Agarwood-planted tree inventory in Indonesia

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Abstract. Indonesia has as a country that has a high diversity of agarwood-producing trees (APT) species compared to other countries in Asia. Unfortunately, the populations of APT species have declined significantly. The purpose of this study was to record and maps the agarwood-planted trees in Indonesia as a baseline for future management of this species. The questioners were distributed to 31 of provinces in Indonesia. The feedback came from 21 prefectures (67.7%), consisting from 121 regencies (36.6%) those in detail came from 579 district, 1,257 villages and 4,757 farmers group. The major of APT species planted by farmer groups are *Aquilaria malaccensis, A. microcarpa,* and *Gyrinops versteegii*. The potency of APT in Indonesia is 3.4 million trees, consisting from 0.2 million tree with DBH > 20 cm and 3.2 million tree with DBH < 20 cm. The highest APT in Indonesia is located in Central Kalimantan (24.7%) followed by North Sumatera (17.9%). The prediction of agarwood products and its derivate will be obtained in 2020 with economic value might be reached 1.6 trillion rupiahs if the inoculation technique used the standard procedure recommended by FORDA. These results showed how huge the potential of APT will be developed in the future.

1. Introduction

In accordance to the very high demand of agarwood product in the global market, *Aquilaria* and *Gyrinops* as agarwood-producing tree (APT) have been listed in Appendix II of the Conservation on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 2005 [1]. The demand for agarwood is believe to keep increasing year by year because agarwood-based products have a high economic important to be transformed to many products such as digestive, sedative and antiemetic drug, and also as incense and perfume [2]. However, the production of wild agarwood has been facing to serious depletion by illegal APT harvesting in forest and also the rapid loss of tropical rain forest as their natural habitats [3]. Similar trend have been also happening in Indonesia and as consequences, will never meet the agarwood demand if it is still depend on the product from natural habitat.

High demand of agarwood product in the market is not followed by comprehensive understanding of it formation. The formation of natural agarwood is a mystic, complex and slower time process [4]. The formations are usually trigered by wounding of twigs or branches caused by wind, thunder,

mechanical hacking, slashing, cork boring, or wild animals [5]. Borer insects and caterpillars could also make a hole in the tree and trigger the agarwood formation. The condition then supported by the present of infectious fungi which are abundant in nature in the form of spores or hyphae, which is dispersed through water, wind and soil. Based on those hypotheses, we have been developed a bio-induction technology by using endophytic fungi and promoted agarwood formation in Indonesia [5] supported by FORDA, the Ministry of Environment and Forestry since 1984. Five years after that first induction, various quality of agarwood could be found into market.

The way to make meet between demand and production of agarwood, the sustainable mass planting of APT and bioinduction to obtained agarwood formation should be regulated well. Current condition showed that APT plantation in Indonesia are established in small-scale and run traditionally by farmers, hence they are still sporadic in its pattern of distribution and most are unrecorded. This situation is rather bit different compared to other Asian country [6]. The aim of this study was to record and maps the agarwood-planted trees in Indonesia as a baseline for future management of this species.

2. Methods

2.1 Data

Data were obtained from questioners, open discussion with agarwood farmers and direct field surveys conducted from April to October 2014. Questioners were distributed to 31 of provinces covering 329 of regencies and 25 natures reserve institution all over Indonesia archipelago. Other data were collected from discussion with key-person through direct interview. The key-persons were selected based on their intensive communication in attending technology-transfer of bioinduction organized by FORDA. Meanwhile, other data related to APT activities (cultivation method, APT species, etc) were collected by mean of field surveys in four representative location; West Kalimantan, Central Kalimantan, North Sumatra, and Riau Islands according to map in previous technical report [7].

2.2 Data Analysis and mapping

MS Excel were used to compile data based on APT species, diameter breast high (dbh), the age of the tree, and bioinduction treatment. The APT distribution, based on the number of its dbh classes > 20 cm and < 20 cm was plotted by using ArcView. The Indonesian spatial data map was downloaded from geospatial data gateway site (http://www.bakosurtanal.go.id/download-peta-rupabumi-indonesia-skala-1-1-000-00/, last accessed Feb, 30, 2014). The prediction of agarwood products was calculated by method describe by Turjaman et al. (2014) [7], after two years of inoculation to those of individuals with dbh > 20, agarwood will be formed and yield 2 kg of gubal A, 5 kg of kemedangan and 5 mL of agarwood oil.

3. Results and Discussion

APT in Indonesia may take from various ways, those: pure stand (monoculture), agroforestry (mixed with cash crops such as citronella, banana, lemon, guava, soursop, durian, etc). According to data collected in this study, there are 4,757 farmers groups have been establishing APT, which is distributed in 1,259 villages, 597 district, 121 regency and 21 provinces. The biggest APT plantation owned by farmer's group was found in Central Kalimantan which area covered of 140 ha; while the smallest was 0.1 ha. It is also common that APTs were planted as border trees delineating certain area of ownership. Contrasting with those of APT characteristics in other countries such such as Laos, Vietnam, Cambodia, Thailand, and Malaysia [8], APT in Indonesia are still purely traditional and those they were not integrated in its management.

3.1 APT distribution

Total population of APT in Indonesia is 3.4 million trees (figure 1). The highest potency of APT was recorded from Central Kalimantan (0.8 million trees), while the lowest was Jambi (818 tress).

Sumatera and Kalimantan Island contribute more than 85% of APT plantation in Indonesia and both islands are known as the main producer of wild agarwood, which called "malaccensis" as its trading name. People in both islands have been very familiar with the product becauses of its high economic values.

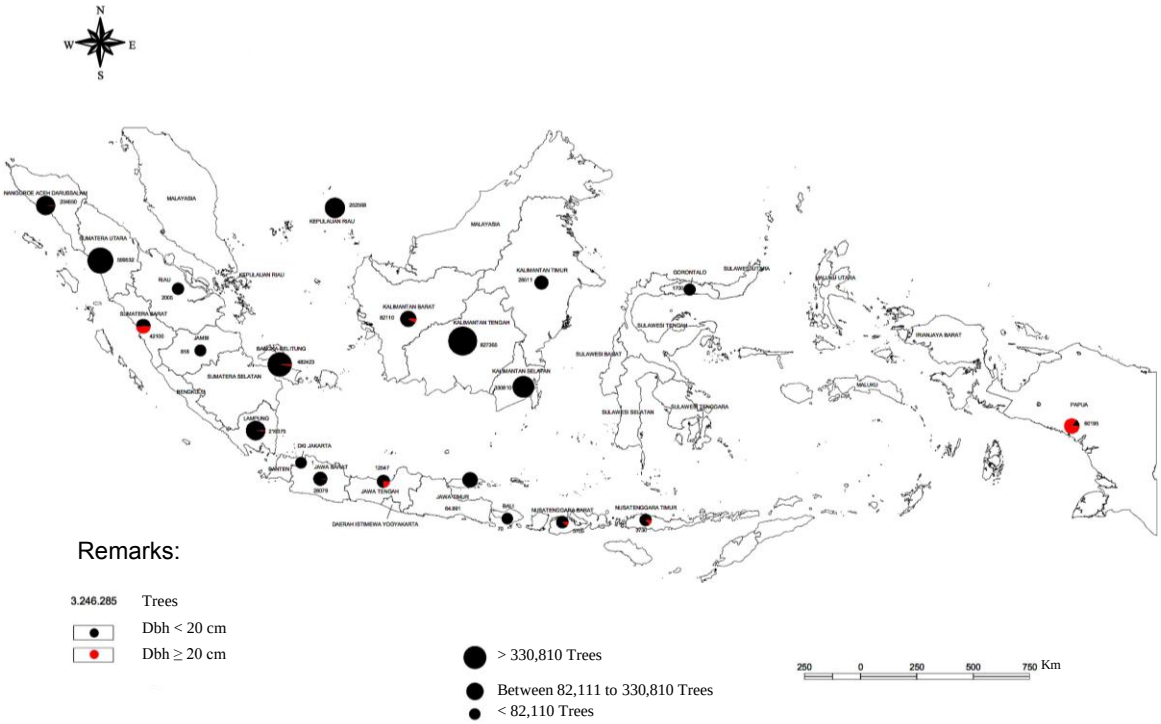

Figure 1. The potency of APT cultivation in Indonesia

The population of APT for each province was showed in the pie pattern; the bigger population of APT was indicated with the bigger of the pie pattern compared to each other. The size of dbh were categorized to be < 20 cm (black color), and > 20 cm (red color). The APT population distribution for each province is displayed in figure 1. The population of APT dominated by smaller one (dbh < 20 cm, 97%), totally. These indicated that farmers started to intensively plant APT for since 10 years ago.

Among those of APT species, *A. malaccensis* gains its popularity to be the APTS chosen in western Indonesia, followed by *A. microcarpa*, *A. beccariana* and *A. hirta*. In eastern Indonesia, *Gyrinops versteegii*, *A. filaria* and *A. cumingiana* are APT species which is having interest to be planted by farmers. Locally the species is known also as "*filaria*". The most familiar "*filaria*" species is *G. versteegii* which distributed in the island of Lombok, Flores, Sumba, Sumbawa, Celebes, Moluccas, and Papua [9]. Table 1 shows several species, which is commonly planted as APT with the high preference of the farmers were *A. malaccensis* and *G. versteegii* [10,11]. Furthermore, table 1 also shows the natural distribution and cultivation APT species in Indonesia. There are also exotic species were planted in very small scale by farmers groups in Deli Serdang – North Sumatera, which is include the species of *A. subintegra* and *A. crassna*. From the Table 1, we also can distinguish that APT of species *G. versteegii* have been widely planted to the western part of Indonesia.

Table 1. Distribution of APT species cultivation in Indonesia

No.	Scientific Name	Distribution	
		Cultivation	Natural
1.	*A. malaccensis*	West Java, Central Java, East Java, Bali, Bangka Belitung, Riau, Aceh, West Sumatera, North Sumatera, West Kalimantan, Central Kalimantan, East Kalimantan, and South Kalimantan	Bangka, Jambi, Riau and South Sumatra, Kalimantan, Sulawesi, Moluccas and Papua *
2.	*A. microcarpa*	North Sumatera, and South Kalimantan	Malay Peninsula, Sumatra (Sijunjung, Palembang and Lampung), Belitung, Bangka and throughout Borneo *
3.	*A. subintegra*	North Sumatera	Thailand *
4.	*A. crassna*	North Sumatera	Indochina and Thailand *
5.	*A. filaria*	Papua	Moluccas, Nusa Tenggara and Papua **
6.	*G. versteegii*	West Java, Central Java, East Java, Bali, West Kalimantan, East Kalimantan, West Nusa Tenggara, East Nusa Tenggara, Gorontalo, and Papua	Lesser Sunda Islands (Lombok, Sumbawa, Flores, Sumba) and North Celebes (Minahasa) *

Sources : *) [10]; **) [11]

3.2 Prediction of Agarwood and its derivate products

From all current potency of APT plantation, 50% (0.09 million trees) of the 0.19 million trees (dbh ≥ 20 cm) were inoculated by bio-induction techniques proposed by FORDA. Bali become the area with highest application of FORDA bio-induction technique followed by Bangka, Belitung, Aceh and Central Kalimantan. Although West Sumatera, East Nusa Tenggara, and Papua own more than 0.02 million trees with dbh ≥ 20 cm, but is no record that farmer do FORDA's bio-inoculation. in Bali the technique have been intensively introduced and disseminated since 2011. This program seemed to attack farmers' interest and started to practise the techniques to their APTs.

Current condition shows that bio-inoculation technique was quite successful to accelerate agarwood formation, hence its products were marketable. However, establishment of APT will require long time of investment. So APT cultivation need more diverse of product, not only rely on its agarwood product but also other product that can be optimized. Based on our previous serial research and field experience, the whole product APT (Glubal A, Kemedangan, and agarwood oil) can be predicted and calculated.

With the increasing demand of the agarwood products and its derivate, it is automatically will increase the farmers interest in cultivating APT. This will triggered the development of the APT in many provinces. Based on our finding in the abundances of APT (figure 1), other provinces in Indonesia will turn to the new APT centre area such as North Sumatra, Riau, Bangka-Belitung, Lampung, South Kalimantan and Central Kalimantan. Some problems could influence quantity and quality of cultivated agarwood products, i.e. pest and disease, fake inoculant, and agarwood marketing. APT cultivated in a large scale is prone to pest and disease attack. Recently, the most important pest found is *Heortia vitessoides* Moore (Odontiinae, Crambidae) that has caused severe damage at several APT in Indonesia [9]. Many fake inoculants sell to agarwood farmers, but the result of inoculation was not good. Furthermore, there is an urgent task for the Indonesia government to be present as both regulator and also facilitator to support this huge opportunity of community economic

growth. Agarwood cultivated need special rule and regulation to transport, market, and export non-quota, it should be difference with wild agarwood regulation which is under control of CITES management [12].

4. Conclusion

As a non-timber forest product, wild agarwood had an impact to social, cultural and economic to society and environment. Now, it had significantly declined and the effort to replace its should be developed by agarwood cultivation. In this study, APT plantations were found in 21 provinces distributed in 121 district with more than 4,757 farmer both individuals or groups. The total area of APT varied from 0.1 to 140 ha through monoculture, and agroforestry plantation technique. The total population of APT was recorded 3.4 million trees approximately, including *A. malaccensis, A. microcarpa, A. subintegra, A. crassna, A. filaria*, and *G. versteegii* tree species. In 2020, the economic value for plantation was predicted reaches about 1.6 trillion rupiah. Based on this finding, Indonesian governments should be supposed the agarwood community to overcome the problem and create a regulations to guarantee and ensure that all agarwood cultivation will protect the farmers and profitable to society.

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5. References

[1] CITES 2004 *Consideration of Proposals for Amendment of Appendices I and II- Aquilaria spp. and Gyrinops spp*. (Bangkok: 13th *meeting* conf.) CoP17 Prop: XXX
[2] Yang L Qiao C Xie D Gong N-B Lu Y Zhang J Dai J and Guo S 2013 Antidepressant abietane diterpenoids from chinese eaglewood *J. Nat. Prod* **76** 216-222
[3] Lee S H and Mohamed R 2016 *The Origin and Domestication of Aquilaria, an Important Agarwood-Producing Genus* ed R Mohamed (Singapore: Springer) chapter 1 pp 1-20
[4] Santoso E 2013 *Agarwood formation by fungal bioinduction technology* ed A Susmianto M. Turjaman and P Setio Track Record : Inoculation agarwood (Indonesia-Bogor: FORDA Press) chapter 3 pp 22-66
[5] Lee S Y, Mahat Ng W L, Nazre M N and M Mohamed R 2016 DNA barcoding of the endangered *Aquilaria* (Thymelaeaceae) and its application in species authentication of agarwood products traded in the market *Plos One* 1-21
[6] Turjaman M, Hidayat A and Santoso E 2016 *Development of Agarwood Induction Technology Using Endophytic Fungi* ed R Mohamed (Singapore: Springer) chapter 4 pp 57-71
[7] Turjaman M, Hidayat A, Rosita T and Santoso E 2014 Estimation of annual agarwood production and their quality Technical Report (Indonesia-Jakarta: PHKA-ITTO) p 70
[8] Turjaman M 2013 Agarwood upstream-downstream industry ed A Susmianto M Turjaman P Setio Track Record: Inoculation agarwood (Indonesia-Bogor : FORDA Press), Bogor, chapter 12 pp 185-216
[9] Sitepu I R, Santoso E, Siran S A and Turjaman M 2011 Fragrant wood gaharu: when the wild can no longer provide. (Indonesia-Bogor: ITTO PD425/06 Rev.1.; R&D Center for Forest Conservation and Rehabilitation) p 67
[10] Traffic 2004 Recommendations on the proposals to amend the CITES appendices at the 13th meeting on the conference of the parties Bangkok (Thailand) 2-14 October 2004 p 33

[11] Susilo A, Kalima T and Santoso E 2014 Field guide: identification of *Gyrinops* agarwood producing trees International Tropical Timber Organization (Indonesia-Bogor: ITTO) CITES Phase II Project p 34
[12] Santoso E 2015 Valuation of agarwood cultivated technology (Indonesia-Bogor: FORDA Press) p 167