holes. This process is repeated in another 60 days and left for a few months. In TIIC method, the inoculum is injected through a cannula for a more extended period after the drill injury. This process requires a larger amount of inoculum, but the quantity of agar obtained is quite high; thus, this is the most popular artificial inoculation method. In PIBR method, the tree is injured through deep cuts in the tree trunk, a little deeper than the bark of the tree, and the inoculum is pasted in the injured areas. They offer their service mostly on a percentage basis (usually 70% company: 30% grower but varies from case to case). The company also claims that they only uses herbal formulations for artificial induction.

One of the techniques used by the Z Black Diamond LLP for artificial induction of agarwood formation

The inoculation cost in Peninsular India is either on a percentage basis or per tree basis. The Vanadurgi Agarwood India Limited has recently standardized a few inoculums, such as Oud MIT16, Oud MIT18, Oud LB-1, and Garomone-A5, and are sold under their brand label. The plants have been harvested only on a trial basis till now. The inoculation techniques in other southern states are not standardized. The unavailability of standard inoculums is affecting the artificial induction of agar formation in plants and the quality of the chips and oil. Also, about 10% mortality was observed in the inoculated trees. Once the inoculation process is standardized, trees will be ready for mass inoculation.

In Kerala, the success rate of previously inoculated plants is almost zero. Such trees are harvested (Rs. 10,000/- to 20,000/- per tree) and are only used for 'Agarbatti' (incense stick) and 'Bakhoor' (incense-added wood pieces and powders) productions. New methods are tried, and the growers and inoculation agencies are waiting for the results.

The Indian Council of Forestry Research and Education–Rain Forest Research Institute (ICFRE-RFRI), Jorhat released fungal inocula for artificial induction of agarwood in *A. malaccensis* for marketing in the brand name 'Sasi Inoculant'. It is available in two forms *i.e.*, liquid and paste. The 'Sasi Inoculant', sold by ICFRE-RFRI was used to infect 1,000 trees in Tripura (8 districts), 184 trees in Meghalaya (6 districts) and 659 trees in North Bengal (2 districts). The farmers of Tripura and Meghalaya sold such artificially inoculated agar trees at a rate of Rs. 90,000/- per tree.

Yield

According to Ibrahim & al. (2018), a 10-year-old tree may yield 15–20 kg of agarwood, which upon processing yield 3–4 kg of chips. These chips, if distilled, can yield 10–15 g of oil. Ahmed & al. (2019) have stated that after 10 years of planting with intensive management, each infected tree may yield about 30–40 kg of distillable wood product for oil extraction, depending on infection intensity. Borah & Deb (2019) have mentioned that the microbial infection takes a long time to

spread, and naturally, trees about 50 years old have the highest concentration of resins (2.5–5 kg/ tree).

During the present study it has been observed that the yield from agarwood trees is highly variable and unpredictable. Infection and growth of plants are inversely proportional. Premature infection affects the quality and quantity of the yield. In Northeast India, the yield is generally higher than South India. Natural infection is observed mostly in Golaghat, Sivasagar, Jorhat, Karimgang, Cachar districts of Assam, Jiribam district of Manipur, Mokokchung district of Nagaland, North Tripura and Unakoti districts of Tripura. Several trees in these areas, natural infection is observed even in trees less than 1 years of age and <10 cm of GBH. Sometimes, artificial infection is also done in trees having partial natural infection to increase the yield. In trees devoid of natural infection, artificial infection is induced.

The yield is extremely variable in Northeast India ranging from 300 g to 3 kg (rarely up to 4 kg) of chips per tree at present, depending on the intensity of infection, age, height and GBH/ DBH of the tree, harvesting time, season, climate, resin/oil content, fermentation in distilleries etc. From the oil-grade chips/ non-exhausted wood/dust/ 'Churan' obtained during finishing of the chips, 10–22 g of good quality of agar-oil can be extracted from a single tree. However, in several distilleries in Northeast India it has been observed that often up to 90% of wood (including non-infected parts) from a single harvested tree is used for distillation to get higher amount of oil, even from the plants <30 cm GBH, but the quality is being compromised in these cases. The yield of 'Boya oil' is also variable, ranging from 20–40 g per 100 kg of non-infected wood. In South India, 200 g to 1 kg chips and 10–15 kg oil-grade chips/wood are obtained from a single tree.

4. Impact of harvest on other species for the exports requested

Harvest impact severity: **Low**

Two species of *Aquilaria* is found in India in wild, *viz. A. malaccensis* and *A. khasiana*. *Aquilaria malaccensis* is reported to be found in the wild in Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and West Bengal, whereas *A. khasiana* has very restricted distribution and reported only from Meghalaya. However, during the present study *A. malaccensis* is located in wild only in Arunachal Pradesh, Assam, Manipur, Nagaland, and Tripura. Whereas *A. khasiana* is located in Meghalaya and also in Assam (new location). *Aquilaria malaccensis* is up to 40 m tall tree, while *A. khasiana* is up to 5 m high shrub or small tree. The inflorescence of *A. malaccensis* is usually branched into 2–3 terminal umbellate subsessile to shortly peduncled cymes, each with 8–13 flowers, and the stamens are with subsessile anthers; whereas it is a subsessile terminal or extra-axillary fascicle with up to 10 flowers in total and the stamens are with sessile anthers in *A. khasiana*. Since it has a very restricted distribution with minimum number of plants in wild and the non-

availability of this species in cultivation/ plantation, there is no chance of harvest of *A. khasiana* in the name of *A. malaccensis*.

STEP 7: EVALUATION OF IMPACTS OF TRADE

7. What is the impact of legal and illegal trade on national population of the species concerned?

1. Magnitude and trend of legal trade

Trade impact severity: **Low on wild population.**

The harvest and trade from wild population is almost zero in India at present.

Trade impact severity: **Low on cultivated population.**

The harvest and trade of *A. malaccensis* are being done only from the plants under cultivation. The estimated number of plants of this species is very high and therefore, the present impact of trade is low. The trend of legal trade from the cultivated population is increasing in India after the notification of export quota in November 2021.

The agar chips and oil are highly traded internationally due to their use as incense, especially in the countries of the Middle East. Agarwood can fetch as much as US$ 1,00,000 per kg for superior pure wood material or US$ 100 per kg for low quality (Naef, 2011). They are also extensively used as a perfume or as a fixative for high quality perfumes, and are largely exported to the European countries. The global agarwood chips market expanded at 7.7% Compound Annual Growth Rate (CAGR) during 2018 to 2022 and ended up at a valuation of US$ 44,050.7 million in 2023. As per the study by the Persistence Market Research, the sales of agarwood chips across the world are estimated to increase at 7.1% CAGR to reach a market size of US$ 87,467.6 million by the end of 2033. (https://www.persistencemarketresearch.com). In its purest form, oud oil can cost up to US$ 80,000 per litre in international market. The global market for agarwood is estimated at US$ 32 billion and by the end of 2029, it is expected to reach US$ 64 billion.

According to the CITES Trade Database, from 2017 to 2021, India re-exported over 141 tonnes (exporter-reported quantity) of agarwood to United Arab Emirates, Kuwait, Oman, Qatar, Saudi Arabia, Singapore, and Thailand (TRAFFIC, 2023). The United Arab Emirates imported more than half of the overall reported quantities. India imported more than 142 tonnes of agarwood simultaneously (importer reported quantity) from Australia, Saudi Arabia, Qatar, Lao People's Democratic Republic, United Arab Emirates, Malaysia, Thailand, Singapore, Indonesia, Bhutan, Switzerland, France, and Vietnam (TRAFFIC, 2023). Over one-third of the agarwood was imported from Indonesia and Singapore (TRAFFIC, 2023). The import and re-export data with respect to India is provided here.

INDIA: IMPORT (2018 to 2022; Source: CITES Trade database)

YEAR	CHIPS		OIL		DUST/POWDER		LOGS		Total imp. rep. qty. (kg)	Total exp. rep. qty (kg)	Exp.	Origin
	Imp. rep. qty. (kg)	Exp. rep. qty (kg)	Imp. rep. qty. (kg)	Exp. rep. qty (kg)	Imp. rep. qty. (kg)	Exp. rep. qty (kg)	Imp. rep. qty. (kg)	Exp. rep. qty (kg)				
2011	1,71,57.5	37,392.65	–	6.56258	–	–	–	–	17,157.5	37,399.21	BT, FR, ID, MY, SA, SG,	BD, TH, ID, MY
2019	46,265.84	29,746.68	5.28	6.2856	–	–	–	–	46,271.12	29,752.97	AE, FR, ID, MY, SG, TH	ID, BD, VN, MY, TH
2022	14,405.5	56,510.5	–	1.63225	–	–	–	–	14,405.5	56,512.13	FR, ID, MY, QA, SA, SG,	BD, ID,TH, MY
2021	22,150	95,900.8	–	0.015	–	–	–	8,000	22,150	1,03,900.8	FR, ID, QA, RE, SG, TH	BD, ID, MY
2022	–	47,621.6	–	–	–	–	–	6,821.6	–	54,443.23	BD, FR, SG	BD, ID, MY

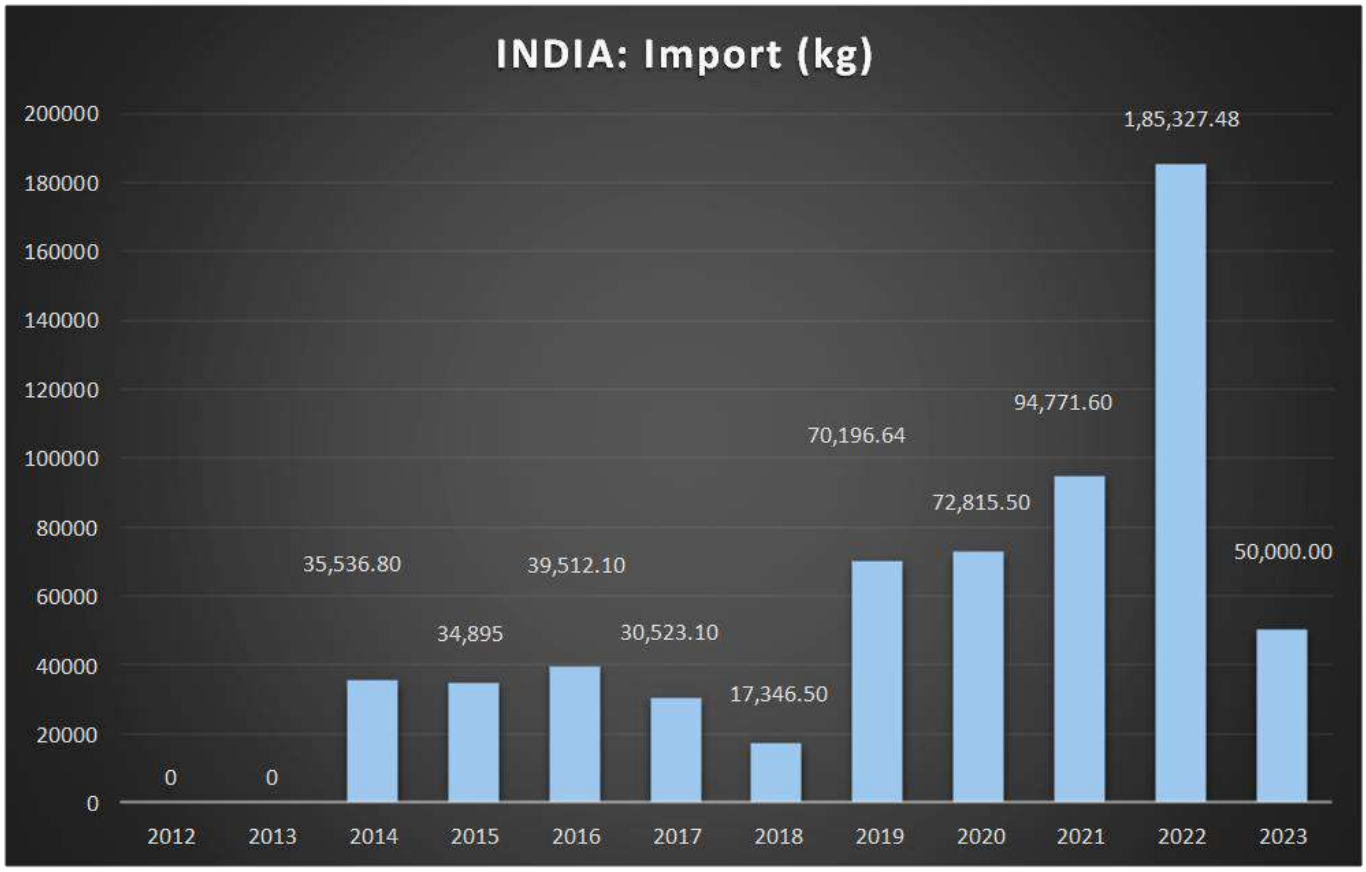
INDIA: RE-EXPORT (2018 to 2022; Source: CITES Trade Database)

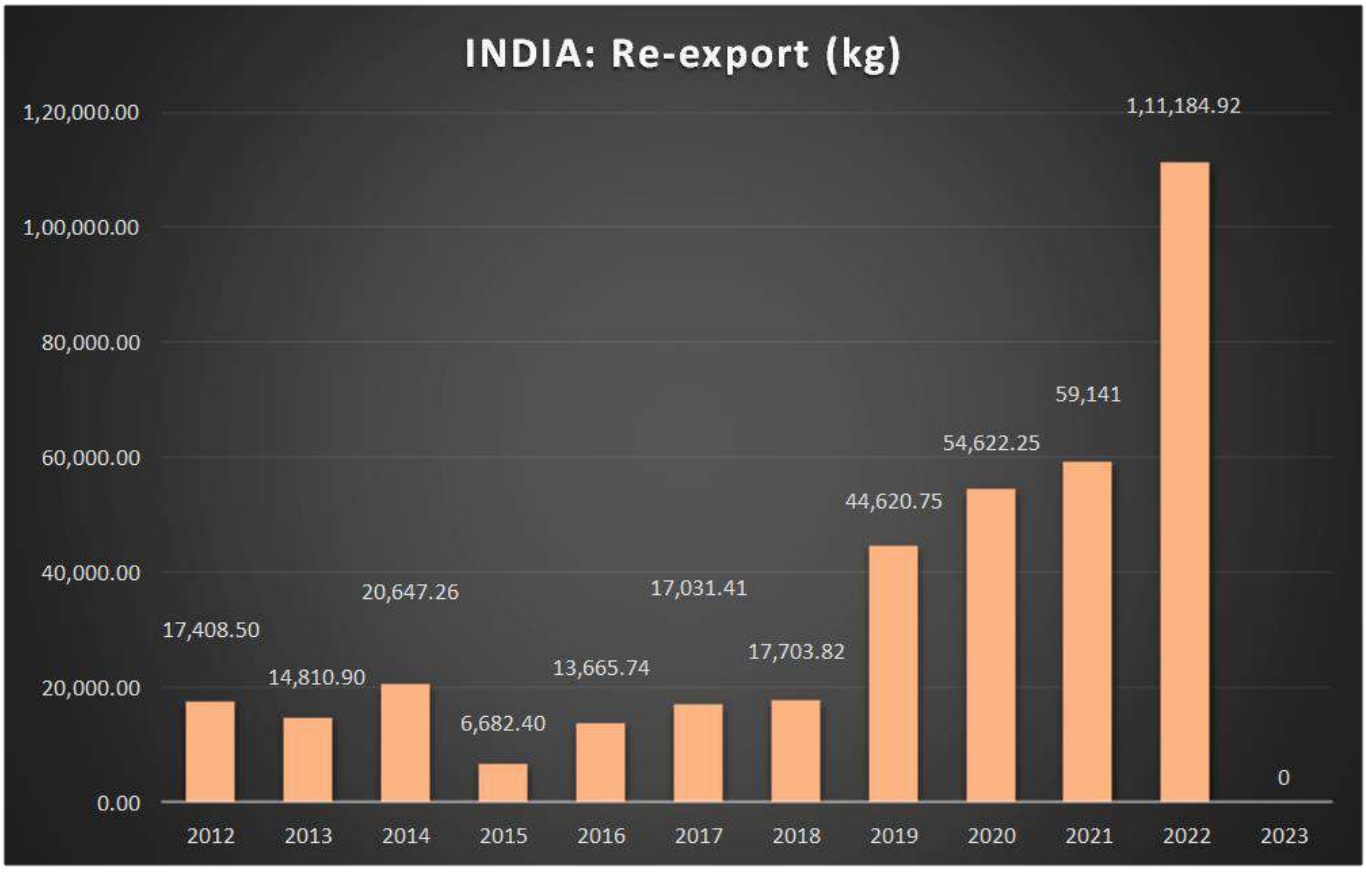
YEAR	CHIPS		OIL		DUST/POWDER		Total imp. rep. qty. (kg)	Total exp. rep. qty (kg)	Imp.	Origin
	Imp. rep. qty. (kg)	Exp. rep. qty (kg)	Imp. rep. qty. (kg)	Exp. rep. qty (kg)	Imp. rep. qty. (kg)	Exp. rep. qty (kg)				
2018	10,400.95	19,115.49	–	–	–	–	10,400.95	19,115.49	AE, KW, QA, SG, TH	ID, MY, TH
2019	22,361.39	39,168	–	–	22,905	–	45,266.39	39,168	AE, KW, QA, SA, SG	ID, MY, TH, XV,
2020	34,067.84	38,425.18	3.44	–	961.057	6,781.225	35,032.34	45,206.4	AE, KW, QA, SA, SG, TH	ID, MY, TH
2021	51,404.25	65,045.4	–	–	6,781.225	–	58,185.47	65,045.4	AE, KW, QA, SA, SG, TW	ID, MY, TH
2022	1,266.5 & 50,000 (Live)	–	–	–	–	–	51,266.5	–	PH, SG	MY, TH

Note: Imp – Importer, Exp. – Exporter, Imp. rep. qty. – Importer reported quantity, Exp. rep. qty – Exporter reported quantity; BH – Bahrain, BD – Bangladesh, BT– Bhutan, CD – Democratic Republic of the Congo, DE – Germany, FR – France, ID – Indonesia, KW – Kuwait, MY – Malaysia, OM – Oman, PH – Philippines, QA – Qatar, RE – Reunion, SA/ KSA – Saudi Arabia, SG – Singapore, TH – Thailand, TR – Turkey, TW – Taiwan, UAE/AE – United Arab Emirates, US – United States of America, VN – Vietnam, XV – Eastern Europe.

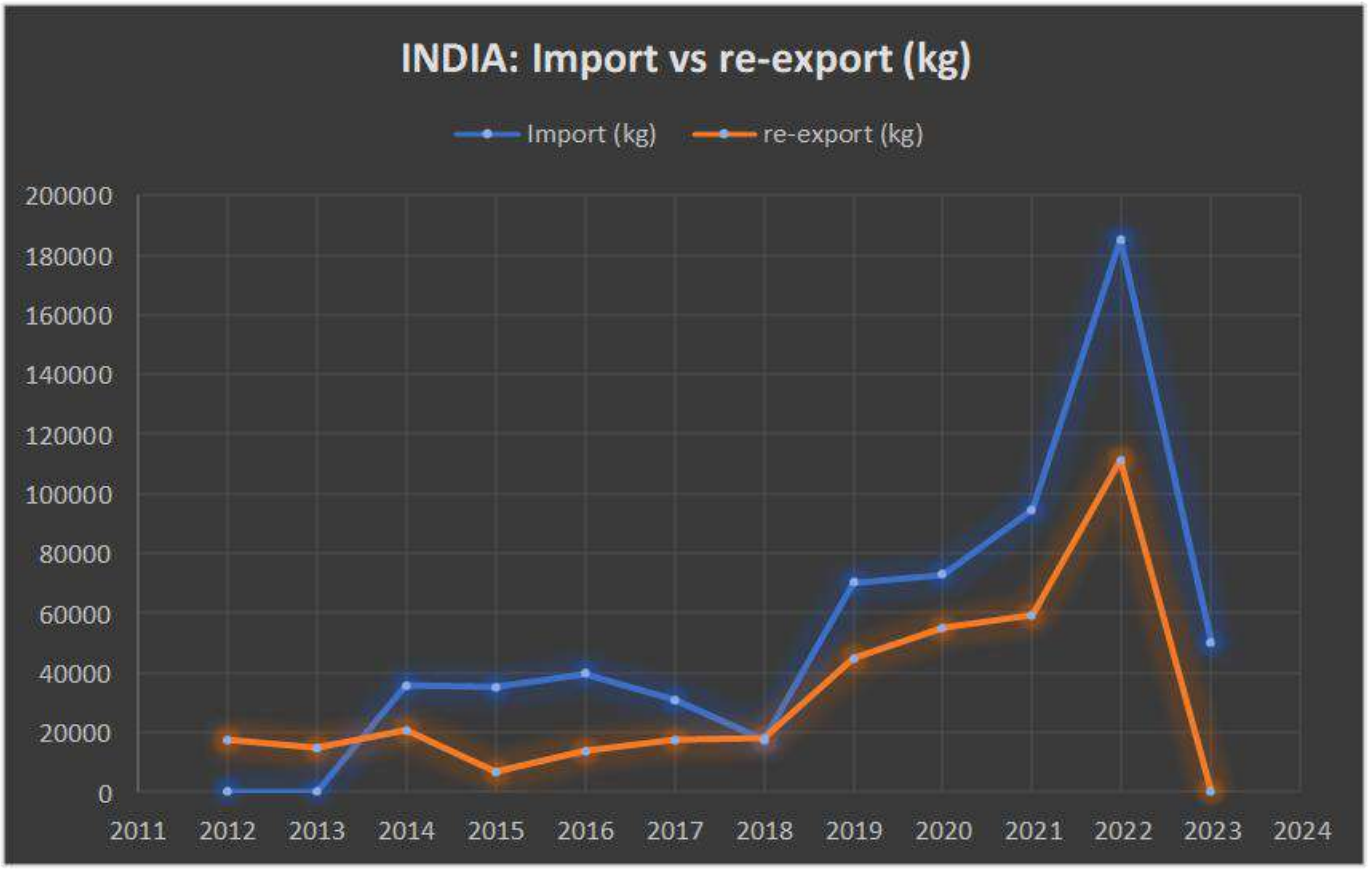
Agarwood Import Report (Source: WCCB)										
Year	Northern Region		Southern Region		Eastern Region		Western Region		Grand Total	
	Consign-ment	Import (kg)	Consign-ment	Import (kg)	Consign-ment	Import (kg)	Consign-ment	Import (kg)	Consign-ment	Import (kg)
2012	-	-	-	-	-	-	-	-	0	0
2013	-	-	-	-	-	-	-	-	0	0
2014	-	-	1 (A. Chips)	100	13	35,436.80	-	-	14	35,536.80
2015	-	-	-	-	16	34,895	-	-	16	34,895
2016	-	-	-	-	13	39,512.10	-	-	13	39,512.10
2017	-	-	-	-	14	30,329.10	3	194	17	30,523.10
2018	-	-	-	-	12	17,038.50	2	308	14	17,346.50
2019	2	8,000	-	-	27	58,998.44	6	3,198.20	35	70,196.64
2020	1	9,500	-	-	14	60,935.50	7	2,380	22	72,815.50
2021	-	-	-	-	16	90,885.80	10	3,885.80	26	94,771.60
2022	-	-	1 (Seedlings)	50,000	36	1,30,974.20	14	4,353.28	51	1,85,327.48
2023	-	-	2 (Seedlings)	25,000+25,000 = 50,000	-	-	-	-	2	50,000
Total (2012—2023)									**210**	**6,30,924.72**

Agarwood Re-export Report (Source: WCCB)										
Year	Northern Region		Southern Region		Eastern Region		Western Region		Grand Total	
	Consign-ment	Import (kg)	Consign-ment	Import (kg)	Consign-ment	Import (kg)	Consign-ment	Import (kg)	Consign-ment	Import (kg)
2012	-	-	-	-	45	17,408.50	-	-	45	17,408.50
2013	-	-	-	-	33	14,810.90	-	-	33	14,810.90
2014	-	-	-	-	17	20,647.26	-	-	17	20,647.26
2015	-	-	-	-	7	6,682.40	-	-	7	6,682.40
2016	-	-	-	-	18	13,665.74	-	-	18	13,665.74
2017	-	-	-	-	37	17,031.41	-	-	37	17,031.41
2018	-	-	-	-	20	17,607.82	5	96	25	17,703.82
2019	21	5,402	-	-	29	36,890.75	18	2,328	68	44,620.75
2020	7	2,794	01 (A. Chips) 01 (C. Oil)	61.150+3.44 = 64.59	61	48,437.66	13	3,326	83	54,622.25
2021	15	4,982.40	1 (A. Chips)	16	69	50,204.30	20	3,938.80	105	59,141
2022	11	2,814	-	-	93	1,04,888.49	20	3,482.43	124	1,11,184.92
2023	-	-	-	-	-	-	-	-	0	0
Total (2012—2023)									562	3,77,518.95





Source: Wildlife Crime Control Bureau (WCCB)



In past, India exported agarwood to Pakistan under a trade agreement signed on 22nd January, 1957 (https://www.mea.gov.in/bilateral-documents.htm?dtl/5799/).

Agarwood chips, oil, and other agarwood products are less consumed in India. Hence, price of agar chips and oil are very less in India as compare to the global market. Due to high demand and high international market value, agarwood products are usually exported. As per our observation, India has the capacity to export agarwood chips and oil worth thousands of crores annually. Usually, the market price of the 1 tola (11.66 g) agar oil (*i.e.,* pure oil/ high grade oil/ 'Malor') in Assam and Tripura ranges from Rs. 6,000/- to Rs. 17,500/- depending on quality; whereas the price of chips ranges from Rs. 10,000/- to Rs. 3,00,000/- per kg, depending on the quality, however the price of best quality chips raises up to Rs.10,00,000/- and even more. The price of 'Sem' (the highest quality of agarwood) in Assam ranges from Rs. 2,00,000/- to several crores depending on the infection and size. The price of 'Boya' oil is much low than the pure oil/ high grade oil, *i.e.*, Rs 1,000/- to Rs. 1,500/- per tola (11.66 gm). The 'Bangtang' with sufficient infection to draw out some amount of chips are having price ranges from Rs.1,500/- to Rs. 3,500/- per kg. However, the 'Bangtang' with low traces of infection which cannot be utilised for extraction of chips are utilized in oil extraction and costs Rs. 300/- to Rs.1,000/- per kg. The further chiselled stage is called 'Chap Bangtang' which costs Rs. 30,000/- to Rs. 50,000/- per kg. This is further chiselled to get the refined dark brown to black infected parts which are known as 'Chips'. The 'Churan' or residual dust obtained during the processing of chips is used in 'Malor oil' production having price ranges from Rs. 1,000/-

to Rs. 5,000/- per kg, whereas the price of 'Chipping' (mostly non-infected whitish strips, sometimes with <30% infected parts) obtained during processing of chips is Rs. 100/- to Rs. 2,000/- per kg and used for preparing the 'Boya oil'. The quality and price of chips and oil obtained by artificial infection is much less than the natural ones. The products are mostly purchased by the dealers from Hojai district of Assam with less price and then sold by them to Middle East and Europe for much higher price.

In Assam and Tripura, sometimes 3–6 years old small trees are also harvested by the farmers due to monetary problems. In some remote places of Tripura the price of naturally infected trees of 3–4 years of age costs only Rs. 2,000/- to Rs. 3,000/-; the price is Rs. 10,000/- to Rs. 12,000/- and Rs. 30,000/- to Rs. 50,000/- for the trees aged up to 12 years and 20–30 years, respectively. The average cost of a mature tree in home gardens in Upper Assam fetched the price from Rs. 28,986/- to Rs. 20,08,238/- with an average of Rs. 2,49,090/- (Borah & al., 2014). The farmers/ growers sell their trees/ harvested trees mainly to the Hojai vendors.

In Meghalaya, the growers/dealers sell the resinous wood obtained by 'Ghap/Ghab' method (artificial induction) at a cost of Rs. 25,000/- to 2,00,000/- per sac (20–25 kg) (depending on the agar quality) to Siju and Hojai vendors for further processing. They also sell the 'Deckmal' or 'Moramal' at the cost of Rs. 3,000/- to Rs. 8,000/- per sac (20–25 kg) to Hojai vendors. In Manipur, the price of the chips ranges from Rs. 10,000/- to Rs. 60,000/- per kg based on different quality. About 1,000–3,000 kg of chips are obtained from Jiribam district annually (local source). Since the district is close to Assam, oil grade chips as well as raw woods are transported to Assam. The Islamnagar market in Hojai (Assam) is the largest agar market in the country, with more than Rs. 1 crore average turnover per day.

The Islamnagar agarwood market in Hojai (Assam)

Golaghat district of Assam itself has around 500 distillation units. Most of the distilleries of Assam are located in Hojai. Few are present in Dibrugarh and Nagaon districts. As per available information, there are four distillation units in Tripura; one each in North Tripura and South Tripura and two in Unakoti district. Only one functional oil distillation unit is found in the entire state of Manipur, which is situated at Kwakta, Bishnupur districts owned by Rehhal groups. The capacity of the distillation chamber owned by is 120 kg wood (two units) and an average of 1.2 kg oil is extracted per month. The oil and chips are directly sold in Mumbai and Delhi based markets as well as in Assam. The raw materials collected are obtained from their own plantations and from farmers of Churchandpur and Bishnupur districts. Chips and oil are marketed to Assam, Mumbai and Delhi based markets. Only one sales outlet of agarwood products is found in Manipur owned by Rehhal group which is situated at Imphal. Agarwood chips (Rs. 40,000/- per kg onwards), oil (Rs. 15,000/- per tola), agar tea, and some perfumes are sold here.

Agarwood chips and wooden crafts have high demand in northern Kerala. The major buyers are people working in Gulf countries. Exclusive Oudh markets are found in Kasaragod, Calicut, Malappuram, and Palakkad districts of Kerala where chips, oil, and oil-based perfumes are sold. The chips sold here are mainly imported from Assam. In addition, the chips and wooden crafts are brought from Cambodia and some other countries of Southeast Asia.

Markaz market, Calicut

The KAFAI producer company set up an 'Agarbatti'/ incense stick factory at Koottanad, Palakkad district with a capacity of 10 kg per day. Apart from that agar based products such as soaps, attar, perfumed tissues, perfumes, incense sticks, and 'Bakhoor' (incense-added wood pieces and powders) are manufactured by their third party. The raw materials for the 'Agarbatti' are non-infected wood and the 'Bakhoor' which is exhausted wood obtained after the oil extraction. Apart from KAFAI, small-scale 'Agarbatti' units are also found in different parts of Kerala and Karnataka. In Tamil Nadu, fifty trees were harvested recently by the farmers of Neyveli and adjoining areas. The chips were sold in Assam markets for a price ranging from Rs. 30,000/- to Rs. 40,000/- per kg. The remaining inoculated trees are in harvestable stage. A distillation unit is installed in that area but not functioning due to the lack of raw materials.

In Hyderabad (Telangana) the uses of agarwood products such as attar, perfumes, 'Bakhoor' and incense sticks are very common. The raw chips and oil are imported from north-eastern states and used in many industries. Oudh markets are found in Tolichowki, Nampally, and Ghansi Bazaar of Hyderabad where raw chips, oil, and oil-based perfumes are sold. The market price of 1 tola agar oil in Hyderabad ranges from Rs. 9,500/- to Rs. 13,000/-, whereas the price of chips ranges from Rs. 20,000/- to 2,50,000/- per kg depending on the quality. The present international export of agar is allowed only through Mumbai, Kolkata, Kochi, Delhi, Chennai, Tuticorin, and Amritsar airports (Yadav & Badola, 2019).

2. Magnitude of illegal trade

Trade impact severity: **High on wild population in past; low on wild** and **high on cultivated population at present.**

Illicit felling of agarwood trees for trade was customary in Assam, even as early as 1905–06. In past, the inhabitants of Dakhshinbagh, Sylhet (now in Bangladesh) were the major traders in agarwood chips and oil, who used to lease 'Assam Agar Mahal' (area in forest leased for extraction) on a three-year term for extraction of agarwood (Chakrabarty & al., 1994). Wild agarwood was heavily extracted from Arunachal Pradesh during 1950 to 1980, causing high depletion of the natural stock. Similarly, the wild stocks in Assam and Tripura were also considered almost extinct (Chakrabarty & al., 1994). Chakrabarty & al. (1994) also reported that the lack of plantations in Mizoram and Meghalaya was the reason for much illegal harvesting from natural forests. The species was also much depleted in Manipur and Nagaland due to overharvesting. Presently the wild plants of agarwood are confined mostly to some Protected Areas and a very few remote non-forest areas. Hence, the harvest and trade of agarwood in India is now only from the cultivated/ planted populations, except extremely rare incidents of wild harvest. Therefore, the trade impact severity on wild population is evaluated here as low at present.

Aquilaria malaccensis was listed in Appendix II of CITES for the first time in 1995 based on India's proposal at CoP9 in 1994. The export from India was banned till November 2021, but re-export was allowed. The absence of export quota for a long period and other trade related restrictions in India caused an increase in informal trade/ export of agar chips, oil, powder etc. to Middle East and other foreign countries. It also caused an increase in costs of agarwood chips and oil in the global market as India is a major agarwood trading nation with which most importing countries have long trade records. In some situations, the rise in price of agarwood chips and oil is due to the global application of CITES's regulation which has an impact on supply continuity.

The illegal trade of agarwood and its derivatives has continued in India, with more than 1.25 tonnes chips and 6 litres of oil/derivatives reportedly seized in six states of India during 2017 and 2021 (TRAFFIC, 2023). Assam, Delhi, Kerala, Maharashtra, Telangana, and West Bengal reported incidents of agarwood smuggling to Bahrain, Saudi Arabia, Kuwait, Thailand, and the United Arab Emirates (TRAFFIC, 2023).

Though India has an export quota since November 2021, and *A. malaccensis* is presently found under extensive cultivation/ plantation in Northeast and South India, the informal trade is still continuing due to the complex process for fulfilling official formalities for legal trade and export. The villagers/ growers of major harvesting states planted trees in private lands, sometimes in leased lands, for their livelihood. However, the growers/ farmers were unable to trade agarwood legally due to imposing several legal restrictions during last few decades in harvesting and trading of cultivated/ planted agarwood, lack of NDFs and unavailability of export quota before November 2021, and lack of procedural knowledge in obtaining CITES export permits, etc. This urged them to sell their plants/ products to the informal traders. The official/ formal process of export with CITES permit involves multiple steps starting from obtaining Legal Procurement Certificate (LPC)/ Certificate of Cultivation/ Certificate of Origin from the local DFOs to getting clearance from DGFT through MoEF&CC. Therefore, majority of the growers and traders are still inclined towards informal trade which is much convenient for them due to well-established, decades-long informal system of trade chain. Though the Assam, Nagaland, and Tripura forest departments have initiated the process registration of plantations and agar-based industries recently, more time is needed to complete the process. Sometimes the informal trade may be practiced by importing low quality agarwood chips, logs etc. and re-exporting high quality materials from India by replacing the imported low-quality materials (source: some local traders in Assam). The pure agar oil is sometime mixed with some other perfumes, or some volatile solvent to bypass the legal restriction for export. Also the agarwood is sometime exported illegally through postal/ courier services. The illegal re-export and import data with respect to India from 2018 to 2022 is provided here.

INDIA: Illegal Trade (Export) Data [Source: WCCB]

YEAR	CHIP (Kg)	OIL (Kg)	Total Quantity (Kg)	Location of incident	Reason of Seizure	Alleged country origin	Alleged final destination
2018	-	-	-	-	-	-	-
2019	184.35	5	189.35	IGI Airport, New Delhi	No CITES permit	IN	BH, TH, SA
2020	16.088	6.312	22.40	IGI Airport, New Delhi	No CITES permit	IN	US, KW, AE, QA, PH
2021	-	-	-	-	-	-	-
2022	-	-	-	-	-	-	-

INDIA: Illegal Trade (Import) Data [Source: WCCB]

YEAR	Description of specimen	Total Quantity (Kg)	Location of incident	Reason of Seizure	Alleged country origin	Alleged final destination
2018	-	-	-	-	-	-
2019	WPR	0.3	Foreign Post Office, New Delhi	No CITES permit	ID	IN
2020	-	-	-	-	-	-
2021	-	-	-	-	-	-
2022	-	-	-	-	-	-

Note: BH – Bahrain, KW – Kuwait, PH – Philippines, ID – Indonesia, IN – India, QA – Qatar, SA/KSA – Saudi Arabia, TH – Thailand, UAE/AE – United Arab Emirates, US – United States of America.

In India, the first export quota was implemented in November 2021. Thereafter, some companies have started legal export with CITES permits. Recently in 2023, the M/S Mamon Enterprise of North Tripura exported 2.5 kg agar oil to M/S Fragrance Force General Trading LLC, Dubai with valid CITES permit as per the approval by MoEF&CC (SU Division) F. no. 5-24/2023-SU dated 4th October, 2023. Hence, the Management Authorities/ State Forest Departments are advised to conduct awareness programmes/ meetings to educate the growers, traders, exporters (especially of the harvesting states) about the process of obtaining CITES export permit and its benefits and also to encourage to export their agar chips, oil and other products with valid CITES permits.

Agarwood cultivation in South India is getting false publicity during last few years due to the lack of technical knowledge on inoculation and harvesting. Thousands of seedlings are sold by local nurseries claiming that Rs. 10,00,000/- to Rs. 15,00,000/- profit could be generated from a single tree. Seedlings are sold for Rs. 150/- to Rs. 400/-. Apart from these, many fraudulent activities took place, especially in Kerala in the name of inoculation. Many people were charged Rs. 5,000/- to Rs. 20,000/- for inoculating a single tree by offering a buyback agreement.

Sometimes, the low-quality agarwood chips are painted and polished to give finishing of high-quality chips. Also, the broken/smaller chips are sometimes fixed with glue to sell with higher price.

3. Impact on livelihood

Aquilaria malaccensis was listed in Appendix II of CITES in 1995 and its export from India was legally banned till November 2021. The absence of export quota till November 2021 and other trade restrictions in India had high adverse effects on livelihood of the people associated with agarwood trade in India. Several lakhs of people in India are associated with cultivation, maintenance and management, harvest, processing, production, transporting, marketing, trade, export of chips, oil, and other value-added products of agarwood. Assam is the hub of agarwood chips and oil extraction units. More than 9,100 agar oil extraction units were present in Assam for producing the best-quality agarwood oil in India. However, due to loss in business several units are closed at present. Most of the households of Naharani (Golaghat district) and Hojai districts of Assam are involved in the processing of chips. Almost similar situation is also observed in some parts of Tripura and Manipur. As this is mainly labour based sector, lakhs of labours are working in the agarwood processing units. Their per day labour charge is Rs.1,200/- to Rs.1,400/-. The agarwood trade is one of the main sources of income for the people of Northeast Indian states with an estimated annual trade value of more than thousands of crores in international markets. In north -eastern states the agarwood cultivation has high potential to improve the livelihood of the rural communities or the growers/ farmers.


TEER

Role of agarwood in the livelihood of local people

STEP 8: EVALUATION OF THE EFFECTIVENESS OF MANAGEMENT MEASURES

8.1. What management measures are in place for the target species?

1. Management of wild harvest impacts: Medium

The Wild Life (Protection) Act, 1972 prevents the removal of any plant from any Protected Area in India. The Indian Forest Act, 1927 regulates domestic harvests and transport of agarwood within a state as well as from a state. Harvesting from Arunachal Pradesh, Assam and Meghalaya is prohibited by State bans (under the Indian Forest Act, 1927), while harvesting in Manipur is restricted by an administrative order. Harvesting of agarwood from government lands is prohibited in Tripura since 1994.

The harvesting of cultivated plants of agarwood from non-forest areas is permitted but controlled by the state's Forest Departments. However, According to the 'Assam Trees Outside Forest (Sustainable Management) Rules, 2022' agarwood species from which essential oils and other derivatives are extracted is listed under Schedule III along with *Santalum album* L. There is no requirement to obtain any kind of permission for tree felling, conversion and transportation of outturn when the logs/ products are meant for consumption within the state. However, all the plantations have to be registered in Plantation Registering Authority after attaining 5 years of age. Timely registration of plantation may make the owner eligible for incentives under these rules and any other promotion policy of the Government. The permission for felling trees from non-forest areas including trees from registered and non-registered plantations can be granted. However, an application has to be submitted in the online portal to obtain the Certificate of Origin which has to be obtained when proposed felling site is located at a distance of above 5 km from the nearest forest. This certificate is used in the case of transportation of outturn within Assam. Irrespective of the distance from the nearest forest, the owner shall not remove, damage, uproot the stump of the felled trees for at least 60 days from the date of removal, disposal, and transportation of the outturn. If the owner desires to transport the outturn outside Assam, within Northeast India, irrespective of the distance of the plantation from nearest forest, the owner is required to apply to the concerned Divisional Forest Officer (DFO) for water marked Transit Pass. If it has to be moved outside Northeast India, it shall be permitted only by Railways as per the direction or guidelines of Hon'ble Supreme Court of India and/or by any order, notification, guideline as issued by the MoEF&CC, Government of India time to time.

The cultivation of *Aquilaria maleccensis* (as '*A. agallocha*') was promoted by the National Medicinal Plants Board (NMPB), Department of AYUSH, Government of India, in Andhra Pradesh, Arunachal Pradesh, Assam, Kerala, Manipur, Meghalaya, Mizoram, Nagaland and West Bengal. The agarwood was included in the prioritized list of medicinal plants for cultivation of NMPB and provided 75% subsidy on this crop to farmers till 2018. Subsidy is also introduced by the Assam and Tripura state governments for planting agarwood trees to minimise the impact of harvest and also to promote agarwood business for improving livelihood of the people of their states.

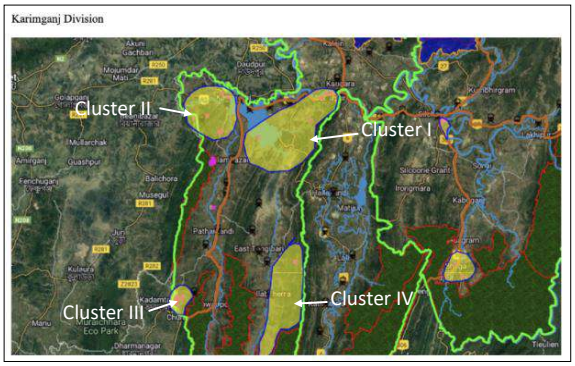
2. Management of trade impacts: Medium

The export of agarwood was prohibited according to the Chapter XVI, Part I, of the Export & Import (EXIM) Policy framed by the Ministry of Commerce, Government of India, for 1992–97, where the export of all wood products (including log, timber, chip, powder, flake, dust etc.) of all species was banned. But as per Sl. No. 34 & 44 of Part V of the same chapter (Chapter XVI) of the EXIM Policy, plants, plant portions, and derivatives obtained from wild and processed timber of all species, excluding sandalwood and red sanders wood, may be exported subject to specified terms and conditions. This provision therefore may permit the export of agarwood derivatives and timber in processed form. *Aquilaria malaccensis* was listed in the Negative List of Plants Species for Export notified by the Directorate General of Foreign Trade (DGFT), Government of India vide Notification No. 2(Re-98)/1997-2002, dated 13th April, 1998. Therefore, the export of *A. malaccensis*, including portions, derivatives and extracts obtained from the species resourced from the wild was prohibited. Later, according to EXIM Policy (2009–2014) published by the DGFT, export of agarwood and its derivatives is restricted and is subjected to the provisions of CITES due to its listing in Appendix II of CITES in 1995. Any violations of the EXIM policy make the goods liable for confiscation and the individual(s) liable to punishment under India's Customs Act, 1962. India notified its export quota in 2021 vide notification no. 45/2015-2020 dated 29th November 2021 where 25,000 kg of agarwood chips and powder per annum, and 1,500 kg of agar oil per annum were permitted for export.

Assam and Tripura Forest Departments have recently taken several initiatives to promote agarwood cultivation and trade to support economy of the agarwood farmers and people associated with agarwood industry. *Aquilaria malaccensis* is listed in Schedule III of 'The Assam Trees Outside Forest (Sustainable Management) rules, 2022' and therefore, exempted from obtaining prior permission for felling, conversion and transportation of outturn from non-forest areas when they are meant for consumption within the state. However, permission is required to establish a chain of custody if the outturn is transported outside the state. In Assam, Lieu Transit Passes (LTPs) are issued by the Forest Department to those who have legally transported agarwood from neighbouring states (Manipur, Mizoram, and Nagaland).

According to the recently notified 'Assam Wood Based Industries (Promotion and Development) Rules, 2022', no agarwood processing and agar-oil extracting unit could be established or run without a valid registration granted in favour of the unit. All the existing unit holders should apply for registration under these rules and get registered with the Divisional Forest Officer (DFO) concerned within 3 months of notification of these rules (12 January, 2023). The Forest Department of Assam took initiative to legalize agarwood industries in Assam and identified 28 clusters in 7 divisions (Dibrugarh: 3 clusters, Doomdoma: 1 cluster, Golaghat: 7 clusters, Jorhat: 4 clusters, Karimganj: 5 clusters, Nagaon; 4 clusters, Sivasagar: 4 clusters) with more than 784 companies, dealers, and traders associated with agarwood business. In Assam, 4 agarwood

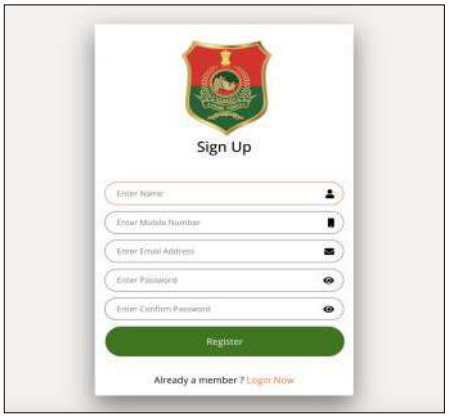
industries have been registered. Till now 66 existing agarwood industries have applied for license on the Assam WBI portal (https://wbi.assam.gov.in) (source: Assam Forest Department).

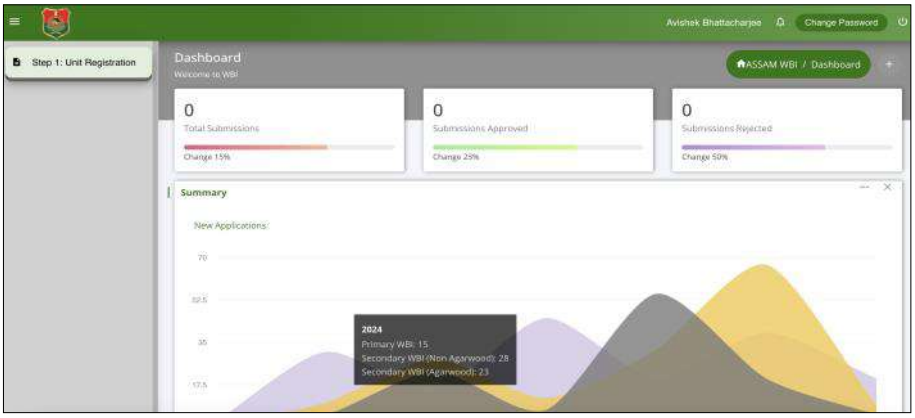


Cluster I	
1	Shanz Industry
2	Oahir Oud Extraction Factory
3	Alam's Oud Factory
4	A.Hafiz &Sons
5	AL-FATEH PERFUME
6	A B ENTERPRISE

S. No	Cluster Image	Co-ordinates	Cluster Name
1		North: 92.55,24.88 South: 92.52, 24.80 East: 92.57, 24.87 West: 92.51, 24.81	Cluster 1

Mapping of agarwood industries by Assam Forest Department: A sample map showing 'Karimganj: Cluster I' (one of the 28 clusters)

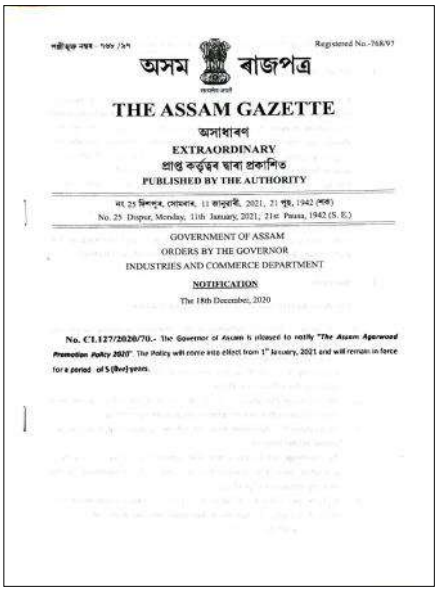




Online portal of Assam Forest Department for industry registration

The Government of Assam implemented 'The Assam Agarwood Promotion Policy 2020' (in effect from 1 January 2021) to ensure sustainable utilisation and trade of agarwood (*Aquilaria malaccensis*). The Policy has sought to cover various aspects of the agarwood sector for the benefit of all the stakeholders. It aims to promote the agarwood-based industries by providing subsidies and proper market linkages. Promotion of agar cultivation is done among growers by providing incentives to nurseries and plantations. Artificial inoculation is also emphasized by providing subsidy. Government and private agencies producing any inoculum are also funded. All industrial units including distilleries processing agar oil, perfumery and packaging are provided with Capital Investment Incentives. The training institutions and skill development centres are also sponsored to provide training on plantation techniques, artificial induction of agarwood as well as online marketing. National level research organizations as well as private institutions working in collaboration with some Government institutions are funded for agar related projects. The Industries and Commerce Department of Assam is the nodal department for giving out these incentives.

In October 2023, the Hon'ble Chief Minister of Assam laid the foundation stone of the Assam Agar International Trade Centre in Golaghat, which is the first of its kind in the entire country. The centre will have 150 bighas of land for agar plantation, research and training centres, industrial sheds, exhibition hall, open air space for exhibition, laboratory with tissue culture facility and B2B facilities. The trade centre, when commissioned, will promote business growth of agarwood entrepreneurs. The Forest Department of Assam (Social Forestry) distributed 1 crore saplings of trees, including 45,42,682 (around 4.54 million) saplings of *A. malaccensis* freely in different parts of Assam on a single day, *i.e.*, on 17 September, 2023 under the campaign 'Amrit Brikshya Andolan, 2023' (https://aba.assam.gov.in). This year, *i.e.* in 2024, the Assam state government is planning to distribute 1 crore agarwood saplings freely.


অসম ৰাজপত্ৰ

THE ASSAM GAZETTE

অসাধাৰণ

EXTRAORDINARY

প্ৰাপ্ত কৰ্ত্তৃত্ব দ্বাৰা প্ৰকাশিত

PUBLISHED BY THE AUTHORITY

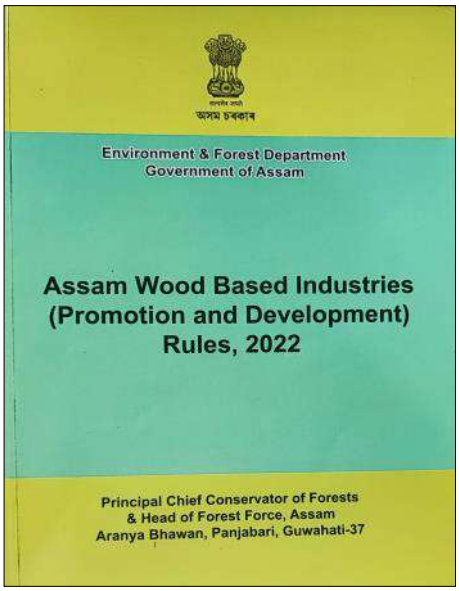
GOVERNMENT OF ASSAM

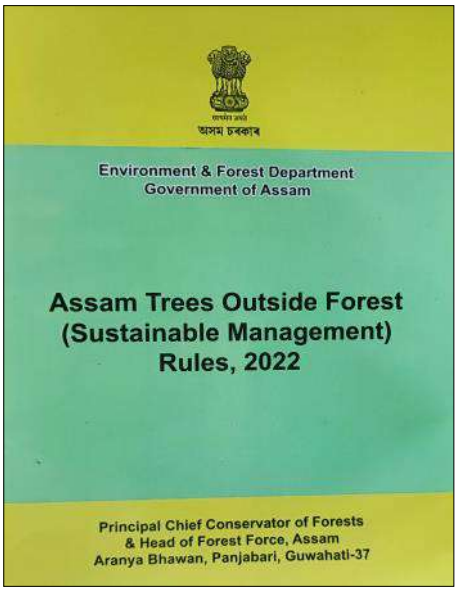
ORDERS BY THE GOVERNOR

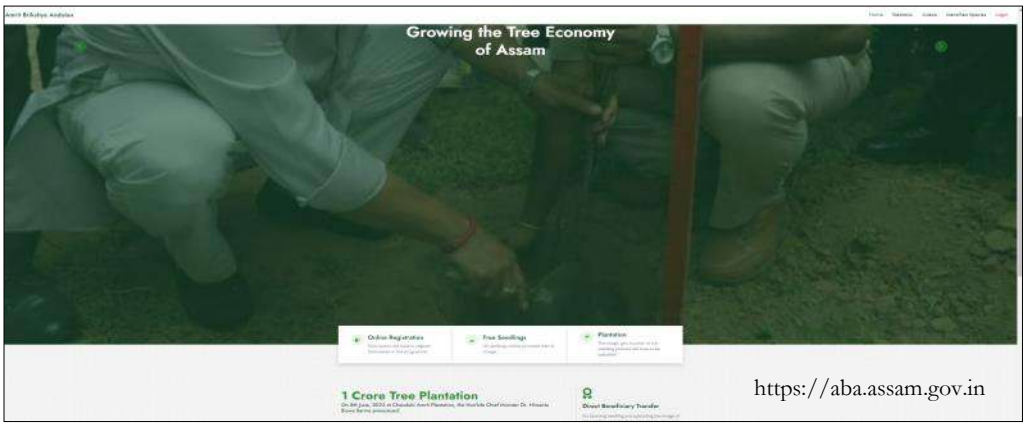
INDUSTRIES AND COMMERCE DEPARTMENT

NOTIFICATION

The 18th December, 2020

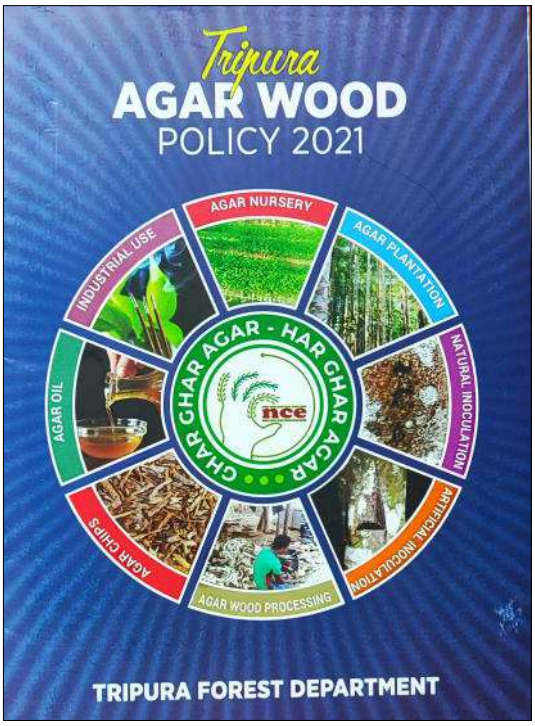






Similarly, the Government of Tripura implemented 'Tripura Agarwood Policy 2021' to ensure sustainable utilization of the agarwood by emphasizing on all the aspects of cultivation, harvesting, processing, transit and trade. It has also been implemented with an objective to promote trade in agarwood by easing the procedures of procurement, processing and selling of various products, within the country and export subject to the provisions of CITES. Agartala, the state capital of Tripura is believed to have origin of its name from agarwood. According to the policy, agarwood has a huge potential of creating another "Economic Revolution" in Tripura after rubber, bamboo

and other major forestry crops of Tripura. The policy aims to double the agarwood plantation by the year 2025 in Tripura and also attempts to make Rs. 20 billion industry in the next 5 years.



The Policy also covers incentives to promote the agarwood sector. The State Government has urged banks to take up projects to finance large scale artificial inoculation of agar trees. This is done to encourage more growers to initiate the process in areas lacking natural infection. All eligible new industrial units for distillation of agar oil, perfumery, and packaging are provided with Capital Investment Incentives as applicable by relevant provisions under Tripura Industrial Promotion Scheme, and North East Industrial & Investment Promotion Policy (NEIPP) Scheme of Government of India. Training is sponsored in various institutions and skill development centres for capacity building in various aspects of the agarwood sector. Research institutions are also incentivized to carry out research related to novel techniques of induction of agarwood, distillation methods, finding superior varieties, and other developmental methods.

The Tripura Government is proactively working towards enhancing the supply chain capabilities in the Agar Sector. Through the "Ghar Ghar Agar, Har Ghar Agar" campaign, the Tripura Forest Department is enhancing private plantations for giving monetary benefits to thousands of potential beneficiaries of the state. This campaign is also creating awareness of the potential value of agar plantations while encouraging intercropping for interim returns, artificial inoculation and the registration of trees in private plantations. units are to be established or run with a valid registration granted in favour of the unit. Under the provision of the 'Tripura Wood Based Industries (Establishment and Regulation) Rules, 2006, registration of the existing and new agarwood processing units are encouraged. The NTFP Centre of Excellence is also facilitating research on inoculation and planting materials and has collaborated with the Fragrance and Flavour Development Centre for launching the 'Tri Agar' Brand. Three leading global companies of Indian origin *viz.,* Dabur, Emami, and Patanjali have shown interest in investing at least Rs. 1,600 crore in agar-based product manufacturing units in Tripura considering the availability of raw materials.

The Government of Tripura is organising Buyer-Seller Meets during the last few years to catalyse large scale investments and create more entrepreneurs in the agarwood sector in Tripura. The other harvesting states in India do not have any agarwood policy at present. However, Nagaland Forest Department is in process to draft the agarwood policy.

The Ministry of Development of North Eastern Region (DoNER), Government of India has recently constituted (November, 2023) the Inter-Ministerial Task Force for the promotion of agarwood.

3rd International Buyer Seller Meet of Agarwood Products (5-7 October, 2023)

Seedlings/ saplings stock at the nurseries of different Indian states recorded during October–December 2023

Assam: The Assam Forest Department has reported to have raised a total of 2,259,642 agar saplings in various forest divisions and some of which are also visited during the field survey. An estimate of total number of saplings found growing in the nurseries of Forest Department in Assam is given here.

Name of forest division	Location	No. of agar saplings raised
Cachar	Smithnagar, Monierkhal Range, Sonai	2,12,500
Karimganj	Duhalia	1,50,000
Karimganj SF	Borthal	1,50,000
Hailakandi	Noxatilla, Mtijuri Range	1,45,000
Kamrup West	Laduguri, Borduar RF	70,000
Sonitpur West	Chattai Hill, Chariduar Range, Balipara RF	3,20,000
Nagaon	Nagaon	2,27,000
Nagaon SF	Mikirbheta, Kuloi SF Range	5,942
Nagaon South	Milikbasti, Hojai RF	90,000
Golaghat	Morajan, Naojan Range	50,000
Sivasagar	Sivasagar	10,000
Sivasagar SF	Somdar	45,000
Jorhat	Lohpohia, Jorhat Division	50,000
Dibrugarh	Jokai RF	10,000
Dibrugarh SF	Dibrugarh	2,000
Guwahati SF	Pirpara, Mirza	200
Lakhimpur SF	Lakhimpur	81,000
Barpeta SF	Chenga	2,00,000
Dhubri	Sirgram RF, Salkocha Range	1,01,000
Dima Hasao West	Borowapu	2,10,000
Dima Hasao East	Eco Park, Langting	30,000
Charaideo	Sola Nursery	1,35,652
Chirang	Dholpani Block	1,00,000
Total		**23,95,294**

An estimation of agarwood saplings raised in some of the private nurseries in Assam is given below.

District	Name and location of the nursery	No. of agar saplings raised
Hojai	Bhowmik Enterprise, Lanka	8,00,000
	Evergreen Enterprise, Lanka	3,00,000
	Middle Assam Nursery and Agarwood industry, Lanka	3,00,000
	M/S Moonbul Nursery, Lanka	10,00,000
Golaghat	Gayatri Nursery, Bokolai	3,000
Sivasagar	Marigold Nursery	1,000
	Flora Nursery	400
	Rangghar Nursery	1,000
	Juihul Nursery	1,000
Kamrup Metropoliton	Daffodil Nursery, Sonapur, Guwahati	5,00,000
	M/S Rahman Enterprise, Kahilipara, Guwahati	13,00,000
Total		**42,06,400**

Nurseries in Lanka, Assam with readily available agarwood saplings for sale/ distribution

A nursery of Flower Valley Agro-Tech Pvt. Ltd. in Hojai, Assam with agarwood saplings

Agarwood saplings at Sola nursery, Charaideo, Assam

Agarwood saplings at a nursery of Flower Valley Agro-Tech Pvt. Ltd. in Durgapur, Hailakandi, Assam

Agarwood saplings at Kukura Chowa nursery, Sivasagar, Assam

Agarwood saplings at a nursery in Likson Gaon, Golaghat, Assam

Agarwood saplings at a nursery in Bokajan, East Karbi Anglong, Assam

In addition to these registered nurseries many households of Golaghat and Jorhat grow agar saplings in their backyard by collecting seeds from their plantations. These saplings are further sold and distributed to other households as well.

Tripura: Estimation of saplings raised by Tripura Forest Department in various districts is as follows.

District	Name and location of the Nursery	No. of agar saplings raised
North Tripura	Central Nursery, Panitilla	60,750
	HTN Bangshul, Juri	5,200
	South Tuisama Field Nursery	90,000
	Churaibari Nursery	1,35,779
Sephaijala	Sepahijala, Melaghar Beat Office Complex Nursery	14,000
	Jatrapur beat office complex Nursery	20
	Bishalgarh Range Office Complex nursery	24
	Radhanagar Big nursery	50,000
	Charilam Nursery	4,000
	Gopinagar Central Nursery	25,500
	Pathaliaghat Hi-Tech Nursery	15
Gomati	Kumarai Bari High Tech Nursery	21,531
	Ampi Hi-Tech Nursery	43,235
	Paratia Central Nursery	19,135
	Kakraban Range office Nursery, Udaipur	2,100
	Murapara Beat Nursery, Udaipur	2,600
	Govindatilla NBM Nursery, Amarpur	45
	Atharabhola Central Nursery, Udaipur	3,902
	Khupilong Model Nursery, Udaipur	40,000
South Tripura	Amlighat Central Nursery	2,03,000
	Muhuripur Central Nursery	12,240
	Raishyabari Nursery	4,900
	Durgapur Central Nursery	11,000
West Tripura	Sadar Territorial Central Nursery	42,772
	Mohanpur Nursery	1,430
	Singerbil Beat of Mohanpur Range	19,743

Unakoti	Holly Nursery	2,45,000
	Jarultali Arboretrum cum Nursery	74,155
	Jalai Beat Office Nursery	2,725
	Pecharthal Nursery	48,399
	Jarultali Beat Nursery	1,651
Khowai	Padmabil Hi-Tech Nursery	1,05,950
	Khasiamangal Central Nursery	1,10,000
Dhalai	Manu Central Nursery	19,000
	Hi-Tech Nursery, Chailenta Range	24,000
	Durgachowmuhani Government nursery	550
	Central Nursery, Jawaharnagar	30,600
	Central Nursery, Salema	10,125
	Karnamanipara Central Nursery	44,000
	Mungiakami Central Nursery	32,208
	Japan Chakma Para Central Nursery	99,102
	Kanchancherra Hi Tech Nursery	52,184
	Central Nursery Manu, Longtharai Valley	37,992
	Chawmanu Central Nursery	3,032
	Big Nursery, Bhubhancherra	18,700
Total		**17,72,294**

Agarwood saplings at Padmabil Hi-Tech Nursery, Khowai, Tripura

Agarwood saplings at Hi-Tech Nursery, Chailengta, Dhalai, Tripura


Agarwood saplings at Durgapur Central Nursery, South Tripura

Agarwood saplings at a home nursery in Kadamtala, North Tripura

Agarwood saplings at a home nursery in South Tripura

Like Assam, several households in North Tripura and Unakoti districts raised seedlings/ saplings (200–15,000/ home-nursery) in their home-gardens. Apart from these two districts, seedlings/ saplings are also found to be maintained in some of the home-gardens and private plantations in Khowai, South Tripura, Gomati, and Dhalai districts.

Karnataka: The Vanadurgi Agarwood India Ltd. in Karnataka holds about 1,97,000 saplings in their different estates. The 5–10 cm long seedlings are majorly brought from Assam and grown in their nurseries. The plants are then sold for Rs. 75/- to Rs. 150/- per plant after two months when they attain a height of 1–2 ft. Apart from that, agarwood farmers also raise seedlings in their own farms at large scale.


Vanadurgi Nursery, Koralkoppa, Chikkamagaluru district, Karnataka


Vanadurgi Nursery, Hassan district, Karnataka

Kerala: A total of 17,700 seedling/ saplings stocks are found in Kerala in which majority are found to be raised by KAFAI. About 10,000 seedlings are sold in Kerala annually. Seedlings are mainly brought from Assam; however, farmers also raise seedlings from the seeds of mature plants and sell them for Rs. 100/ - to Rs. 200/- per plant.

Seedlings raised in plantations, Trivandrum district, Kerala

Seedlings raised in home garden, Kollam district, Kerala

KAFAI Nursery, Palakkad, Kerala

Telangana: Around 22,000 saplings are reported at Red Gold Nursery, Shadnagar and Mahadhvyth Corporate Farming, Mahabubnagar.

Andhra Pradesh: Around 1,20,000 saplings are reported from Sree Raja Rajeshwari Nursery and Sree Aakanksha Nursery at Kadiam.

Arunachal Pradesh: Around 1,25,000 saplings were reported to be grown in M/S. SOPO Nursery, Lyang Nursey, Capital Agro-forestry Nursery, Good Luck Nursery, The MM Nursery and Sunday Nursery of Papum Pare district, Namsai Khen Nursery, Singkai Sapling House of Namsai district and Lego Nursery of Lower Dibang Valley district.

Most of the saplings are grown from seeds brought from Golaghat, Hojai and Sivasagar districts of Assam.

Nurseries in Naharlagun, Papum Pare, Arunachal Pradesh

A nursery in Roing, Lower Dibang Valley, Arunachal Pradesh

Goa: Valkini Nursery, Sanguem – 940 saplings; Aquem Nursery, Margaon – 51 saplings.

Meghalaya: According to the reports, the Forest department of Meghalaya is also raising agar seedlings/ sapling in some of their nurseries.

Silviculture Hi-tech Nursery, Umkhuti – 7,200 saplings; Silviculture Umsaw range, Umsaw – 90,000 saplings; Rongrengiri Silviculture range, William Nagar – 1,70,000 saplings; Social Forestry Polypot Nursery under Dadenggre Range – 1,000 saplings.

Agar saplings in Silviculture Hi-tech Nursery, Umkhuti, Ri-Bhoi, Meghalaya

Agar saplings in Rongrengiri Silviculture range, William Nagar , East Garo Hills, Meghalaya

Mizoram: The Forest Department is growing agar seedling/ saplings in the following nurseries. Aizawl district: Central Nursery, Tuirial – 1,020 saplings; Central Nursery, Sairang Dinthar – 2,580 saplings; Tamdil Nursery, Tamdil Wetland Saitual – 20 saplings. Serchhip district: Vachadil, Thenzawl – 5,000 saplings. Lunglei district: Thenhlum Nursery – 2,000 saplings; Mualthuam Nursery – 1,800 saplings. Hnahthial district: Bungtlang Nursery – 1,800 saplings.

Another private Nursery, Zeuzera Aloe International Company in Lawngtlai district is recorded to have 15,000 saplings.

Agarwood saplings in Tamdil nursery, Keifang range, Aizawl, Mizoram

Agarwood saplings in Central Nursery, Tuirial, Aizawl, Mizoram

Manipur: Seedlings/ saplings are also reported to be raised in forest nurseries of Bishnupur, Noney and Tengnoupal forest divisions and in some private nurseries of Manipur.

CAMPA forest nursery, DFO office, Jiribam, Manipur

Nagaland: Around 40,000 saplings are raised in Tuli area by the planters in their plantations/ home-gardens.

West Bengal: Forest department of North Bengal raised saplings in the following nurseries: Darjeeling Silviculture (Hill) Division: Modern Nursey-I, Kurseong Research Range, Sukna, – 260 saplings; Jalpaiguri Division: Lataguri Modern Nursey, JR Range – 42,000 saplings; Alipurduar: Modern Nursery, BCR Range, Rajabhatkhawa – 65,400 saplings. The seedlings/ saplings are grown from the seeds brought from Golaghat district of Assam.

Agarwood saplings in Lataguri Modern Nursery, Jalpaiguri, West Bengal

Agarwood saplings in Modern Nursey-I, Kurseong Research Range, Sukna, Darjeeling, West Bengal

Uttar Pradesh: Around 500 seedlings are grown in the Central Nursery of ICFRE-ERC, Prayagraj district (data provided by ICFRE-ERC).

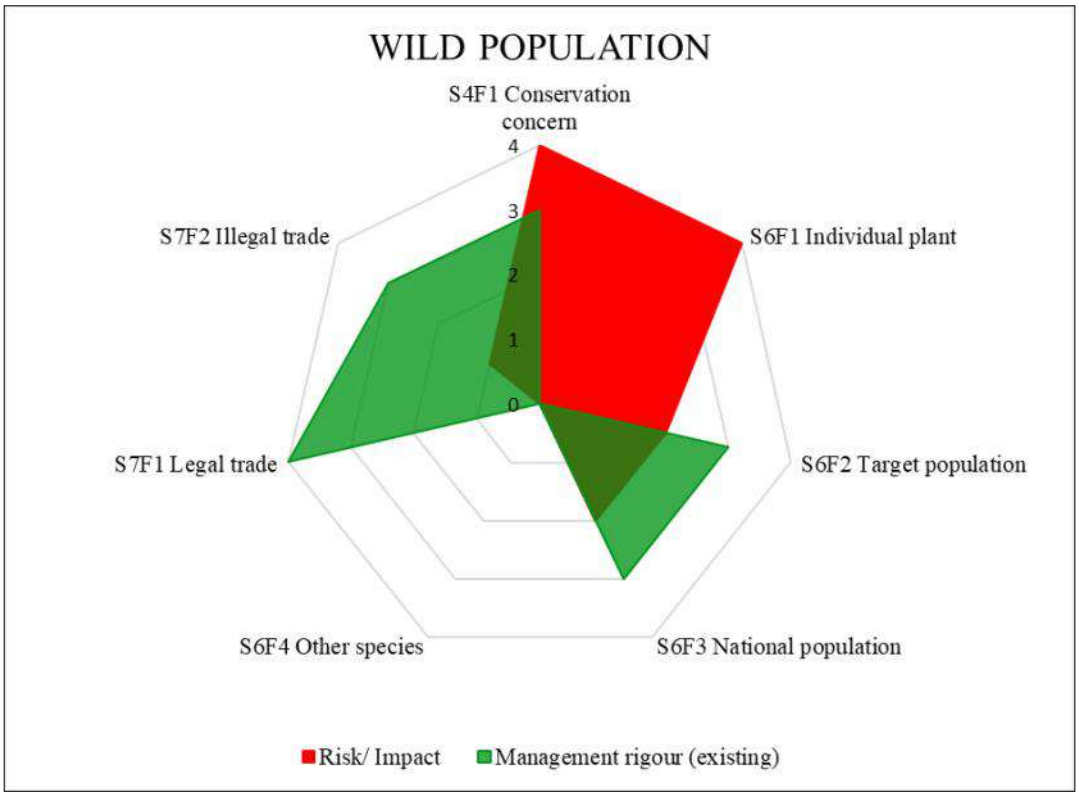
Uttarakhand: Around 50 saplings are reported to have in Departmental Nursey, Haldwani, Nainital district.

8.2. Do existing management measures adequately mitigate (= reduce the severity of) the harvest impacts and trade impacts identified?

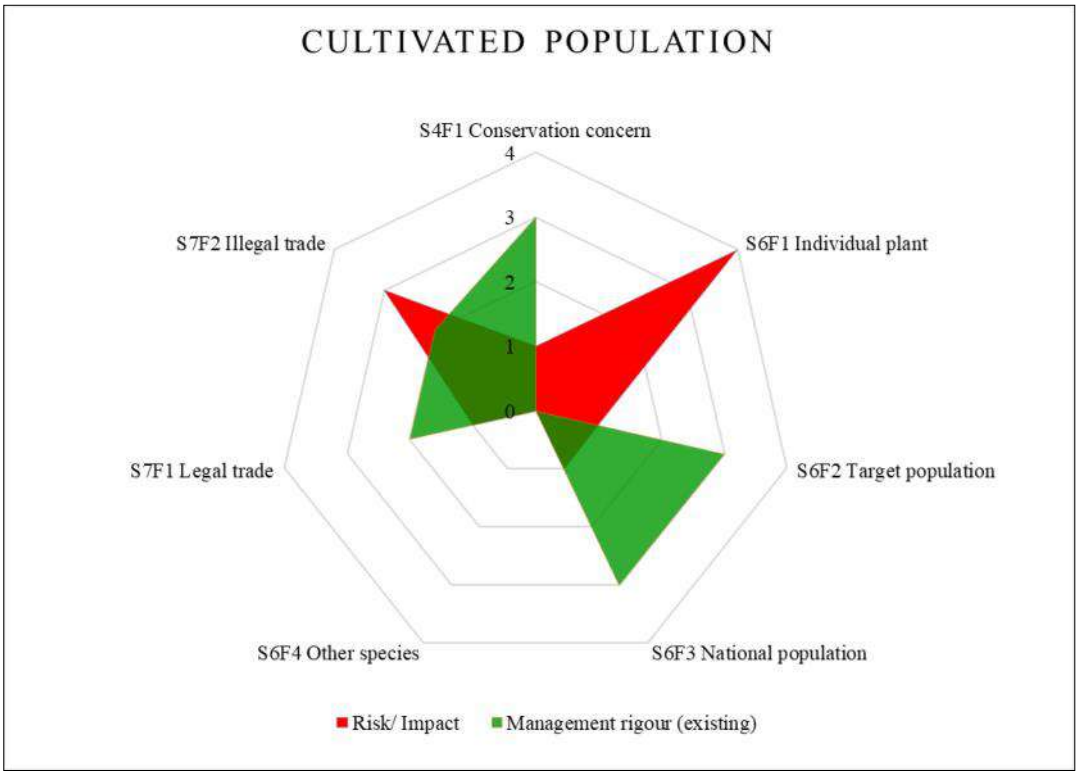
The management measures were not adequate in the past to reduce the severity of the wild harvest and trade. However, the Government of India and the state governments of some of the major harvesting states and Range States took several positive managements measures in recent years. The Assam and Tripura Forest Department started re-introduction of the species in some of the Protected Areas. Similar efforts are needed by other Forest Departments where the species occurs in its natural habitat. More strictness should be imposed by the Government for protection of the remaining wild plants. The Forest Department must ensure that no illegal harvest of agar plants is taking place from wild or Protected Areas and Reserve Forests.

The management measures are much better now than the past to reduce the severity of the plants under cultivation due to harvest and trade. India has more than 139.89 million plants under cultivation, and the annual harvest and trade volume is lower than the available harvestable trees. Two major harvesting states *viz*., Assam and Tripura have already implemented agarwood policies. The notification of annual export quota and legalization of the trade and export by the Management Authority based on NDFs assessment, promotion of agarwood cultivation and trade, initiation of online/ offline registration of plantations and agarwood-based industries are some noteworthy measures taken by the state Government of Assam towards better management. The State Forest Department of Nagaland and Tripura also started registration of agarwood plantations. However,

the Forest Departments, especially of the major harvesting states/ range states, should prepare detailed inventories of agarwood plants occurring in their forests and non-forest areas based on field survey with geo-coordinates on priority basis. This will also strengthen the traceability mechanism of agarwood plants to be harvested for trade and export.



Spider / radar plot: Comparison of evaluation of risks of detrimental harvest (Steps 4–7) to evaluate the management rigour (Step 8) for wild populations of *A. malaccensis*.



Spider / radar plot: Comparison of evaluation of risks of detrimental harvest (Steps 4–7) to evaluate the management rigour (Step 8) for cultivated populations of *A. malaccensis*.

STEP 9: NON-DETRIMENT FINDINGS AND RELATED ADVICE

NDFs decision

Negative for wild population.

Positive for cultivated population.

NDFs advice

* No harvesting of plants or collection of seeds/ seedlings/ saplings and other propagules should be allowed from the existing wild populations or plants in the Protected Areas (PAs) and Reserve Forests (RFs). However, the collection of seeds and seedlings from the wild should be permissible only to the Forest Departments, which must be limited to the amount necessary to maintain the vigour and productivity of the cultivated parental stock.
* Harvest should be allowed from home/ community gardens, plantations on leased/ patta lands, private or community plantations, or any other types of small-scale/ large-scale plantations.
* The previous export quota was established for the financial year 2021–2024. We recommend the following **annual** export quota for the financial year **2024–2027**.

- **Agarwood chips and powder/ saw dust (non-exhausted) (HS Code 12119080): 1,51,080 kg/ year**
- **Agarwood oil (HS Code 33013010): 7,050 kg/ year**

The new quota estimation is based on extensive surveys in range states and all other agarwood cultivating states of the country which recommends increase of annual export quota of around 6 times for agarwood chips and powder/ saw dust, and 4.7 times for oil, than the existing quota.

Principles applied for fixing the annual export quota

Step 1: Total number of plants (> 2 years old/ 10 cm GBH) = **139.89 million (13.989 crore)**

Step 2: Number of infected plants (natural + artificial; 20% of the total plant considering the entire country) = **27.978 million (2.7978 crore)**

Step 3: Number of harvestable trees (9% of total infected plants considering the whole country) = **2.51802 million (25.1802 lakh)**

Step 4: 10% (by considering the rotation of 10 years for harvesting) of the total number of harvestable trees = **0.251802 million (2,51,802)**

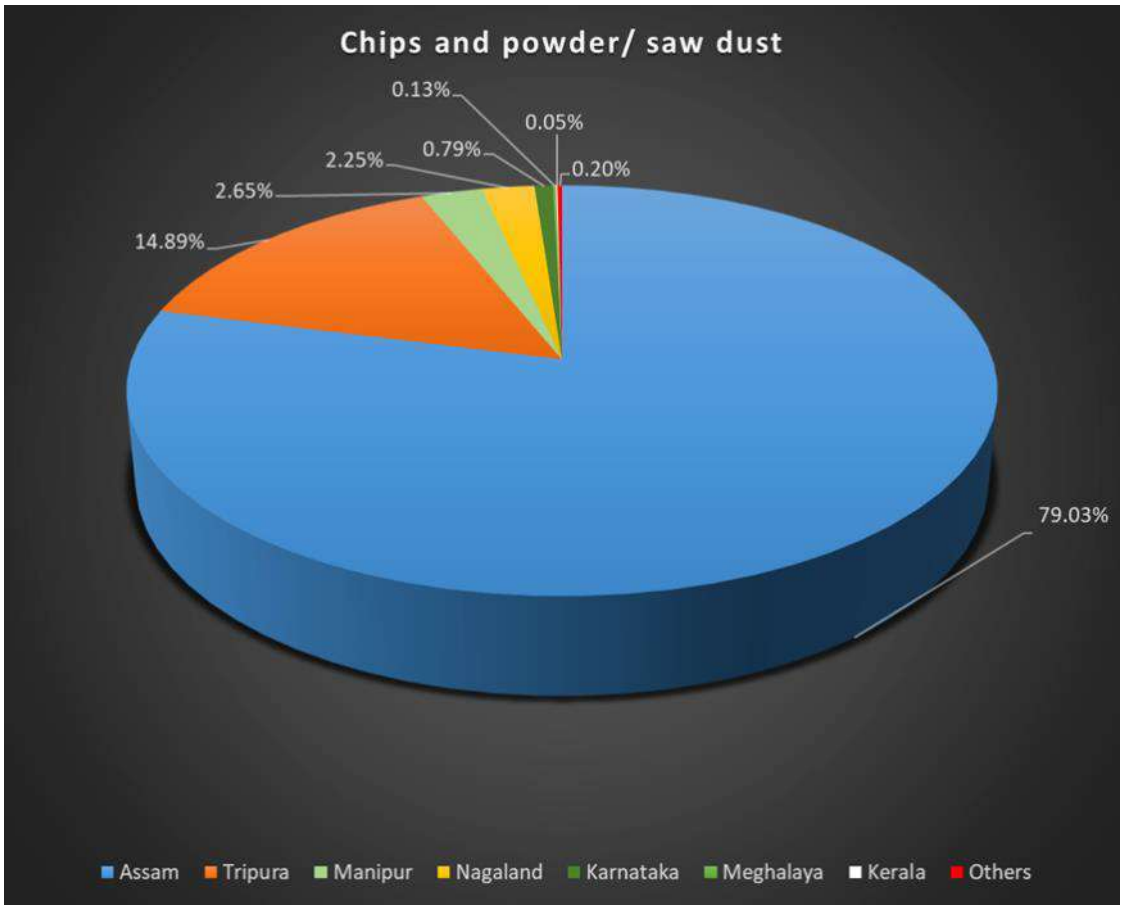
Step 5: Average yield per harvestable tree (considering the entire country) = **600 g of chips/ powder/ saw dust (non-exhausted), 28 g of oil (including all types and grades of oil)**

Step 6: Total yield = **1,51,081 ≈ 1,51,080 kg of chips and powder/ saw dust (non-exhausted), 7,050 kg of oil**

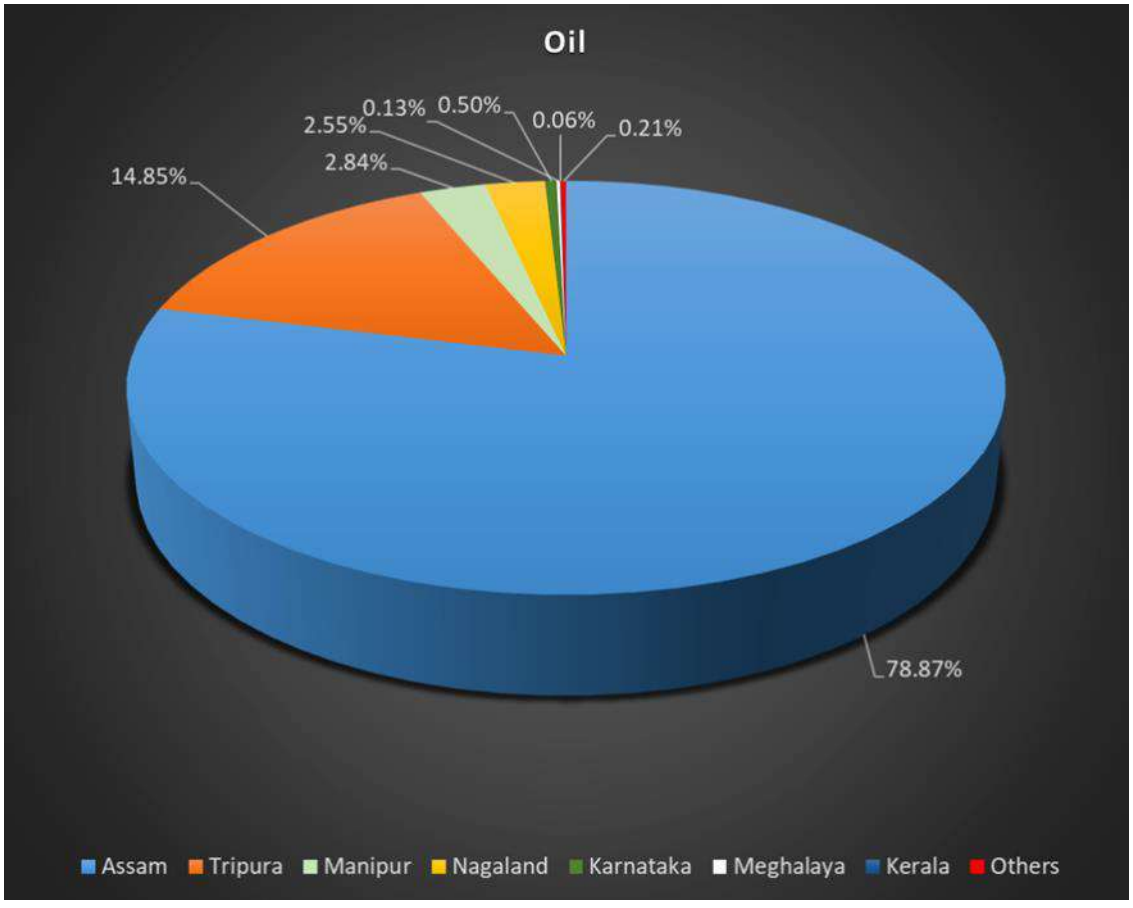
Though the yield of agar chips in some parts Northeast India is higher for a well-infected mature tree of more than 10 years of age, here the average yield per tree is set to 600 g for establishing the export quota by considering the entire country and also by observing the fact that presently the harvest is being done even from the less infected plants below the standard harvesting age (giving less yield) in many parts of the major harvesting states.

The quota proposed here for individual harvesting states is not only according to the total estimated number of cultivated plants but also based on the total number of harvestable trees, region-based average yield, harvest trend, production capacity, export trend, etc. The state-wise quota for all other states is collectively included in 'Others' because the harvest in these states is comparatively very less. The Management Authority may manage the export from the remaining quota [300 kg of chips/ powder/ saw dust (non-exhausted), 15 kg of oil] on a case-to-case basis.

Name of the State	Proposed state-wise quota
Assam	1,19,400 kg of chips/ powder/ saw dust (non-exhausted), 5,560 kg of oil
Tripura	22,500 kg of chips/ powder/ saw dust (non-exhausted), 1,047 kg of oil
Manipur	4,000 kg of chips/ powder/ saw dust (non-exhausted), 200 kg of oil
Nagaland	3,400 kg of chips/ powder/ saw dust (non-exhausted), 180 kg of oil
Karnataka	1,200 kg of chips/ powder/ saw dust (non-exhausted), 35 kg of oil
Meghalaya	200 kg of chips/ powder/ saw dust (non-exhausted), 9 kg of oil
Kerala	80 kg of chips/ powder/ saw dust (non-exhausted), 4 kg of oil
Others	300 kg of chips/ powder/ saw dust (non-exhausted), 15 kg of oil



State-wise allocation of the annual export quota for agarwood chips and powder/ saw dust



State-wise allocation of the annual export quota for agarwood oil

* Registration of the agarwood trees before their felling is essential for effective management. It will help to determine the annual export quota more efficiently and explicitly. The registration process should be simple, less time-consuming. The Assam, Nagaland and Tripura forest departments initiated the registration process. The other growing states should take similar initiative.
* Registration of agarwood processing units and agar-oil extracting/ distillation units should be made compulsory in all the harvesting states.
* Registered agarwood co-operative societies should be formed in the significant harvesting states, which can facilitate the farmers/ growers to sell their products to the legal vendors at suitable price and also guide them in obtaining relevant permissions/ certificates and CITES permits for export.
* The Forest Departments of the Range States should take initiative for raising healthy seedlings/ saplings from authentic and good-quality seeds. It is also suggested that private nurseries should procure high-quality seeds only from government authorised suppliers.
* Agarwood cultivation in the area outside Range States (especially southern India) needs monitoring and support by the respective state Governments. Several agarwood cultivators face high loss after good monetary investment due to growing poor quality seeds/ seedlings, failed artificial inoculations and false promotion. Hence, grassroot-level awareness programmes on procurement of quality planting materials, cultivation, artificial inoculation methods, harvesting and processing, marketing, and trade are required.
* Importing and exporting agarwood chips, oil, and logs/ timber should be monitored, verified and controlled to minimise informal trade. If the import and export is not controlled, increasing the legal export from India will be challenging despite having sufficient export quota.
* The north-eastern states, especially Assam and Tripura, are the primarily producers of agarwood chips, oil and other agarwood products. The Islamnagar market in Hojai (Assam) is the largest agar market in the country, with more than Rs. 1 crore average turnover per day. The Government of Tripura has also taken some initiatives for developing a similar type of market in Kadamtala, North Tripura. Although these north-eastern states are the primary producers, no international exports are allowed in any of the international airports of these states. Presently international export of agar is allowed only through Mumbai, Kolkata, Kochi, Delhi, Chennai, Tuticorin, and Amritsar airports. Hence, to facilitate the business and reduce the long trade chain, the Lokpriya Gopinath Bordoloi Airport, Guwahati and the Maharaja Bir Bikram Airport, Agartala, may also be permitted for exporting agar produce.

* An Indian standard of agar oil (with an Indian Agar-mark) based on quality and chemical properties should be established scientifically using Gas Chromatography-Mass Spectrometry (GC-MS), High Performance Thin Layer Chromatography (HPTLC), etc. and should standardize the price accordingly. Testing laboratories accredited to National Accreditation Board for Testing and Calibration Laboratories (NABL) may be established at least in Guwahati and Agartala to ensure fixed grade-based pricing.

* Based on the genetic diversity analysis of *Aquilaria malaccensis*, it is not advisable to use seeds/ progenies from the plantations located in the Darjeeling and Jalpaiguri districts of West Bengal and the Shivamogga and Uttara Kannada districts of Karnataka for future cultivation and breeding purposes because of expected low genetic variability in these genotypes. To overcome this issue, it is also suggested to establish seed orchards to raise diverse germplasm, close to the private/ departmental nurseries that are engaged in seedling production for commercial purpose.

* To restore the wild population of *A. malaccensis* in its native habitat (*in-situ*), the concerned state Forest Departments should make a significant effort to regenerate the plants inside the Protected Areas/ Reserve Forests/ Community Reserves from the seeds obtained from the existing wild populations by involving indigenous communities, Self-Help Groups, and NGOs. As part of the *ex-situ* conservation, field genebanks can be set-up at various experimental gardens.

* *Aquilaria khasiana,* another agarwood producing species found in wild*,* is reported to be endemic to India, which has a very restricted and fragmented distribution. During the present study, only a few plants were found growing in forest regions in Mawsynram, East Khasi Hills of Meghalaya and in Joypur Reserve Forest, Dibrugarh district of Assam. Strict monitoring and protection of these wild stands of *A. khasiana* in their native habitats is essential to prevent extinction of this Critically Endangered species.

* For the effective re-assessment in future the Forest Departments are suggested to prepare up-to-date inventories of *A. malaccensis* with traceability mechanisms for their respective states, both for the plants occurring in wild, Protected Areas, Reserve Forests and for the plants growing outside the forests (plantations), including private lands.

Agarwood trees in a
home-plantation in Nagaland

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An artificially infected tree in Karnataka

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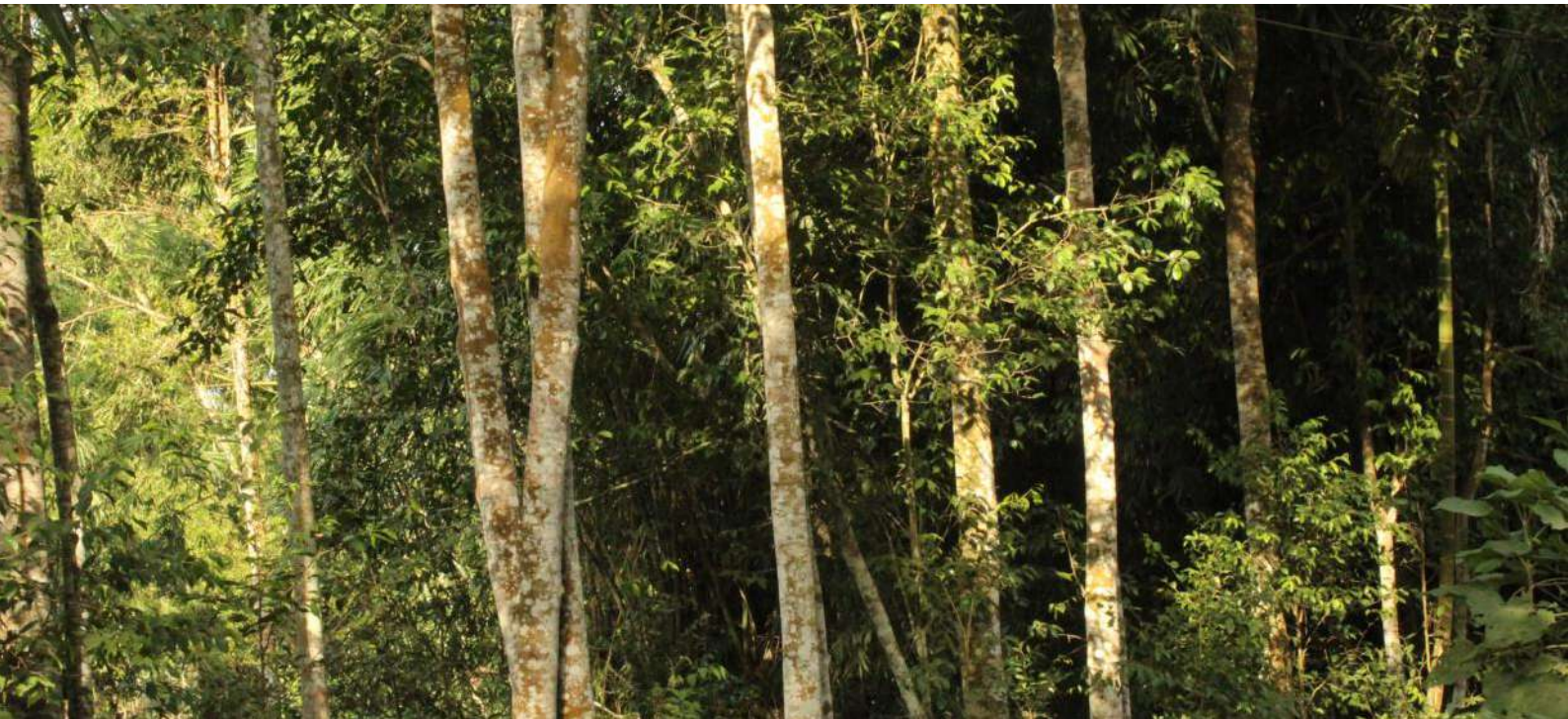

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