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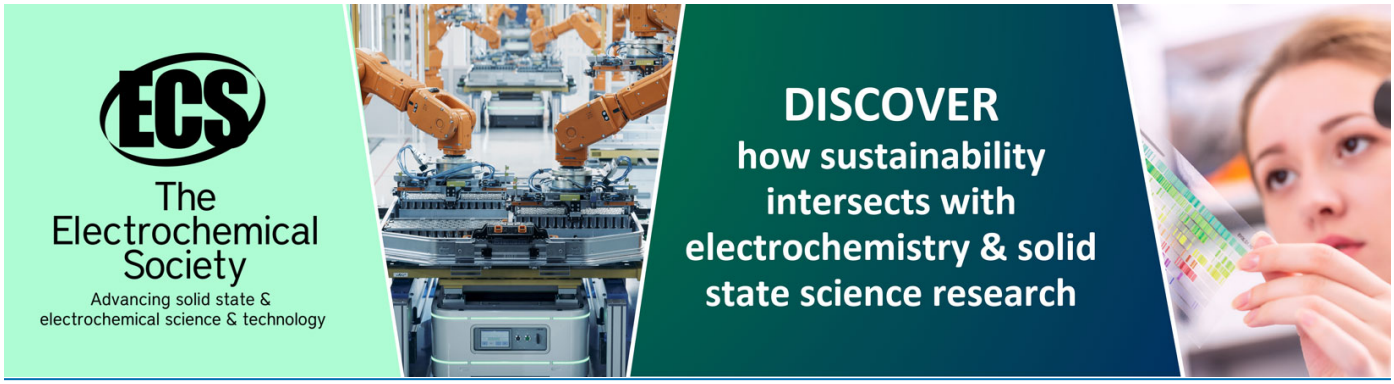

Valuation of a man-made dipterocarp forest as seed source for Shorea red meranti (*Dipterocarpaceae*)

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Abstract. Lack of good quality seeds has been one of the constraints in icreasing the success rate of rehabilitation, restoration and establishment of plantation forest. Establishing seed sources is a way to increase the availability of qualified seeds for various purposes. Gunung Dahu Research Forest (GDRF) has *Shorea pinanga* and *Shorea platyclados* (Dipterocarpaceae) stands that has potential to meet the standard of identified seed stands (ISS). We evaluate two stands of *S. pinanga* (plot 05 and 24) and four stands of *S. platyclados* (plots 04, 15, 20, and 21e) to be quantified for their potential as ISS. Assessment was carried out by evaluating the parameters related to number of mother trees, accessibility, stand quality, management, fruiting history, and origin. Among all assessed plots, highest final score was obtained by plot 20 (131.5), followed by plot 24 (112.5), plot 05 (105.5), plot 04 (87), plot 21e (85), and plot 15 (57). Based on the minimum score of 94.5, the potential plot that can be assigned as ISS are plot 05, plot 24 and plot 20.

1. Introduction

Dipterocarpaceae is a plant family that dominates the lowland rainforest formation in Indonesia. There are consists of 350 species, spread on 9 genus that can be found in Indonesia, those are Shorea, Dipterocarpus, Dryobalanops, Hopea, Anisoptera, Vatica, Cotylelobium, Parashorea, dan Upuna [1]. Many members of this group are commercial wood. Often sold with their commercial names as *meranti, keruing, merawan, mersawa, kamper* dan *resak*.

Forest destruction causes a decline in forest productivity especially for commercial species, one of these is Dipterocarpaceae group which declining in numbers [2]. From 2001 until 2017, Indonesia has lost its forest covering for up to 24.4 million ha [3]. Forest decline is causing the instability of forest productivity. Another problem is the vast degraded that needs rehabilitation in national land rehabilitation program that span across area of 24.197.000 hectares [3].

Shorea is the biggest genus of Dipterocarpaceae that have high value both economically and eclogically. In the global trade, Shorea "red meranti" is a major commodity of tropical hardwood timber. *Shorea pinanga* and *Shorea platyclados* were among commercial species that included as *red meranti* group, those species has different optimal growing altitude. So in their use for planting purpose, both species can be substituted accordingly to the area with suitable elevation. *S. pinanga* natural habitat is located in area with <700 mdpl elevation while *S. platyclados* thrive in 700-1000

masl [4-5]. Planting these species for use in different purposes will require more reliable seed supply, either from continuity, quantity and quality. Aside from those, according to [6] these species are favourable to use in intensive silviculture application (SILIN) for natural forest management.

Until this point, there were not many seed sources of *S. pinanga* and *S. platyclados* that indexed in *Sistem Informasi Perbenihan Tanaman Hutan* (SIPTH), an online codex containing various information on forest plants seed that managed by Ministry of Environmental and Forestry. From available records, there is only one source of *S. pinanga* seeds located in East Kalimantan province and one source of *S. platyclados* seed in Aceh province, there were no records regarding seeds source of both species sourced from Java island [7].

Gunung Dahu Research Forest (GDRF) is the first and only Shorea pkanted forest in Indonesia which span across 250 hectares. GDRF management is under Forest Research and Development Center, Bogor which on beginning of planting period (1997 – 1999), it has two major purposes, which was to research and improve the productivity of degraded lands. Restoration efforts in GDRF utilized various trees from Diptreocarpaceae family, including: *S. leprosula. S. selanica, S. platyclados, S. javanica, S. pinanga, S. stenoptera, S. ovalis, S. palembanica, S. guiso, S. macrophylla, S. balangeran, S. mecisopteryx, S. multiflora, Hopea bancana, dan Anisoptera marginata* [8]. Stands belonging to *S. pinanga* and *S. platyclados* have been identified under flowering and fruiting phase so it's necessary to valuate the feasibility of it's stands as a potential source for Identified Seed Source (ISS). This research aims to analyze the stand potential of *S. pinanga* and *S. platyclados* at Gunung Dahu Research Forest as Identified Seed Source with various supporting factors.

2. Methodology

2.1. Research location

This research was conducted in plot 04, 05, 15, 20, 21e, 24 of Gunung Dahu Research Forest management area, Leuwiliang, Bogor Regency. Data collection for *S. pinanga* was done in plot 5 and plot 24 while for *S. platyclados* took place in plot 4, 15, 20, and 21e. Observation area of those species is presented in Figure 1.

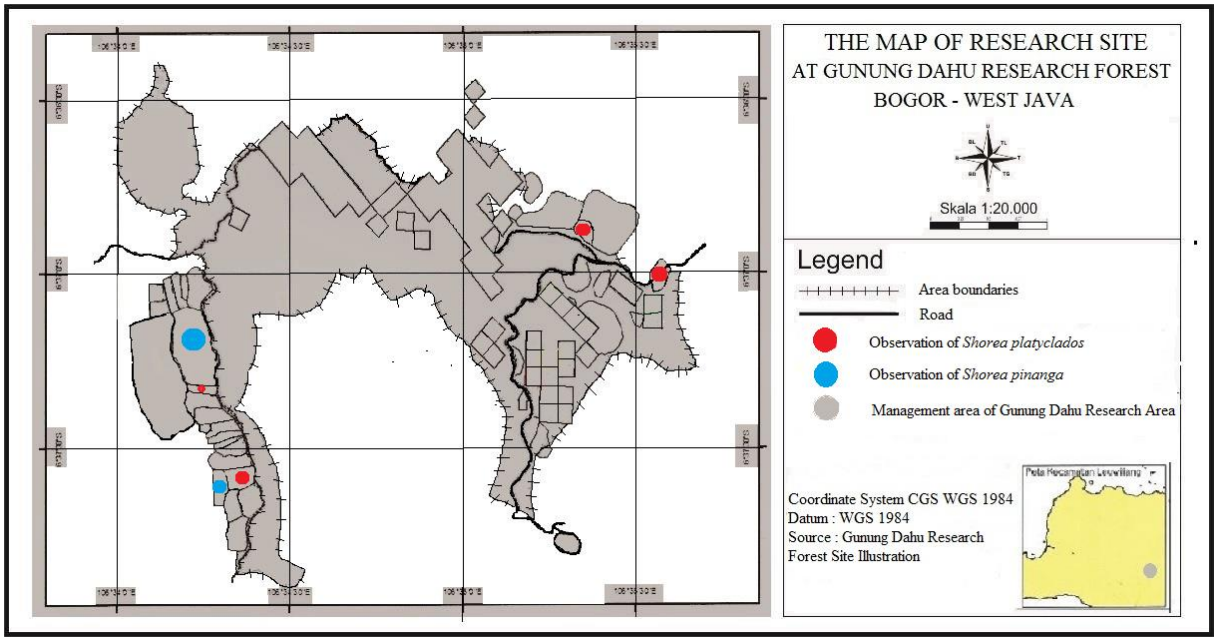

Figure 1. Layout of *Shorea pinanga* plot (blue) and *Shorea platyclados* (red) in Gunung Dahu Research Forest landscape

2.2. Supporting and environmental data collection

There are two kinds of data that used in this research which consists of primary data and secondary data. Primary data were collected from *S. pinanga* and *S. platyclados* mother tree candidates which comprised of diameter, total height, main trunk straightness, health of mother plant, and soil texture. Location accessibility were taken based on stands location. Secondary data collected were plant fruiting history/record, seed provenance, numbers of wildings, cover density, light intensity, and disturbances on the area.

Tree diameter (dbh) was measured at ±1.3 m with minimum diameter required for tree category is 20 cm (MSRM 2005). Total height was measured using Haga-hypsometer [9]. Stand health data were collected each tree individually, using tree health quality assesment technique as required [10], pest and disease related damage as described by [11], and damage types which categorized by [12]. For plot accessibilty, categorization was done following the criteria made by [10] with multiple aspects including plot inclination, distance from basecamp, and also travel time were. Those three accessibility datas were tabulized and processed to determine the accessibilities of each plots.

Data regarding stands fruiting records were obtained from interviews on GDRF management and through available records. Fruiting frequency is categorized as every year, third times, and first time. Information regarding seeds or seedling provenance were obtained from GDRF documents. Variables on seed source security were quantified by identifying incidence of illegal logging, forest fires, land encroachment, livestock herding, and other disturbances.

2.3. Data analysis

From every data that measured and collected, an assessment was done to mother tree candidates for seed source with parameters and scoring as presented on Table 1.

Table 1. Mother plant scoring

Parameter	Class	Score
Wilding Number*	≥ 30	10
	20 ≤ X ≤ 29	7.5
	10 ≤ X ≤ 19	5
	< 10	2.5[a]
Stand health**	Healthy	5[a]
	Unhealthy	0
Trunk straightness***	1	0
	2	6
	3	10
	4	14[a]
	5	18
	6	20
Maximum Total Score		35
Minimum Total Score		17.5

Source: *) Self-processed data; **) [11]; ***) [13]; a) minimum expected score

Minimum score of 17,5 was determined based on primary requirement that mother tree need to have straight and healthy trunk, while scoring for wildings existence were set lower because the in the field showed that not every productive trees yields wilding growth underneath or nearby. After assessment been conducted on each mother tree, the plot assessment was determined for a candidate for identified seeds source area. Scoring for the stand assessment was presented as followed in Table 2.

Table 2. Assessment scoring for Identified Seed Source

Parameter	Class		Score
Numbers of Mother Plant*	$X \geq 25$		60
	$10 \leq X < 25$		30
	$X < 10$		0
Accessibility			
1. Distance from basecamp**	$X < 500$ m		10
	500 m $\leq X \leq 1$ km		7.5
	$1 \leq X \leq 3$ km		5
	$X \geq 3$ km		2.5
2. Travel time**	$X < 10$ minutes		10
	$10 \leq X \leq 20$ minutes		7.5
	$20 \leq X \leq 30$ minutes		5
	$X \geq 30$ minutes		2.5
3. Inclination***	I	$X \leq 8$	10
	II	$8 < X \leq 15$	8
	III	$15 < X \leq 25$	6
	IV	$25 < X \leq 45$	4
	V	$X > 45$	2
Stand quality**			
1. Total Height Average	$X > 25$ m		10
	$21 \leq X \leq 25$ m		7.5
	$15 \leq X \leq 20$ m		5
	$X < 15$ m		2.5
2. Diameter average	$X > 50$ cm		10
	$40 \leq X \leq 50$ cm		7.5
	$30 \leq X < 40$ cm		5
	$X < 30$ cm		2.5
Fruiting history**	Every year		10
	More than twice each year		6
	First time fruiting		3
Area management			
1. Security**	No disturbance		10
	Low disturbance		7.5
	Medium disturbance		5
	High disturbance		2.5
2. Health history** (in 1 recent year)	pest/disease not occuring		10
	Pest/disease occur		5
Provenance*	Known		10
	Unknown		5
Maximum Total Final Score			150
Minimum Total FInal Score			94.5

Source: *) [13]; **) Self-processed data; ***) [14]

3. Results and Discussion

Results from field data collection and measurements for each plot are presented in Table 3. SPi stands (24) have the biggest area among other observed stands. SP stands (21e) have the narrowest area with just 0.6 ha. Soil texture found on the observation areas were consist of sandy clay loam and sandy loam category. All observed stands were situated in steep and very steep inclination, while also had a fairly high cover density above 60%. S. platyclados stands in SP (20) have the highest cover density value of about 84.92%, while SP (05) and SPi (05) stands had the lowest cover density compared to other stands, about 62.82%.

Table 3. Stand condition of *S. pinanga* and *S. platyclados*

No	Stands	Species	Plot number	Area (Ha)	Planting Year	Elevation (mdpl)	Cover Density (%)	Inclination (%)	Soil texture
1	SPi (05)	*S. pinanga*	05	1.4	1998	803	62.82	50	Sandy clay loam
2	SPi (24)	*S. pinanga*	24	10.3	2000	873	68.28	35	Sandy clay loam
3	SP (04)	*S. platyclados*	04	1.6	1998	803	62.82	50	Sandy clay loam
4	SP (15)	*S. platyclados*	15	2.8	1999	853	80.50	40	Sandy clay loam
5	SP (20)	*S. platyclados*	20	2.4	1999	728	84.92	40	Sandy loam
6	SP (21e)	*S. platyclados*	21e	0.6	1999	730	84.66	70	Sandy loam

Number of mother tree is the main parameter in determining whether a stand is qualified for ISS. Number of mother trees that required by MoEF were 25 trees in one stand. Higher number of mother trees on each stand is required for higher ability to preserve its biodiversity. Number of mother trees in each stand is presented in Table 4.

Table 4. Number of mother trees

No	Stand	Number of mother tree candidates	Number of qualified mother trees
1	SP (04)	27	18
2	SPi (05)	40	30
3	SP (15)	8	7
4	SP (20)	96	88
5	SP (21e)	13	12
6	SPi (24)	68	59

Recapitulation on stand assessment based on ISS parameters as described in Table 5. Scoring result for every scored stand candidate are presented in Table 6.

Table 5. Recapitulation of stand assesment based on ISS assesment parameters

Parameter	Stand					
	SP (04)	SPi (05)	SP (15)	SP (20)	SP (21e)	SPi (24)
Number of Mother Tree	18	30	7	88	12	59
Accessibility						
Distance from basecamp(km)	3.4	3.4	4.8	1.8	1.5	4.9
Travel time (minute)	10	10	25	5	4	30
Inclination (%)	50	50	40	40	70	30
Stand Quality						
Average height (m)	17.9	10.4	19.8	21.9	20.1	10.6
Average Diameter (cm)	43.1	25.3	43.3	40.3	36.7	21.6
Fruiting records	Every year	Third times	First time	Every year	First time	Third times
Area management						
Disturbance level	High	High	Non-existent	Low	Low	Non-existent
Health history	Healthy	Healthy	Healthy	Healthy	Worm Pest	Healthy
Origin	K, S	K	K, S	K, S	K, S	K

Details: SP= *S. platyclados*; SPi= *S. pinanga,* numbers indicate plot; K= Kalimantan; S= Sumatera island; , numbers in brackets indicates plot number

Table 6. Scoring results of ISS stand candidates from *S. pinanga* and *S. platyclados* species

Parameter	Stand					
	SP (04)	SPi (05)	SP (15)	SP (20)	SP (21e)	SPi (24)
Number of mother trees	30	60	0	60	30	60
Accessibility						
Distance from basecamp	2.5	2.5	2.5	5	5	2.5
Travel time	7.5	7.5	5	10	10	5
Inclination	2	2	4	4	2	4
Stand quality						
Average height	5	2.5	5	7.5	7.5	2.5
Average diameter	7.5	2.5	7.5	7.5	5	2.5
Fruiting records	10	6	3	10	3	6
Area management						
Security	2.5	2.5	10	7.5	7.5	10
Health history	10	10	10	10	5	10
Origin	10	10	10	10	10	10
Final score	87	105.5	57	131.5	85	112.5
Decision	Disqualified	Qualified	Disqualified	Qualified	Disqualified	Qualified

Based on criteria from Ministry of Environment and and Forestry, identified-seed source/ISS should meet the criteria of accessible, have adequate number of mother trees, average stand quality, recorded to have already bear fruits, secure, healthy, and seeds with known provenance is preferable. Stand condition of *S. pinanga* and *S. platyclados* ISS candidates were presented in table 3. ISS selection should, avoid selecting unproductive stand that has no record of fruiting. All observed stands candidates had uniform spacing of 4×4 m, but each stand has its own area width and planting year. The difference in planting year may caused variability in fruiting time.

Soil texture that found in GD RF (table 3) contains fair amount of sand, which categorized as sandy loam and sandy clay loam. According [15], *meranti* (*Shorea spp.*) can live in an area saturated with lime, sandy, swamp or even heath forest saturated with quartz sand. Sandy and loamy soils did not inhibit the growth of Dipterocarpaceae species that planted in GDRF.

One of the key parameter in ISS stand assesment is the existence of mother tree. Number of mother tree is the main parameter in recommendation for ISS selection. Stand that has low number of mother tree has lower potential be used as seed source compared to stands with more than 25 mother trees. Assesment results on mother tree candidates shows that not every stand had 25 or more mother trees, only SPi (05), SPi (24), and SP (20) that had more than 25 mother trees (table 4). Stands with mother tree less than 25 can be reconsidered as a seed source if it has a minimum of 10 mother trees but such a small number of parent plants considered to reduce the genetic diversity by means of genetic erosion from inbreeding. According to [16] ideal numbers of mother tree in one stand should be 25–30 individuals to minimize genetic erosion as a result of inbreeding. Genetic erosion could potentially harm any stand by lowering its genetic diversity. According to [17] inbreeding could lower the growth and wood quality (height, diameter, volume) of *Eucalyptus urophylla*. Repopulate mother trees to desired number of 25 individual or more is a preventive way against decline in genetic diversity.

The biggest contributing factor behind disqualification of individual to be selected as mother tree is low straightness category, both caused by the condition of curved or pest-damaged trees. Damage reports found the occurrence of termite attack in SP (04), open wound and gumosis in SP (20). Another trees with open wound in SP (24). Highest damage variability was found in SP (05), consists of canker, termite mounds, or dried crown.

Disqualified tree candidates (table 4) is resulted from scoring lower than minimum final score that previousl set to maintain the seed quality produced from ISS. Excluding trees with low straightness is avoided to minimize the amount of offspring that hold similar trait. Bad trunk shape can lower the commercial value of its wood. Use of unhealthy trees were also avoided

Based on table 5, *S. platyclados* from plot 04 and 20 that's been recorded tobear fruit every year. Species of Dipterocarpaceae family had unregular flowering and fruiting season [6]. The fruiting of Dipterocarpaceae could be influenced by multiple factors, one of them is climate. According to [18] climate is suspected as the major external factor for Dipterocarpaceae to have mass flowering, this include the existence *of* ENSO (El-Nino Southern Oscilation). Mass fruiting season in Kalimantan often preceded by long dry season caused by ENSO.

Stand quality were presented as average stand heights and tree diameters (Table 5). Meranti (*Shorea* spp.) is highly commercial timber that according to [19], both species of *S. pinanga* and *S. platyclados* are categorized as first grade commercial wood. Trees with excellent height and diameter with good straightness is needed to accommodate for construction purposes. Comparison of total height and trunk diameter between plots within the same species showed no significant difference. Biggest difference was found in comparison between different species. *S. platyclados* has a better stand quality than *S. pinanga*. That is taken from the higher height and diameter average of *S. platyclados* stands compared to *S. pinanga*. The lower score of *S. pinanga* indicates that it is better suited in habitat with lower elevation. However, both of these species were able to maintain good growth and some even produced fruits.

Location elevation/altitude factor as seen in table 3 affected the tree growth performance. GDRF elevation were about 700 masl. Height and diameter average of *S. platyclados* on each plot were higher than *S. pinanga* (table 5). That was considered to different habitat compatibility. According to [5] the optimal elevation for *S. platyclados* growth ranging from 700–1000 masl, while *S. pinanga* as stated by [4] best suited in ridge areas below 700 masl. The origin of DRF stands provenance were already clearly recorded, with *S. pinanga* originated from Kalimantan and Sumatra island while *S. platyclados* originated from Kalimantan island.

Ease of access is an important factor to consider in ISS selection. Location inclination and high accessibility could affect seed collection, distribution and monitoring activities at site. All plots can be traveled using motor vehicle (table 5), except SP (15) and SPi (24) that needs further 1.5-1.6 km trip on foot. Travel time between basecamp and plot location was varied. The shortest route was SP (21e) that only need 4 minutes of travel time from the basecamp. While the longest plot to reach was SPi (24), which need 30 minutes of travel time because only accessible by foot. Further plot will affect the monitoring of stand security which resulted in less intense monitoring compared to nearby location from basecamp.

All plots had a high inclination percentage (table 5), that could be constrain in seed collection activities. SP (21e) had the highest inclination percentage of 70 % which will creaty big diffivulties to carry out seed collection activites. Location that can't be accessed by motor vehicle and have high inclination could hinder seed collection and distribution activities.

GDRF area management was considered excellent in terms of security (table 5). Societies already understand the importance of forest. There were no more illegal logging happened in the area. Gathering activities are now limited to bamboo that spread on different areas with few area utilized for gardening found under SP (21e). Ecotourism development occurred at plot 04 and plot 05 areas turned into a parking lot and supporting facilities. Ecotourism officials also actively clearing the area below the stands, resulting in no found wildings in plot 04.

No disturbance from illegal logging is due to people benefitting from forest environmental services in the forms of ecotourism and water source. People began to realize and participating in stand protection efforts. There were four ecotourism locations that developed in GDRF areas, and conduct illegal logging will negatively impact ecotourism sustainability. People also utilize water sources from GDRF areas for irrigation, daily household activities and waterfall tourism.

Record on pest attack was in stand SP (21e) in form of caterpillar. The origin of trees were also recorded and become additional point in determining ISS criteria. Assesment results for stands (table 6) shows that not all stands in GDRF could be appointed as ISS. There were three stands (SPi 05, SPi 24, dan SP 20) that exceed the minimum total score of 94.5. Biggest factor behind the disqualification of some stands was the lack of mother tree counts. Higher mother tree count were possessed by *S. platyclados* of plot 20, followed by *S. pinanga* of plot 24, and *S. pinanga* of plot 05.

S. platyclados stands in plot 20 (SP 20) has an overall high score in all parameters so it is recommended to be appointed as *S. platyclados* ISS. SP 20 has the highest stand quality scores both on the total height and diameter. Those qualities could increase the stand potential to produce high quality seeds. According to [20] with higher height and greater diameter, trees may produce seeds with greater probability to achieve optimum physiological ripening. Aside from that, plot 20 was located near the main road, providing easy access for seed collection activities. Recommended stands for *S. pinanga* ISS were SPi (24) and SPi (05), SPi (24) has a higher total final score than SPi 05.

Disturbance found in *S. pinanga* stand were found in plot 05 from the existence of ecotourism spot in the area. Ecoutourism officials routinely clearing the areas below the stands, so there were no wildings found in plot 05, even though the trees already bear fruits more than once. There is a need for special treatment if SPi (05) were appointed as ISS. The shortcoming of Plot 24 if appointed as ISS is its far distance from basecamp and also not located near the main road. The trip must be continued on foot for about 1.5 km from the main road, difficult terrains could hinder the monitoring activities whether to prevent disturbances or a simple fruiting observation.

SPi (05) and SPi (24) stands as *S. pinanga* ISS and SP (20) stand as *S. platyclados* ISS have a better potential if compared fom other ISS from other locations outside GDRF. Another *S. pinanga* seed source was ISS in Tengkawang Gunung Selatan, East Kalimantan that encompass an area of 30 Ha but unequipped with information regarding number of mother trees and its productivity. Same issue found on *S. platyclados* seed source in Meranti Kedabuhan, Aceh Provinsi which spanning across an area of 2.37 Ha which similar to SP (20), but also no additional information regarding its productivity and numbers of mother trees. Both seed sources were last certified in 2013, with no mention of informations regarding its re-certification [7].

Another example for comparison is Datar Alai nature forest which appointed as ISS with 20 individuals of *Shorea leprosula* mother trees and eight individuals of *Shorea parvifolia* mother trees [21]. Gunung Dahu's site has a higher number of well-managed mother trees, with a relatively easier access compared to Mahang-mahangan communities (*Macaranga* spp.) in KHDTK Kintap which appointed as (*Macaranga* spp.) ISS. According to [22] 10.7 ha area is needed in order for KHDTK Kintap to maintain 25 mother tree individuals per stand for each Mahang species.

4. Conclusion

Based on the minimum score (94.5), three plot of *S. pinanga* and *S. platyclados* those were plot 05, plot 24 and plot 20 can be assigned as identified seed stand (ISS). The result of this study can be used as recommendation for GDRF management in choosing the best *S. pinanga* dan *S. platyclados* stands to be designated as ISS.

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