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NON-DETRIMENT FINDINGS (NDF) OF *Aquilaria malaccensis* FROM INDONESIA

Ministry of Environment and Forestry

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National Research and Innovation Agency

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Background

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is one of the international agreement bodies controlling international trades of endangered biota. This convention regulates international trade by listing them in its Appendices I, II, and III. All member countries must follow all CITES rules and ensure that their export of species listed in CITES appendices comply with CITES regulations. Indonesia has been a member of CITES since 1978 and is therefore obligated to follow CITES regulations regarding the international trade of species listed in its appendices.

CITES has listed *Aquilaria malaccensis* in Appendix II since 1994. The main reason for the listing was large numbers globally, and their sustainability has become a global concern. The conservation status of this species in the International Union for Conservation of Nature's Red List (IUCN Red List) was classified as critically endangered (CR).

Aquilaria malaccensis is one of agarwood species which is the trade name of a resinous product from the infected trees. The trees were infected by fungus known from the genus Fusarium, Baryodiplodia and Pythium. Rahayu et al. (1998) also reported that seven fungus infected agarwood producing trees had been isolated from various locations in Indonesia such as Acremonium, Diplodia, Fusarium, Libertella, Scytalidium, Thielaviopsis, and Trichoderma. The use of agarwood is in various ways such as for medicine (especially in China and India), perfumes and incenses (particularly in Japan, Middle East and Arabic countries) and for insect repellant (in many countries) as well as for preservative other products and accessories.

The NDF assessment follows the Guidance for CITES Scientific Authorities: Checklist to assist in making non-detriment findings for Appendix II exports" (Rosser & Haywood, 2002) with several modifications.

1. Biological Characteristics

1.1. Lifeform and growth

Generally, *Aquilaria malaccensis* is a tree which attains a height of 25-50 meters and a diameter of approximately 60 centimeters. The trunk is monopodial and straight, occasionally featuring buttresses. The bark is smooth, exhibiting thin cracks, and is gray-brown in color, while the inner bark is white, and the sapwood is yellowish-white to light brown. A recent study documented the largest known individual of *A. malaccensis* in Giam Siak, Sumatra, measuring nearly 1 meter in diameter and 35 meters in height.

The leaves of *A. malaccensis* are oval to ovate, thin, and glabrous, measuring 5-14 cm in length and 2.5-5 cm in width. They exhibit an acuminate apex and an acute to obtuse base, with margins that are undulate. The adaxial (upper) surface is dark green, while the abaxial (lower) surface is a lighter green and may occasionally be pubescent. The petioles are 4-6 mm in length and can also be hairy. The secondary veins are irregularly pinnate, comprising 12-16 pairs that are distinctly visible on the adaxial surface, with the veins on the abaxial surface being finely pubescent.

The inflorescences of *A. malaccensis* are umbellate and emerge at the terminal ends of twigs, beneath the leaf axils, and above the petiole axils. Each inflorescence typically comprises 2-3 branches, with each branch bearing approximately 10 flowers. The peduncle

length ranges from 5-15 mm. The flowers are tubular, measuring 5-6 mm in length, and exhibit a yellowish-green hue. The pedicels are 3-6 mm in length. The inner surface of the floral tube is glabrous, whereas the outer surface is pubescent.

The reproductive cycle of this species begins when the trees are approximately 5-6 years old (Sitepu et al., 2011). Flowering typically commences at an age of 6-7 years, when the stem diameter reaches about 10 cm, with a single fruiting period yielding up to 1,000 seeds (Soehartono and Newton, 2001a). Mulyaningsih and Yamada (2007) reported in wild population, *A. malaccensis* start to produce flower and seed at > 20 cm diameter, or between 6 - 10 years after planting, are reported to produce thousands of seeds during one seasons fruiting periods

Fruit maturation occurs variably among individual trees, generally observed in trees with a trunk diameter of around 35 cm (Paoli et al., 2001). In Sumatra, the flowering and fruiting periods of agarwood-producing species occur between August and October, although some trees may flower and fruit in May. In contrast, in Kalimantan, these periods occur between January and May. The fruit is a smooth, ovate capsule measuring 2.5-3.5 cm in length and 2.5 cm in width, with a blunt apex and a narrow base. The pericarp is thick and glabrous, and the fruit is borne on a pedicel approximately 1 cm in length. The seeds are ovoid and black, measuring about 10 mm in length and 6 mm in width, with a distinctive curved base resembling a bushy tail that is red in color. Typically, each fruit contains 1-2 seeds.

There is no special study on growth rate of the agarwood-producing species has been conducted for the wild population. Six years diameter measurement of the 2 Ha permanent plots for forest dynamic studies in West Kalimantan, revealed that the annual growth rate for *A. malaccensis* is 0.5 cm/year. Diameter measurement of the planted *A. malaccensis* conducted in Bengkulu, Sumatra showed that the annual growth rate for the early stage is about 2 cm/year (Asgarin, 2004). A small plantation trial of *A. malaccensis* trees has been conducted both inside and outside the forest to obtain insight requirements of these trees in regards to soil, drainage and lights demands (Wulffraat, 2006). This study revealed that the growth rates of both height and diameter increment is fastest with the *Aquilaria* trees planted in open areas. A mean tree height of 4.8 cm by the end of 2002 and 5.45 cm with 10.1 cm in diameter by November 2003.

1.2. Regeneration ability

Flowering season of agarwood-producing species start at early of dry season and fruiting have occurred in the end of dry season (Ding Hou, 1960). In West Sumatra, fruiting seasons of agarwood in April-Mei (pers. comm.). Based on a field survey carried out by the researcher of Indonesian Institute of Sciences (now: BRIN), *A. malaccensis* produces fruits from sapling stage at < 10 cm diameter. Paoli et al. (2001) recorded that in natural forest in Kalimantan, reproductive maturity starts at approximately 35 cm dbh.

Since Soehartono and Newton, (2001a) said that the seed production of *Aquilaria* will decline above dbh of approximately 40 cm. It was recorded that at least one thousand fruits were produced by a 10 cm in diameter individual of *A. malaccensis* planted in Bogor. The number of fruit production increases accordingly with diameter growth, individuals with 30 cm in diameter produce at least 3.000 fruits (Partomihardjo-pers. comm.). Seed production of *A.*

malaccensis peaked at a dbh of approximately 40 and 50 cm respectively. At the optimum producing stage an individual tree is able to produce up to 19.000 seeds in a single season. Seed viability is about one week and germination takes place between 15 – 60 days.

As a minor component of forest community, trees of agarwood producing species have poor stocking seedlings revealed from natural regeneration. From demographic study of primary forest revealed no saplings stage was recorded within two permanent plots of primary forest at Betung Kerihun National Park, West Kalimantan (Suzuki et al. 2003), but data from Muller in central Kalimantan expeditions conducted by Bogor Botanic Garden reported that some seedlings and saplings have been found near mother tree. Paoli et al. (2001) reported that there are several seedlings and saplings near adult trees, especially at a distance of 20 m.

Propagation of *A. malaccensis* can be achieved vegetatively through methods such as grafting, cuttings, uprooting, and tissue culture utilizing shoots, as well as generatively using seeds. Agarwood seeds are classified as recalcitrant, meaning they have a short viability period and rapidly lose their germination capacity if stored for extended durations. Germination of seeds occurs within 15 days under light intensities of approximately 60-80%, necessitating the shade provided by the parent tree (Soehartono and Newton, 2001b). Cultivation of *A. malaccensis* has been undertaken in various regions, including West Kalimantan, East Kalimantan, South Kalimantan, Riau (Pekanbaru), Jambi (Sorolangun Bangko), South Sumatra (Palembang), West Java (Bogor), and Banten.

1.3. Dispersal efficiency

The genus *Aquilaria* have interesting dispersal modes. From their seeds which are tangled from the apex of the fruit valve, on filiform funicles, glossy dark colored and possessing tails or other aril like structure indicated for zoochorous dispersal mode (Ding Hou, 1960). However, no observation has as yet revealed more exact data on its functioning. From its feature is no doubt to mention that for the far distant dispersal, seeds of these plants have been dispersed by birds. This phenomenon has been shown by the wild population of *Aquilaria* within old traditional rubber plantations in Sumatra and Kalimantan as well. Several field studies informed that most seedling (65%) of these species occurred within 5 m distance under the mother tree, indicating limited dispersal system.

Habitat

Generally, *A. malaccensis* can be found in forests from lowland up to submontane ecosystems at the elevation 0-1000 m. It grows in areas with 20-33 ºC temperature, 60-100% of humidity, 56-75% light intensity, 0-50% of slope, 6.4-7 of soil pH, and 10-75% of soil humidity, with rain intensity 1.200-2.000 mm/year (Kessler dan Sidiyasa 1994; Sumarna, 2008; Pribadi, 2009; CITES, 2003 & Harvey-Brown, 2018). This species may grow in rocky, sandy, or calcareous soils, well-drained slopes, and ridges, or areas near swamps. This species can also occur as an emergent tree (Page & Awarau, 2012). The suitable areas have *acrisols*, *ferralsols*, *gleysols*, *histosols*, and *nitosols* types of soil.

2. Distribution and Population

2.1. Distribution

In Indonesia, *A. malaccensis is distributed* in the western part of the country i.e., Sumatra and Kalimantan. However, based on the herbarium specimen, this species also recorded from small islands near Sumatra, i.e., Bangka, Belitung, Karimun and Singkep. Agarwood *A. malaccensis* may be found in the forest (state forest and community forest) or non-forest areas. At the state forest area, this species grows both in the conservation area (e.i., natural reserve or national parks) and in the production forest. In the past, people hunted agarwood only in the production forest of Kalimantan and Sumatra and spent weeks to months. The resulting gathering is known as wild agarwood.

Based on our study using a species distribution model by maximum entropy algorithm, we found that the suitable habitat for *A. malaccensis* in Indonesia is around 26.45 million ha and moderately suitable around 30.48 million ha (In-prep, 2023). According to the World Database on Protected Areas, approximately 11.17% of suitable habitats and 12.36% of moderately suitable habitats are located within conservation areas. The remaining habitats are situated in non-conservation areas such as plantations, agricultural lands, or settlements. These suitable habitats have soil types including acrisols, ferralsols, gleysols, histosols, and nitosols. These findings indicate a substantial amount of suitable land is available for establishing new agarwood plantations in the country. Our analysis and mapping of the distribution of *Aquilaria malaccensis*, based on herbarium specimen records, shows an Extent of Occurrence (EOO) of approximately 1,874,073.689 km² and an Area of Occupancy (AOO) of around 364 km² (Figure 1).

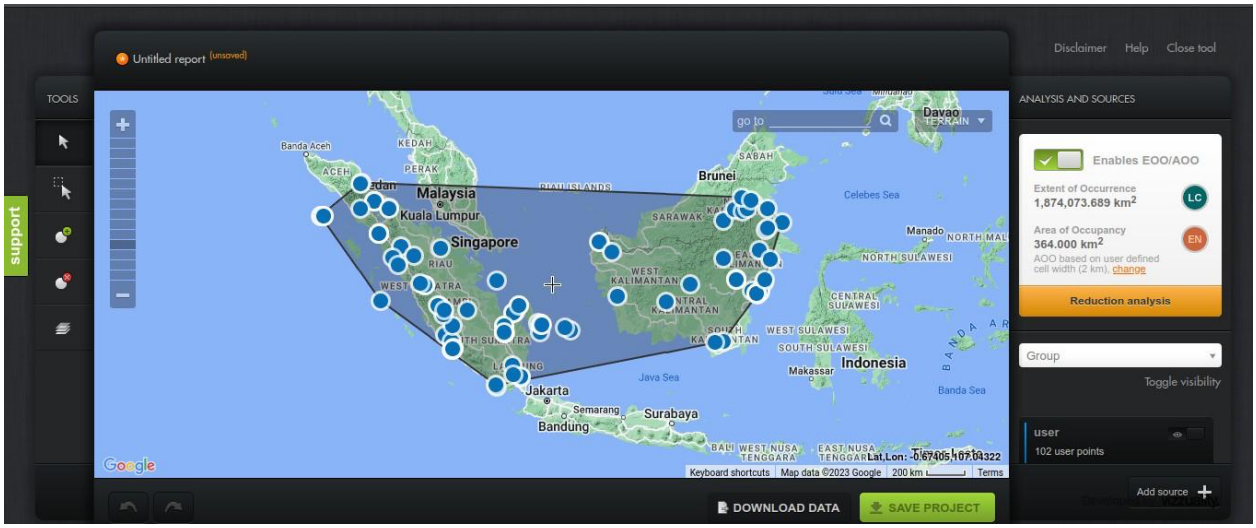

Figure 1. The Extent of Occurrence (EOO) and Area of Occupancy (AOO) of *Aquilaria malaccensis*

2.2. Population Density

The information on population size in the natural habitat is scattered and is still limited because Indonesia is a large archipelagic country. The estimation of *A. malaccensis* is based on literature reviews, the data from temporary field excursion carried out by a scientist group, and a combination direct survey which was conducted by local officer (BKSDA). The population of *A. malaccensis* in general is relatively low since these species are known as a minor component of the forest community.

Based on the latest our study in 2023 in some locations in East Kalimantan, it could estimate that the population density is approximately 1-3 individuals/hectare (unpublish reported, pers. comm). With an estimated density of 3 individuals per hectare (ind/Ha), the quota of 24,110 kg can be sourced from non-conservation areas spanning approximately 2,708,413.2 hectares. This area constitutes approximately 11% of the total non-conservation area across Aceh, West Kalimantan, Central Kalimantan, and East Kalimantan provinces (totaling 24,186,007.29 hectares). Therefore, in 2024, the quota for source code W has been set at 24,110 kg, marking a 74% decrease from the W quota allocated in 2023 that was allocated 95.500 kg.

Indonesia decided and has been reported to the Secretriat in 2024 an annual export quota of 24,110 kg from the wild. It brings sustainability for the existence of this species since this constitutes of only 0.00011% of the total population, while regeneration rate per year of *Aquilaria malaccensis* is 10%, hence the increase of the population per year is 9.99%.

Over the past 15 years, research indicates that the wild population density of A. malaccensis in various regions of western Indonesia ranges from 0.5 to 10 individuals per hectare. These studies were conducted in state forest areas, including both conservation and non-conservation zones. A survey in Berau, East Kalimantan (Abdurrachman et al., 2009) identified 29 trees within a 48-hectare area, resulting in a density of approximately 0.61 individuals per hectare. The maximum observed tree diameter was 44.7 cm, with the minimum diameter exceeding 10.0 cm. The average annual diameter increment was 0.40 cm (± 0.402 cm), with a maximum growth rate of 0.64 cm per year for trees in the >40 cm diameter class. Another study (Sumarna, 2008) in Tabir Ulu District Forest, Merangin Regency, Jambi Province, found seven trees per elevation distribution group (<100 m, 200 m, >200 m), with an average of 287 seedlings per parental tree (20.3 m² crown canopy). In Rojolelo Forest Park, Bengkulu, Sumatra, there were 11 *A. malaccensis t*rees with diameters up to 50 cm and 200 seedlings per parental tree (Partomihardjo et al., 2010). Furthermore, Pribadi (2009) reported 37 locations of wild A. malaccensis in Kutai National Park, within a 4,883.75-hectare area. It was observed that the number of mature stands is consistently lower than younger stages, likely because this species requires shade during the seedling stage but needs adequate sunlight as it grows taller.

The size of the wild population of *A. malaccensis* in several areas in western part of Indonesia ranged from 1 to 10 individuals per hectare. The research was conducted in state forest areas, both in conservation areas and non-conservation areas. A population survey in Berau, East Kalimantan (Abdurrachman, et.al., 2009) showed that there are 29 trees in total area 48 ha or it had density approximately 0.61 ind/ha. The maximum diameter of the *A.*

malaccensis tree was 44.7 cm while the minimum diameter was above 10.0 cm. The average diameter increment was 0.40 cm (± 0.402 cm) per year. Meanwhile, the maximum growth was 0.64 cm per year for diameter class >40 cm. The other survey (Sumarna 2008) in Tabir Ulu District Forest, Merangin Regency, Jambi Province found there were seven trees per unit group of elevation distribution (<100 m, 200 m, >200 m) of *A. malaccenssis* and the population potency of seedling at nature average from each parental tree mean amount to 287 seedling (20.3 m^2 crown canopy). The survey in Rojolelo Forest Park, Bengkulu, Sumatra showed there were 11 trees of A. malaccensis which the diameter is up to 50 cm and 200 seedlings in each parental tree (Partomihardjo et. al, 2010). Furthermore Pribadi (2009) stated that in Kutai National Park there were 37 points of wild *A. malaccensis* in an area of 4,883.75 Ha. The number of mature stands is always less than younger stages, considering that this species needs shades at the seedling stage but requires sufficient sunlight as they grow taller.

3. Threat Status

The major threats to *Aquilaria malaccensis* are as follows:

a. There are non-official reports of Illegal harvest from the community that live around the forest area. However, its trends have been declining due to the lower return and higher uncertainties of product availability compared to capital invested. On the other hand, forest rangers are increasing their patrols where the species occurred and monitors product distribution.
b. Lowland forested areas where the species were naturally distributed were converted to mining concessions, palm oil plantations, farms, and settlements.
c. Fungal and pest attacks, (esp *Heortia vitessoides*) were observed in several nurseries which were dedicated for replanting and farming areas. However, studies have shown that certain practices have effectively managed these threats.

These major threats were considerably managed due to great exposure on the species' products. Authorities have been promoting and supporting the species cultivation in various types of land use over the last decade. Local authorities have developed several Forest Management Units (FMU/KPH) to reinforce agarwood production with mixed planting strategy in palm plantation, community's forest and farms.

4. Harvest Management

Annual CITES quotas are set by the Directorate General of Conservation on Natural Resources and Ecosystem as the Management Authority based on the SA information. The scientific information is used as an essential basis for reviewing and verifying the quota submitted by each province. Such considerations include: 1) the natural distribution of the species; 2) the trend of quota realization in the last 5 years; 3) socio-economic aspects; 4) the legality of the traded agarwood and/or the wood products. Since the scientific information is limited, the quota is set under a very strict condition following a precautionary approach

Quotas for CITES traded commodities are set with the aim to minimize the impact of the harvest to the natural populations. The annual total quota of of *A. malaccensis* is set based on: 1) the submission of the export quota by the province where the natural distribution of *A.*

malacensis is located, 2) the Scientific Authority (SA) taking into account the latest availability of data and information of the targeted species, 3) the issues of quota recommendation by the Scientific Authority (SA) to the Management Authority (MA), 4) Decision of final quota export by the Management Authority (MA).

In the process for setting the quotas, the CITES Scientific Authority invited broad stakeholders such as experts from a wide range of disciplines, including scientists from other research organizations, universities and NGOs. Once initial quotas are set,SA submits this quota to MA that compiles the final quotas into an Annual Decree on the national totals for allowable harvest and trade.

5. Management

5.1. Quota

Species management of *A. malaccensis* exported with source code W is implemented by imposing an annual quota. The quota is set based on available information on population, distribution, level of trade activities per province, indicated by previous years used quota and proposed quota for the following years. The mechanism of setting quota is outlined in Figure 2.

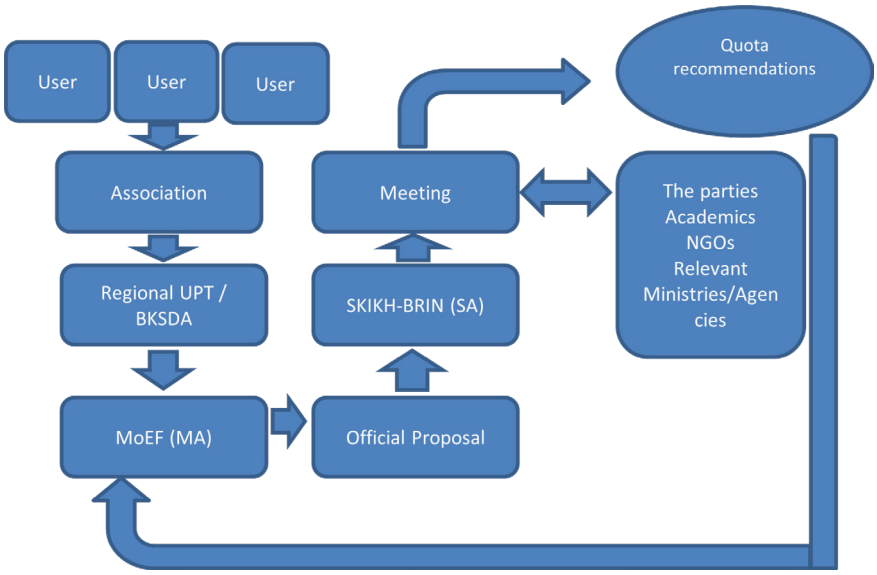

Figure 2. The Proposed harvested Quota of Wild Plant and Animal Species Flowchart

The quota is distributed to domestic permit holders who operate in specific harvest areas. Permit holders usually employ several registered agarwood hunters. These hunters are varied in skill, and can be categorized as forest and non-forest hunters. Those who operate in non-forest areas would differentiate between registered and non-registered plantations.

Based on Government Regulation No. 7/1999 on the Preserving Plant and Animal Species dan Minister of Environment and Forestry Regulation No. P.106/2018 on the Second Amendment to the Minister of Environment and Forestry Regulation No. P.20/2018 on Protected Plants and Animals, agarwood species is not listed as a protected species. However,

its utilization is regulated by Government Regulation No. 8/1999 on the Use of Wild Plant and Animal Species dan Minister of Forestry Decree No. 447/2003 on Administration Directive of Harvest or Capture and Distribution of the Specimens of Wild Plant and Animal Species.

Quota for *A. malaccensis* in the last five years are set to continuously be lower in the following years, in order to provide better opportunities for the natural regeneration of agarwood, to promote plantation or farmland. This initiative aims to improve the traceability of traded agarwood and encourage the utilization from plantation.

5.2. Monitoring of harvest

Following the aforementioned regulation, distribution of specimens of Appendix II species must be managed with a controlled extraction from the wild and a set of documentation (Figure 3). The annual national quota is set for each province by the management authority based on recommendation from the scientific authority. Figure 8 shows that those who gather agarwood are required to have a harvest/capture permit. Business actors carrying out domestic and foreign distribution are required to have a distribution permit. Such actors would have several registered gatherers. Since the annual quota is distributed to these workers, permit holders must report their activities to the government. Every transported specimen or product of appendix II species must be accompanied by a domestic transport document (SATS-DN) issued by the provincial unit of Ministry of Forestry (BKSDA), and a cross-border transport (SATS LN) or CITES permit issued by the Directorate General (DG) of Forest Protection and Nature Conservation, or (following nomenclatural changes) DG of Nature Resource and Ecosystem Conservation, in the event of export. Only permit holders who may apply such documentation (Figure 8).

In the case of agarwood from plantation, agarwood harvested from such areas will not be limited by an amount of quota. As long as the specimens are confirmed and verified by the field officer to have originated from that mentioned plantation, they may transport as much as the plantation could produce. However, those plantations must be registered and documented before harvesting, with a set of standard information as regulated in Directorate General of Forest Protection and Nature Conservation Regulation No. P.25/2014 on Administration of Agarwood Plantation Registration. Such documentation is deemed exhaustive by the locals, especially those in areas away from the provincial capital, which makes the progress of registration rather slow (Figure 8).

The administration of export requires further verification of other documents, i.e., phytosanitary certificates, export approvals from the Ministry of Trade and export/import notifications from the customs office. The process of document verification could be monitored by a website application called Indonesia National Single Window (INSW). The INSW is a single window service operated by an institution under the Ministry of Finance, to handle related export-import and/or national logistics documents electronically, which includes customs documents, quarantine documents, licensing, port/airport documents, etc. Whenever a documentation fails in the system, the process of permitting will not be continued.

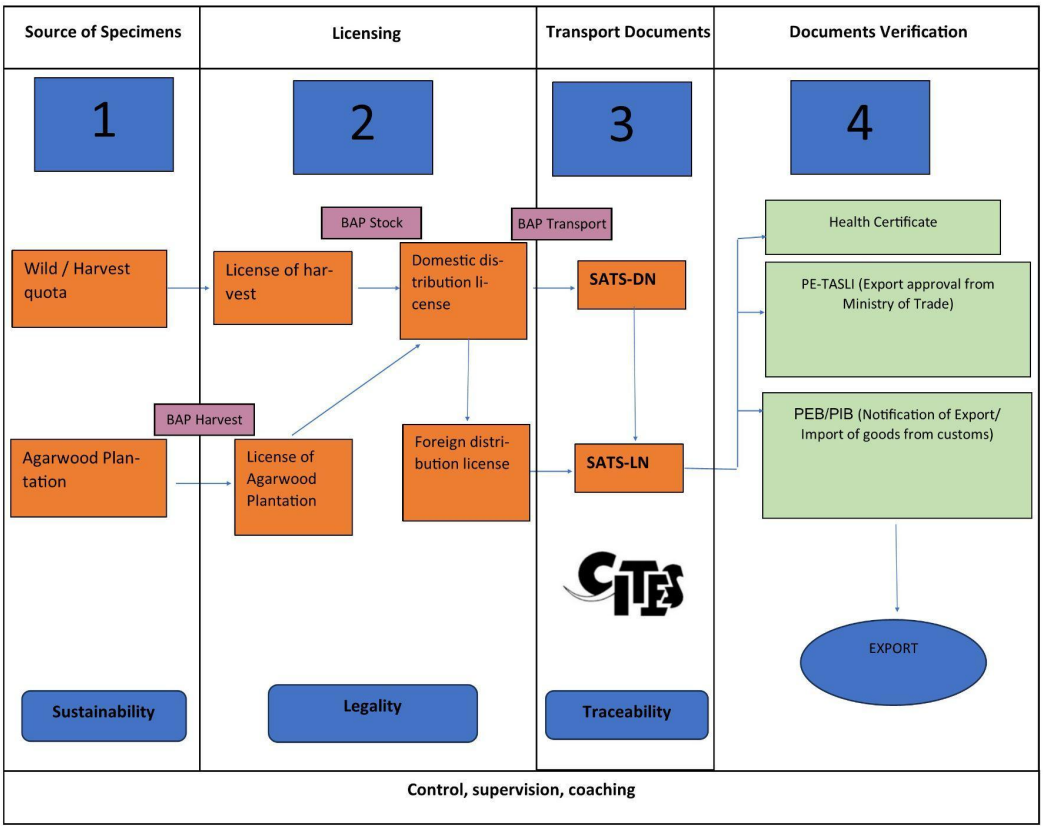

Figure 3. The management procedure under the national regulation.

CONCLUSION

The NDF study on agarwood producing species systematically followed IUCN Checklist of NDFs with modified (Rosser, 2008). The basis of the web chart is following Rosser and Heywood (2002). The following information gathering and research priorities were identified (Figure 4).

In the analysis, each indicator was evaluated based on 5 criteria, with scores ranging from 1 to 5, where 1 represents the lowest risk and 5 the highest. A radar plot was used to illustrate the scoring. Among the 18 indicators, 4 were identified as having negative impacts, with scores between 3 and 5, while the remaining 14 showed positive impacts, with scores between 1 and 2. The higher scores for the four indicators indicate potential negative effects on the management of *Aquilaria malaccensis* in Indonesia, highlighting the need for additional measures and regulations. The lower scores for the 14 indicators reflect positive impacts on the management of *A. malaccensis*, emphasizing the importance of maintaining these indicators for sustainable harvesting and trade. These all results indicates that the utilization of *Aquilaria mallacensis* is **not detrimental to the wild population** of agarwood *A. malaccensis*.

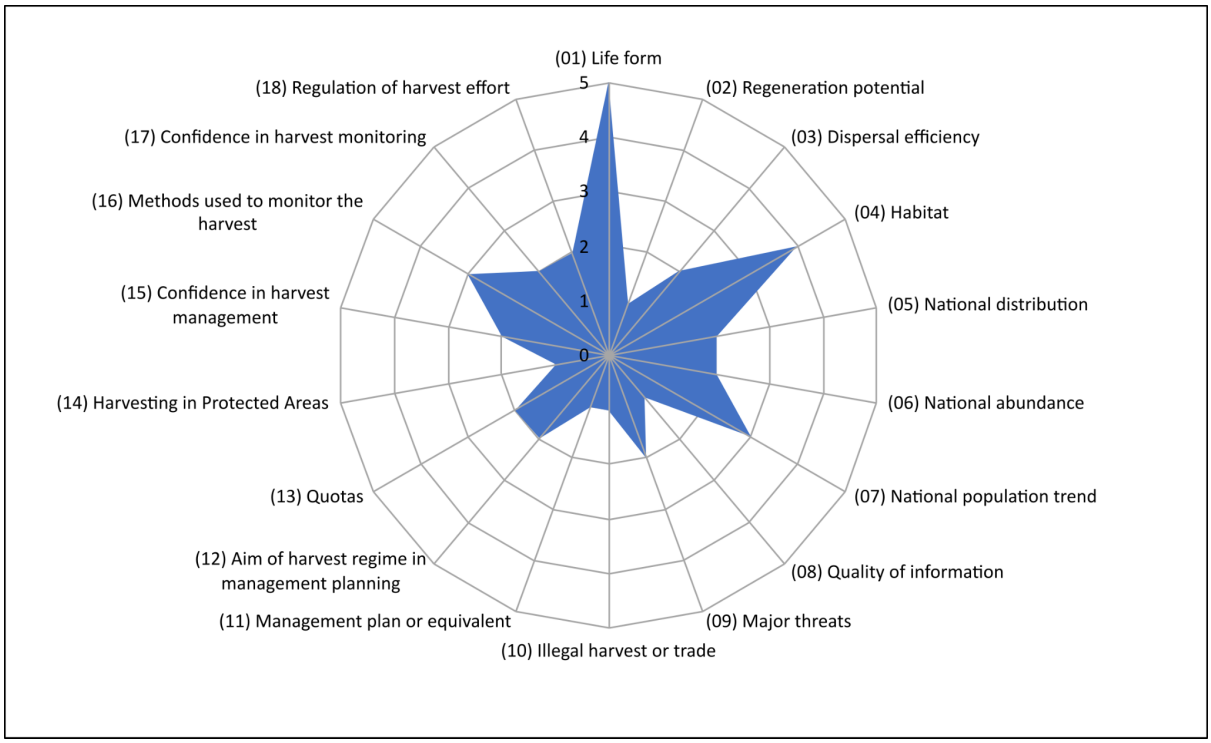

Figure 4. Radar plot of Non-detrimental Findings for *Aquilaria malaccensis* from Indonesia

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