Population, economic value and the trade of *Dalbergia latifolia* in Lombok, West Nusa Tenggara, Indonesia

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**Abstract.** *Dalbergia latifolia* is a valuable rosewood timber species locally known as sonokeling. This species is naturally found in India and Indonesia even though some reported it was cultivated. Like other rosewood, this species is mainly used for musical instruments, carving, or furniture. Since all *Dalbergia* species listing in CITES Appendix II following COP 17, international trade of products derived from this species must be controlled through a licensing system in accordance with CITES provisions. This permit granting must be based on a set of scientific sound information, such as distribution, population size, and trade system. This research aims to present the economic value and trade system of sonokeling timber through survey and interview in Lombok, West Nusa Tenggara. The population of the standing stock was varied, between 12-34 individual/400m$^2$. Most of the local farmers treat the species as an additional source of income following its rising economic value since the listing. Previously, people use it only for firewood that traded with some low prices. The change has brought the provincial government to impose a regulation for sonokeling trade activities in West Nusa Tenggara.

1. **Introduction**

*Dalbergia* is a genus of trees, shrubs, or woody climbers of approximately 250 species belonging to the Fabaceae family [1]. The genus has a wide distribution, in the old and new world tropics [2]. Many of Dalbergia species have economic value, producing high quality timber such as Brazilian rosewood (*Dalbergia nigra*), Madagascar rosewood (*Dalbergia maritima*), Huanghuali rosewood (*Dalbergia odorifera*), and Indian rosewood (*Dalbergia latifolia*) [3,4].

*Dalbergia latifolia* or Indian rosewood is locally known as sonokeling and recognized as the species that produce medium-weight to heavy hardwood with a straight bole, smooth texture, straight to wavy grain, and resistance to termites and fungi attacks [5]. This characteristic makes it highly valued in the market. This species is native to India and also thought to be native in Java although mostly found in plantation areas (e.g. teak forest) [2]. In Indonesia, the species occurs in Java and West Nusa Tenggara (Lombok and Sumbawa) [2], but also reported from East Nusa Tenggara (Timor), Sulawesi, and Sumatra [6]. Based on information from the locals, the trees are mostly found in private properties, mixed with other plants of timber or fruit trees, but also in forest rehabilitation areas. Its preferred habitat is the evergreen or deciduous forest with moist, well-drained soils, or on a substrate with poor soil nutrients, rocky, and dry, up to 600m above sea level [5]. The population densities of *D. Latifolia* were reported 108 individuals per hectare in state forest in West Lombok, 707 individuals per hectare in private (individual) land in West Sumbawa, and 702 individuals in community forest in East Lombok [7].
*Dalbergia* timber species worldwide is known for its durable, light, and strong heartwood with beautiful colors of brownish to dark purplish, and yellowish sapwood [5,8] which degree determine its commercial value. In 2012, the average international price was reported to be USD 49,656 per m³ for instrument blanks and USD 16,575 per m³ for sawn wood [9]. Local price in Indonesia for sonokeling can reach up to IDR 35,000,000 (USD 2,500) per m³ after CITES listing [10] while another report [11] also mentioned the price is around IDR 17,000,000 (USD 1,412) per m³. With this high price and international recognition for one of the world’s most valuable timbers, Indian rosewood is used primarily for high-end furniture, carving, and musical instruments. Unfortunately, the non-sustainable harvest systems, deforestation, forest conversion may be brought this species to threatened globally although some species have been planted to some extent such as *Dalbergia sissu* [12,13] and *Dalbergia latifolia* [14].

Since 2017, all *Dalbergia* species was listed in Appendix II CITES, and *Dalbergia latifolia* is also categorized as vulnerable in the IUCN Red List (2018) [15]. The listing of all *Dalbergia* species in the CITES Appendix was agreed upon proposals that revealed the complication in controlling the trade of the earlier-listed rosewood species from Africa and tropical America [16]. False trade documents often use species names that were not included in the list which adding the rest of the species name under the genus was believed to resolve the problem. Trade in appendix II species specimen must be legal and traceable. License to trade wild-harvested specimens can only be granted whenever the authority has stated that such removal from the wild will not detrimental to the survival of the species [17]. While traded specimen declared from cultivated sources shall have proper documentation demonstrating legality and differentiating it from a specimen taken from the wild. The non-detrimental evaluation is based on information on national distribution, population size and structure, and trade activity. Such information for *Dalbergia latifolia* in Indonesia is thought to be somewhat insufficient, considering the increasing trade activities following the CITES listing. Therefore, this study aimed to present the economic value and trade system of sonokeling timber through survey and interview in Lombok, West Nusa Tenggara as one of the timber sources.

2. Method and Material

2.1. Study area

This study was conducted in Lombok Island, West Nusa Tenggara Province, Indonesia. Five sampling sites in three regencies were selected (table 1 and figure 1). Ranggagata Village (CL), Taman Baru Village (WL1), and Telor Jago (WL2) were planted in a mixed-plantation system and is managed by local people; Senang Galih Village (EL) is managed by a private company using a monoculture system, while Nature Park Bangko-Bangko (WL3) is managed by the Forestry Regional Office (BKSDA) West Nusa Tenggara as a protected area that also a mixed-plantation system. This study was conducted on 31st July-6th August 2018.

2.2. Data collections and analysis

Data were collected via interview, observation, and fieldwork. The interviews were conducted in semi-structured (the interviewer does not strictly follow a formalized list of questions) method with 20 respondents, consist of BKSDA officers, local traders, and the owner or plantation farmers of *D. latifolia* trees. Some open-ended questions were asked to collect information on the trading and management system in West Nusa Tenggara. Visits were also made to harvest sites.

Two to five plots of 20m x 20m in the sampling sites were established to estimate the population structure of *D. latifolia* (table 1). All sonokeling trees with stem girth at breast height ≥ 15cm were measured using measuring tape [18]. Voucher specimens of the trees with recorded local and scientific names were deposited in the Herbarium Bogoriense for further identification.

Kruskal–Wallis test was used to determine if there were any differences among sampling sites. If showed significant differences between sampling sites, multiple comparisons with Gao test were made.
which was performed using the “nparcomp” package [19] on R 4.0.2 [20]. Nonparametric was chosen due to heterogeneity of variance and small sample size.

Table 1. Research locations

| Code | Location                                                                 | Management system                      | Latitude/Longitude | Plots | Altitude (m asl) |
|------|--------------------------------------------------------------------------|----------------------------------------|--------------------|-------|------------------|
| CL   | Ranggagata Village, Southwest Praya Sub District, Central Lombok District | Mixed-plantation, local people         | S 08°43’07.2” E 116°10’26.7” | 2     | 97               |
| WL1  | Taman Baru Village, Central Sekotong Sub District, West Lombok District   | Mixed-plantation, local people         | S 08°46’33.3” E 116°03’24.9” | 2     | 19-20            |
| WL2  | Telor Jago Village, Sekotong Sub District, West Lombok District           | Mixed-plantation, local people         | S 08°46’33.5” E 116°01’13.4” | 5     | 331              |
| EL   | Senang Galih Village, Sambalie Sub District, East Lombok District         | Monoculture, private company           | S 08°23’49.2” E 116°42’00.9” | 2     | 66               |
| WL3  | Nature Park Bangko Bangko, Sekotong Subdistrict, West Lombok District      | Mixed-plantation, government           | S 08 28’ 46.3” E 116 03’ 10.4” | 3     | 86-87            |

Figure 1. Research sites in Lombok, West Nusa Tenggara.

3. Results and Discussion

3.1. Population

*D. latifolia* in West Nusa Tenggara was found in a hilly area at low altitude, with rocky, and dry soil. This finding is in line with reports of Orwa et al. [21]. Meanwhile, others reported that this species occurs in a flat area and up to 1500 m asl [22]. According to the local traders, farmers, and officers of BKSDA, *D. latifolia* that grow in West Nusa Tenggara was planted since 1970-1980s in reforestation programs. According to forestry officer, most recent reforestation program was carried out in 1997 in
the Nature Park Bangko-Bangko Sekotong area (WL3) by the Forestry Office of West Nusa Tenggara Provincial Government. Seedlings of sonokeling were provided by the provincial government and the head of regency [23,24]. The tree was planted along with *Swietenia mahagoni* (mahogany), *Tectona grandis* (teak), *Paraserianthes falcataria* (sengon laut/silk tree), *Scleichera oleosa* (kesambi/kusum tree), and *Anacardium occidentale* (mete/cashew tree). While tree stands in community lands (CL, WL1, WL2) only known to have been existed since their great grand parents and the seed was from reforestation programs which planted in 1970s/1980s. Locals uses the leaves of *D. latifolia* for animal feed.

The mean density of *D. latifolia* was low, ranging from 12 to 34 individuals per 400 m² or 300–850 individual/ha (table 2). Population in EL (East Lombok) has the highest density which is assumed to correspond with the maintenance system. According to local people in this area, regular weeding is performed until the trees were established or until trees can withstand weeds competition. They also apply compost fertilizer and replace dead trees with the new one. Such maintenance was applied in WL3 but only for a short period of time (2-3 years). The weeding for *D. latifolia* should be done at the early stage of planting until trees reach up to 8 m in height [25]. The maintenance series are essential to produce good quality of wood [5].

Seedling of *D. latifolia* was only recorded in WL3 (table 2). This location appeared to have higher humidity compare to other locations based on its soil humidity and observed dense canopy cover. Sonokeling is one of the tree species with seedling arises from suckers, i.e. shoot spring from the creeping root at some distance from the main trunk. This mode of reproduction was said to be more important as an adaptation to drought conditions [26] such that in *Lannea nigritana* and *Milettia thonningii* in Ghana [27] or *Heterodendrum* and *Casuarina* species in Australia [28]. However, neither seedling nor suckers were found in other research locations, probably due to drier condition or it had being fed by the cattles.

**Table 2. The densities of *D. latifolia* in each research location**

| Location | Seedling | Standing trees density (individual/ha)* | Felled trees density (individual /ha) | Soil humidity (%) |
|----------|----------|----------------------------------------|--------------------------------------|------------------|
| CL       | -        | 450                                    | 0                                    | 20               |
| WL1      | -        | 300                                    | 350                                  | 40               |
| WL2      | -        | 375                                    | 0                                    | 30               |
| EL       | -        | 850                                    | 0                                    | -                |
| WL3      | 32       | 350                                    | 0                                    | 60               |

*D. latifolia* is commonly harvested by clear-felling, leaving the stump to stand. Such stumps of several-days-old cut were spotted at sampling site WL1. Approximately 86% of the felled trees in this location contain good quality of heartwood, showed by the large-darken area, with DBH mostly larger than current standing trees (figure 2). Orwa et al. reported that the heartwood of this species is darken with age and weights about 850 kg/m³ [21]. In Grobogan Regency, Central Java, the KPH (Forest Management Unit) Gundih harvested 2453 sonokeling tree (1191.603 m³) from 25 ha in eight blocks area during the fiscal year 2018 [11]. The number of felled trees and the size of stumps in WL1 might indicate that its production level with mixed-planted management were comparable to that of monoculture tree plantation in Java, disregarding the unknown-differences in planting time.
Figure 2. The felled tree in the harvested area of WL1

Tree size distribution of the current standing stocks suggests that sonokeling owned by local farmer has small diameter (< 20cm) (figure 3). DBH of trees in WL1, WL2, WL3 are significantly shorter than EL, while CL is the shortest (figure 4). Probably, this is due to the differences in maintenance after planting. Moreover, the local farmer often cut the shoots for feeding their cattle especially during the dry season, which impacted on slow growth response. Ardhana has also reported the same condition in the neighbouring island, Bali, where people utilizes young twigs for animal feed [8]. Sonokeling tree in Bali has lower density (2-5 individual/ha) compare to population in Lombok, and lower dominance relative.

Figure 3. Tree size distribution in each research location
3.2. Economic value and trade

In West Nusa Tenggara, *D. latifolia* is traded in the forms of sortimen wood with various sizes, ranging from square to board form (table 3 and figure 5) and might be in customized shape according to buyer requests. The price of sonokeling varies based on the quality of the heartwood/gubal and tree size. Table 3 shows that the highest price is in a board form/A1 since this form is usually used grade 1st sonokeling wood, followed by A3 and A0 which seldom sell in grade 2nd. These sortimen wood then is sent to the primary or secondary industry in Java for export demand. With reference to Safitri and Ashila [10] there are significant differences in pricing that applied in West Nusa Tenggara, probably due to the degree of wood quality and other condition such as colouration or volume of the hearthwood/gubal. Duta Rimba [25] explained that the older *D. latifolia* is usually more expensive, which implies that as the tree diameter is bigger when it becomes older, the log price will be higher. In Lombok the tree size is small which give the impact to the selling price is not as expensive as explained in Safitri and Ashila [10]. The Directorate of Biodiversity Conservation [7] reported that in early 2017 the export volume was 13,254.90 m³ for musical instrument and furniture products. The first grade is identified as wood contains brownish-violet patterns while the second grade of rosewood is labeled as raw material contains a little of heartwood/gubal or wood with a pale color predominance of a yellowish color. This kind of material is usually intended for domestic use only in the form of crafts or furniture. The lowest grade is considered as waste and usually burnt for firewood in the houses or in smallholder-activities such as drying tobacco leaves (figure 5f).

![Figure 4](image-url)

**Figure 4.** The difference among research site in tree diameter. Significant level $\alpha$ = 0.05, significant difference among plots are indicated by different alphabets.
### Table 3. Pricing categories of Sonokeling in West Nusa Tenggara as per August 2018

| Categories | Size | Forms          | Price (IDR)       |
|------------|------|----------------|-------------------|
| A0         | 6cm x 6cm x <1 m | Kaki/balok/square | 3 million/m³ - 5 million/m³ |
| A1         | 14cm - 19cm x 3-5cm x ≤ 1 cm | Papan/board | 6 million/m³ - 15 million/m³ |
| A2         | 20cm – 29cm x 3-5cm x ≤ 1 cm |             |                   |
| A3         | 30cm – 39cm x 3-5cm x ≤ 1cm |             |                   |
| -          | 20 x 20cm x ≤ 1 cm | Balok kaki    | 6 million/m³ - 7 million/m³ |

**Figure 5.** Sonokeling classification in West Nusa Tenggara (a-b) balok/square, (c-d) board (e) balok kaki (f) waste.
Up to July 2020, 22 persons and one HTI (Industrial Forest Plantation) company on sonokeling is registered as traders in West Nusa Tenggara Local Office Forestry Department (BKSDA). Previously, this species was rarely traded in West Nusa Tenggara, usually used as furniture or firewood [29]. Before listed in Appendix II CITES, farmers used to sell and deliver sonokeling wood directly to local buyers at lower prices (figure 6a) which course then changed in some ways after the listing (figure 6b). The striking difference is in the presence of middlemen which indicate the significantly higher demand [30]. The following diagrams summarize alternative courses of the chain of trading system for sonokeling:

**Figure 6.** The chain of trading system for Sonokeling in Lombok, West Nusa Tenggara, a) before listed in Appendix II CITES and b) after listed in Appendix II CITES.

The local trader might role as a trader and/or a middleman. The local traders process raw materials into several forms depend on requests from their buyers. They also handle transporting the wood to factories owned by exporting companies in Java, mostly in the East Java and Central Java Province. In 2019, there were 2,962,734 m³ of sonokeling transported to Java and about 1,605.38 m³ until early October on the next year. Middleman acts as a party who connect buyer to supplier at almost any point, directly or indirectly.

The local traders are the one who known to set prices based on the sonokeling wood quality. According to a local trader, there has been a significant increase in price following the listing of *D. latifolia* in Appendix II CITES. Previously the price is about IDR 2,000,000 (USD 143)/truck (one truck equal to 7.5 m³), while the current price is up to IDR 3,000,000 (USD 214) – IDR 15,000,000 (USD 1071)/m³, about 11.25–56.25 fold / 1125–5625% increase in such a short time. Moreover, more persons are operating as middlemen nowadays, hunting for rosewood supplies which cost is usually owed to the buyer.

The species listing in appendix II CITES has somewhat altered transport activities on *D. latifolia*. As a timber species, its harvest and transport were previously regulated by local government offices only. Since included in the appendix, the transport now should also follow Decree of the Minister of Forestry Number 447/Kpts-II/2003 concerning the Administration Directive of Harvest and Capture and Distribution of the Specimens of Wild Plant and Animals Species. The provincial government of West Nusa Tenggara publishes new regulation through notification letter No. 520/225/DISLHK/2017 concerning the trading of sonokeling (*Dalbergia latifolia*) to ensure traceability, legality, and
anticipation of illegal logging or poaching of rosewood and deforestation. With the new rule, the officers under the Task Force to Combat Forest Destruction (Pemberantasan Perusakan Hutan or P3H) is assigned to verified and clarified the legality of sources. The verification and clarification would include inspection and confirmation of source location, matched with information on land ownership, tree-stands ownership, and its condition. The P3H task force is involving multi-stakeholders in carrying their responsibility, which includes officers from the provincial forest management (BKPH), District Military Command (KODIM), Police County (POLRES), and BKSDA. Only following the task force’s inspection and accompanying procedures, whenever all aspect declared as clear, the applicants can be granted the permit for transporting rosewood domestically.

4. Conclusion

*D. latifolia* in West Nusa Tenggara was planted with the density is ranging from 300-850 individual/ha. Since listed in Appendix II CITES, there has been an increase in a trade price to 11.25–56.25 fold / 1125-5625%, and the chain of trading system has changed into four systems that one mode involving middlemen. There are also more people play as middlemen which indicates the significant change in supply and demand following the CITES listing. The provincial government of West Nusa Tenggara has issued and enforced a notification letter to ensure the traceability and legality of any transported rosewood by establishing the P3H task force.

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References

[1] Li Q, Wu J, Wang Y, Lian X, Wu F, Zhou L, Huang Z and Zhu S 2017 *Holzforschung* **71**(12) 939-49

[2] Adema F, Ohashi H and Sunarno B 2016 *Blumea* **61** 186-206

[3] Barret M A, Brown J L, Morikawa M K, Labat J and Yoder A D 2010 *Science* **328** 1109-10

[4] Vatanparast M, Kltgard B B, Adema F A C B, Pennington R T, Yahara T and Kajita T 2013 *South Africa J.Bot*. **89** 143-49

[5] Soerianegara I and Lemmens R H M J 1994 *Plant Resources of South East Asia* on Timber Trees: Major Commercial Timbers vol 5(1) (Bogor: PROSEA)

[6] Yulita K S, Atikah T D, Wardani W and Susila 2020 *Biodiversitas* **21**(2) 833-41

[7] Directorate of Biodiversity Conservation 2017 *CITES Management Authority and Scientific Authority of Indonesia Report: Information of the Conservation Status, Management and Trade of Dalbergia latifolia in Indonesia* (Jakarta: Ministry of Enviroment and Forestry Indonesia)

[8] Ardhana, I P G 2011 *Jurnal Ilmu Pertanian Indonesia* **16**(2) 81-90

[9] Jenkins A, Bridgland N, Hembery R and Malessa U 2012 *Precious Woods: Exploitation of the Finest Timber* (London: Chatham House) p 11

[10] Safitri K I and Ashila V 2019 *Jurnal Gama Societa* **3**(1) 38-46

[11] Dwianto W, Bahanaawan A, Kusumah S S, Darmawan T, Amin Y, Pramasari D A, Lestari E, Akbar F and Sudarmanto 2019 Study on the existence and characteristic of Sonokeling (*Dalbergia latifolia*) as Appendix II CITES wood *Cof.Ser.: Earth Environ. Sci* **374** 012063

[12] Nabi M, Zhang P, Juma M, Saeed S, Ahmad A, Amir M, Khan A, Jing L, Zubair M and Xue T 2018 *Jour. Biodiv. Env. Sc.* **12**(4) 174-80

[13] Naqvi S A H, Mustaq S, Malik M T, Umar U D, Rehman A, Fareed S and Zulfiqar M A 2019 *Journ. Agric. Res.* **32**(2) 302-16

[14] Thapa H B 2004 *Banko Janakari* **14**(1) 31-40
Asian Regional Workshop (Conservation & Sustainable Management of Trees, Viet Nam, August 1996) 1998 Dalbergia latifolia The IUCN Red List of Threatened Species 1998

COP17 Prop.55

Text Convention Art. IV Regulation of Trade in Specimen of species included in Appendix II

Prasad R, Kotwal P C, Rathore C S and Jadhav Y D 2001 Ec-Fao Partnership Programme (2000-2002) Tropical Forestry Budget Line B7-6201/1b/98/0531 Project Gcp/Ras/173/Ec (Bangkok: FAO)

Konietschke F, Placzek M, Schaarschmidt F and Hothorn L A 2015 Journal of Statistical Software 64(9) 1-17

R Development Core Team 2020 The R project for statistical computing Vienna, Austria

Orwa C, A Mutua, Kindt R, Jamnadass R and S Anthony 2009 Agroforestry database: tree reference and selection guide version 4.0

Heyne K 1987 Tanaman Berguna Indonesia (Jakarta: Yayasan Sarana Wana Jaya)

Suratman, Agus C and Panjono 2017 Jagat Biru Rahayu Lingkungan dan Kehidupan Bermartabat (Yogyakarta: Gadjah Mada University Press)

CIFOR 2008 Rehabilitasi Hutan di Indonesia: akan Kemenakah Arahnya Setelah Lebih dari Tiga Dasawarsa? Ed Nawir A A, Murniati, Rumboko L (Bogor:CIFOR)

Vieira D L M, Scariot A, Sampaio A B and Holl K D 2006 Jour. Trop. Ecol. 22 335-7

Lieberman D and Li M 1992 Jour. Veg. Sc. 3(3) 375-38

Chesterfield C J and Parsons R F 1998. Aus. J. Bot. 33 715-32

Hidayat S 2017 Biodiversitas 18(1) 238-47

Belcher B and Kusters K 2004 Non-Timber Forest Product Commercialisation: Development and Conservation Lessons in Forest Products, Livelihoods and Conservations Case Studies of Non Timber Forest Product Systems vol 1, ed K Kusters and B Belcher (Bogor: CIFOR) chapter 1 pp 1-22