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Traditional and Commercial Utilization of Mangrove resources at Bintuni Bay-West Papua, Indonesia

Mahmud[1*], Wahyudi[2,4], Febriza Dwiranti[3,] and Ai Siti Fatimah[4]

[1] Department of environmental science, Faculty of Forestry, University of Papua, Manokwari West Papua, Indonesia

[2] Department Forest products, Faculty of Forestry, University of Papua, Manokwari, West Papua, Indonesia

[3]Department of Biology, Faculty of Mathematic and Natural Science, University of Papua, Manokwari, West Papua, Indonesia.

[4]Agriculture Doctoral Program, Graduate program, University of Papua, Manokwari, West Papua, Indonesia.

Corresponding author: m.mahmud@unipa.ac.id.

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Abstract. Utilization and commercial timber extraction of mangrove forest to produce woodchip under silviculture system of seed trees method at Bintuni bay Papua Barat–Indonesia has been undertaking for over 25 years without disregarding local people dependence on utilizing its own forest for fulfilling their daily needs. This paper presents traditional utilization and commercial timber extraction of mangrove forest under the seed trees method optimizing toward achieving sustainable mangrove forest utilization. The results indicate that local people are tolerable to utilize mangrove forest and its associated products regardless their forests are managed by the holder of forest concession permit of woodchip producer. Timber extraction of mangroves for commercial purposes at Bintuni bay is highly human labor-intensive works that still been operating until today. Production and movement of 2 m long logs at forest sites mostly are done by human labours with contract system of cubication. It is interesting that operational cost for skidding logs per cubic metre of logging crew for mangrove is higher than that of the terrestrial forest of heavy equipment but its daily productivity is less. Logs are produced mainly from the boles of five commercial species of mangrove of minimum diameter of 10 cm up at DBH while buttresses, twigs, and branches were regarded as logging residues. Productivity of the seed trees to yield natural re-generation represented into population of seedling and sapling per hectare are enormous and good enough to re-establish young mangrove of next cutting cycle, including the most affected areas likes skidding track and logging camp in which natural re-generation is well developed. Former sites of temporary stacking place and unreachable tidal wave are two areas where re-plantation should be carried out. In addition, this silvicultural system clearly shows that traditional and commercial utilization of mangrove forest as well as re-establishment of natural re-generation are functioning well and moving toward to be sustainable utilization and management of mangrove forest.

Keywords: Utilization, commercial, mangrove, timber extraction, Bintuni bay

1. Introduction

Mangrove at Papua Barat Province of Republic Indonesia is natural forest, grow, and scatter intensively at the bird neck area particularly Bintuni bay, Babo, Sorong Selatan, and Raja Ampat. It is occupied at about 430.616,00 ha[1], where is of 124.850,90 ha designed as Bintuni bay preserved area and the remaining areas of 305.766,10 ha are production forest. This natural forest is purely mangrove, evergreen, and unexploited. Bintuni bay is located at relatively geographic isolation area[2], without any disturbances from heavy activity of urban civilization, industry, intensive agriculture, and fishing-pond conversions, government office, and others.

This mangrove forest of Bintuni bay belongs to the National State Forest but inherits traditionally into twelve native clans where customary right of compensation is subjected by the law to the native clans [3]. They live at villages in or closed to their mangrove forest together with other community laying their daily needs of pole used for constructions residential house, fuelwood for domestic cooking, and catching fish, and other marine products from the surrounding ecosystem of mangroves.

Historically mangrove is planted by coastal community in order to generate income form timber and its derivative products [4], utilize their timber for residential raw material of forest people as well as fulfil their daily necessities [5]. Utilization of mangroves timber for commercial scales in Matang Malaysia is mainly for poles and charcoal production [6], and in Pedada bay the Philippine is for residential construction and charcoal production [7]. Recently mangroves are mostly planted and managed for coastline protection, assimilation of waste, source of food, shelter and sanctuary for fauna, spawning and breeding ground for marine life, and barrier storms and tsunami [8], [9].

Native people and holder of forest concession-permit utilize mangrove forest of Bintuni bay for daily usages and commercial purposes of producing woodchip, respectively. First concession-permit of commercial utilization of mangrove timber extraction of 137.000 ha of production forest was for 20 years from 1988 to 2008 (MoF 1988). Second concession permit for the second period of 82.120,00 ha was officially given to the same private logging company at similar location for 45 years period of 2008-2053. Single product of mangrove timber is woodchip mainly from boles of mangrove trees while branches, twigs and buttresses are disregard as logging residue [10].

Silviculture system is essential element for sustainable forest management, dealing with establishment, development, reproduction, and harvesting forest vegetation [5], with appropriate silviculture system leading toward to sustainable forest management and utilization. For over 25 years of mangrove timber extraction of producing woodchip at Bintuni bay, silvicultural system of seed trees method is used and it is a single woodchip producer operated in the Eastern Indonesia today. This fact is in contrast to 26 holders of forest concessions of terrestrial forests in Papua Barat province managing 4.324.975 ha production forest [11]. Silviculture of the mangrove forest is fairly simple compared to that of the inland forest because the former are more homogenous and uniform [12]. With the exception of Asia, in most countries with mangrove formation no systematic silviculture or management is applied to the resources [5], and silviculture practices to manage mangrove forest for commercial woodchip purpose are limited. Therefore, principal guidance, achievements and challenges of this silvicultural system of the seed tree method at Bintuni bay mainly for commercial woodchip production could be widely shared to others and possibly may be implemented or inspire to mangrove forest management for different purposes.

This paper describes traditional and commercial utilization of mangrove forest, with emphasized on silviculture system of the seed tree method, logs production and movement at forest sites, and ability of the seed trees to re-establish natural regeneration in producing seedling and sapling and impact of forest extraction on defects of the seed trees remained as well as the sites of logged over forest areas required for re-plantation.

2. Method

Data collected from related literatures or researches (undergraduate and Master thesis, reports, and other documents) conducted at Bintuni bay mangrove forest were used to

prepare this paper. Field visit was conducted to observe recent practices of the seed tree method. Wide ranges of publications related to mangrove utilization and harvesting practices available on the webs were also used. Data were analysed with Microsoft excel and presented in Figure and Tables. More importantly, one and a-half year of my personal working experience at this mangrove logging company are essentially used to support further explanation that are not stated by the seed trees method.

2.1. Description of the site studied

Bintuni bay geographically is located at the bird neck area of the West Papua Province at New Guinea Island. New Guinea Island is divided into Western and Eastern part, where the Western part belongs to Republic of Indonesia, and the Eastern part belongs to Papua New Guinea. Mangrove commercial timber extraction of forest concession permit located at Bintuni bay is at 00º 24`30,4`` - 002º 41` 28,4`` S and 133º 19` 00.3`` - 133º 58` 27.2`` E. Mangrove grows from 0-6 above sea level with topography from 0 to 2%. Periodically one to two times in a month the maximum tidal wave is accurred in which whole mangrove forest is covered with s by boat to the woodchip plant at Amutu Island Bintuni bay.

3.Results

To get more understandable, cohesiveness and simplicity to the readers, the results are organized here into four sections as follows: 1) traditional utilization of mangrove; 2) Commercial utilization of mangrove for woodchip production; 3) Indonesian silviculture of seed trees method; and 4) Seed trees method evaluation

3.1. Traditional utilization of mangrove forest

Mangrove forest has been supporting livelihood of forest people at the tropical region from the early civilization, offering various good and services [2], [4], and derives principal income from fishing and related activities [4]. Mangrove is special plant in which whole parts of this vegetation could be utilized for various purposes, ranging from food, food additive, dying, medicine, skin protection, or others [13]. Local people in Philippine and Peninsula Malaysia utilize mangrove timber for residential construction, fuelwood, and charcoal [7], [8].

Local community at Bintuni bay traditionally utilizes its mangrove forest for variety of purposes, ranging sources of food, fuelwood, and residential construction material for daily usages. It also provides an extra household income to local people by selling seafood products of Shrimp/Banana prawn *(Penaeus indicus),* Lobster (*Panulirus sap*), Crab (*Scylla serrate* Fosk.) and medicinal plant material [3]. Similar to other native people at Eastern Indonesia, Sago (*Metroxylon sp*) growth at mangrove forest is used for sources of carbohydrate or main staple food and Fern *(Diplazium esculentum)* is kind of vegetable taken from the forest [13].

Langade *(Bruguiera paviflora)* is most preferable species for residential frame construction (Figure 1a) due to its straightness and less-branches. Diameters of 5 – 8 cm are mostly selected as they are easily carried out from the forest to village either with boat or walk. Barks are peeled out to accelerate drying. Tengar (*Ceriop tagal)* is the first option for fuelwood (Figure 1b) as it is easily to be breakdown with axe with less-moisture content and combustible at fresh condition. Sarang semut (*Myrmecodia spp*) is an epiphyte plant on mangrove (Figure 1c) in which its decoction of dry-chopped material is used for medicinal purpose. Collection of Crab (*Scylla* sp) is prepared for selling to regional market (Figure 1d).

Indigenous knowledge on utilizing mangrove for medicinal purposes of five indigenous people of Papua has been summarized [13].

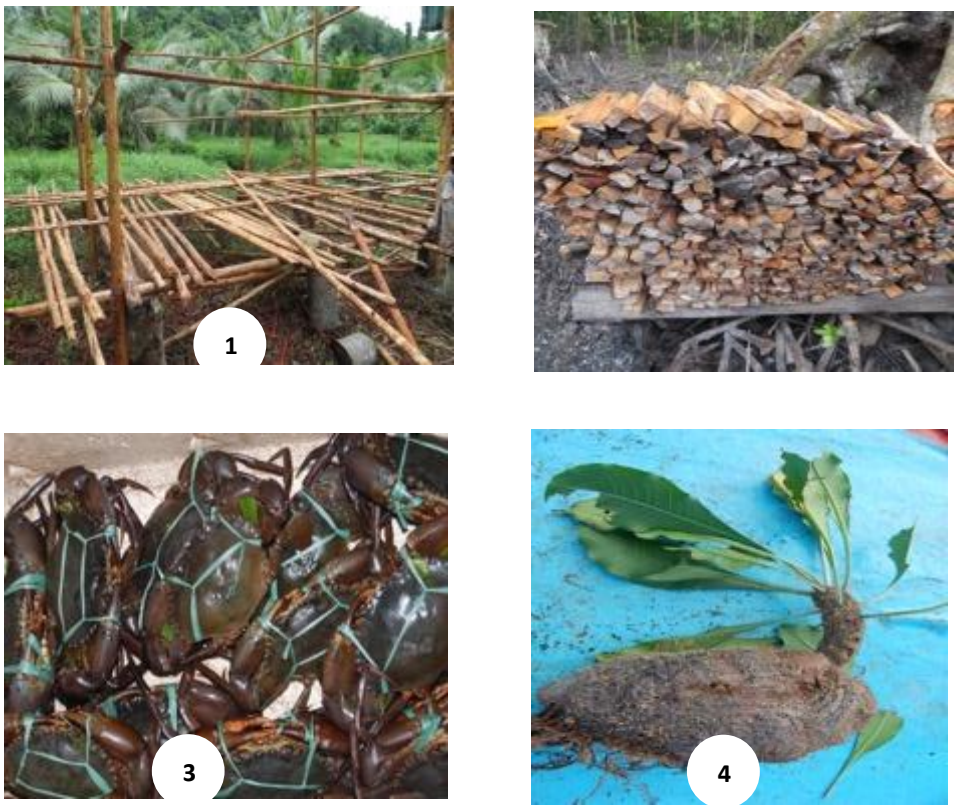

Figure 1 Local utilization of mangrove forest at Bintuni bay Papua Barat Indonesia (a); Poles of small diameter of Langadai (*Bruguiera spp*) used for residential construction (b); Firewood from Tengar (*Ceriop spp*) (c); Edible Mangrove Crabs (*Scylla serrate*) (d) a fresh Sarang semut (*Myrmecodia spp*) for medicinal purposes.

3.2. Commercial utilization of mangrove timber

3.2.1. Production of log and woodchip from mangrove

Commercial utilization of mangrove timber at Bintuni bay started in operation by 1989 under forest concession permit (BUMWI 2013) in which five mangrove species of Rhizophoraceae family are harvested, namely Bakau (*Rhizophora apiculata* Bl, *R. mucronata* Lamk), Tumuk (*Bruguiera gymnorrhiza*, *B. sexangula*, *B. parviflora*), and Ceriop (*Ceriop decandra* (Griff.) Ding Hou, and *C. tagal* [14]. Timber is extracted from forest management unit (FMU) of 100 ha each in which forest inventory, schemes of operation, other supported logging facilities are determined and approved officially. Logs are produced with selective cutting and fitted criteria such as diameter of 10 cm up at diameter breast high (DBH), commercial species, cut at 10 cm above the buttresses, as well as felling direction of less destruction to the remaining vegetation. Workflow for log production to woodchip conversion from mangrove timber is presented in Figure 2.

Initially, the selected mangrove trees are felt down with Chain saw, cut off the top, branches, twigs, and bucked into logs with 2 m long. Logs are bunched next to skidding track (Figure 2a) waiting for debarking. Member of logging crew peel out bark manually using wooden flat-stick (Figure 2b), skidding is conducted manually by human labor in which the debarked logs are mounted, fasten on palm-wood sledge with rope and dragged on the

skidding track to temporary stacking place (TSP) illustrated in Figure 2c. Mangrove logs are stacked and mixed at TSP (Figure 2d). At average, 4-5 logs are dragged in single trip. Skidding is conducted at the lowest level of tidal wave period either day or night with intensive lighting. After volumetric scaling, mangrove logs are loaded into opened-flatten-floating vessels based on gravitation force by loading crews at the lowest period of tidal wave, and they are towed by Tug-boat (Figure 2e) to woodchip plant. Unloading or hauling is conducted at the industrial plant wharf by crane. Logs are transferred into belt conveyor of production line entering to chippers. Woodchip are mounted into yard for storage waiting for export (Figure 2f).

Figure 2 Illustration of logs and woodchip production from mangrove timber at Bintuni bay Papua Barat: (a) bunched 2 m mangrove logs; (b) debarking logs; (c) skidding crew; (d) temporary staking place; (e) opened-flatted floating vessel; and (f) woodchip storage yard.

3. 2.2. Logging residues

Logging residues are any parts of trees that have been leftover at logged over forest areas due to economic and technical reason. Mangrove timber extraction at Bintuni bay results residual wooden material of tress such as branches, twigs, stumps, roots, and buttresses (Figure 3a), and woods used for skidding tracks (Figure 3b). Gathering these woody materials are technically time consuming and economically less productive due to small sizes in diameter, length and asymmetrical shape. As illustrated in Figure 3b, small mangrove timber used for skidding track is contaminated with muddy and oil that significantly determine woodchip appearances. Logic reason why these residual timbers are disregard it is probably related to wage contract system of cubication in which large sizes of logs will satisfy faster than the smaller sizes.

Actual percentage or volume of logging residue of mangrove timber extraction at present is still unavailable but it seems that its quantity is good enough used for woodchip in which small diameter of logs is adequate (Figure 3a). Peeled barks are dump off and disregard on forest floor naturally decompose into nutrient of mangroves.

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Figure 3 Mangrove logging residue left over at logged over forest areas consisting of: a) branches, twigs, stumps, roots, and buttresses; and b) contaminated timber of former skidding tracks.

3.2.3. Logging crews

Employments of human labours of mangrove timber extraction are classified as logging crews consisting of chain saw operator, skidding crew, and loading crew. Member of skidding crew is 5 male workers, 2 couples skidding partner, a food chef and stay at temporary logging camp (Figure 4a). Chain saw operator is responsible for cutting trees and bucking logs of 5 skidding crews. Loading crews are responsible for loading 2 m logs at TSP into opened flatten-floating vessel using gravitation force and they stay at floating camp as presented in Figure 4b.

Figure 4. Logging crew temporary camp (a) and loading crew floating camp (b)

Horizontal log movement (skidding) of the terrestrial forest is regularly done by machine (*skidder*), animal (cattle, horse, or others) for mangrove logs, however, are transported manually by human labours. Heavy equipment and animal are not possible to be used for mangrove skidding due to higher tidal wave occurrences.

3.2.4. Skidding Costs

Log size, type of forest, and end-wood products will influence tools, equipment, and facilities utilized to handling logs as well as determining the cost of log movement in or out forest sites [15]. Equipment used for log handling such as skidding for mangrove and terrestrial forest is different. The previous section highlighted that mangrove extraction at Bintuni bay is human labor intensive while terrestrial forest mostly relies on the heavy machine of skidder or tractor. As consequence skidding operational costs between mangrove and the terrestrial forest are significantly different.

Single trip of skidding crew for mangrove logs are able to drag at average of 0.27 m^3 for distance of 281.20 m with 21.79 minutes [16]. Its volume consists of a single log of diameter 30 cm up or maximum five logs of diameter less than 30 cm. With 5 hours per day, a skidding crew is capable to transfer an average of 3.70 m^3 per day or 46.9 pieces of logs per day. For terrestrial forest, skidding with tractor Caterpillar D7G at two forest concessions at Papua (Jayapura and Bintuni) are able to transport an average of 122.71 m^3 per day in 5 hours [17], and 157.48 m^3 per day [18] . In relation to the cost, skidding cost of mangrove and terrestrial forest at Papua is presented in Figure 5.

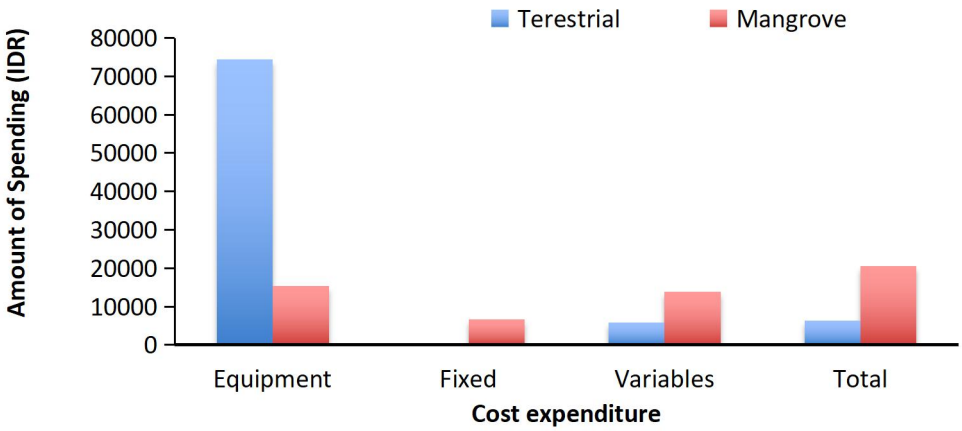

Figure 5. Skidding cost between mangrove and terrestrial forest at Papua case

From this Figure it clearly indicates that even though capital investment due to buying skidding equipment of at terrestrial forests is higher (IDR 75.000,00 /m^3) than mangrove (IDR 15.000,00/m^3), the total skidding cost is lower (IDR 5.000,00/m^3) than mangrove forest (24.000,00/m^3). It seems that skidding cost per m^3 log for mangrove is 4.8 times higher than the terrestrial logs.

3.3. Indonesian Seed Tree Method

Silviculture system of mangrove is probationary and oversight tasks in Indonesia regardless of its largest mangrove forest in the world [19]. Historically Area method system was initially introduced in 1952, and modified into Standard clear-cutting silvicultural system in 1956, and further re-modified to Strip wise-electing-felling silvicultural system in 1972, and then Seed-trees method was introduced in 1978 that have to be applied to manage mangrove forest in Indonesia until today [20].

Seed trees method is a silviculture system of mangrove for commercial utilization under forest concession permit officially introduced in 1978 [21]. This system highlights that timber

extraction and forest regeneration are whole process correlated activities and depend on one to another. It is a combined approaches between harvesting and regeneration, where an appropriate number of individual trees are left cross an area to produce seeds for natural regeneration prior for production of trees for the next cutting cycles [22]. The present silviculture method requires a carefully selection on mangrove tree prior for cutting (selective cutting). It is different to that system used in Matang mangrove forest in Malaysia, where clear cutting is applied. Mangrove silviculture practice at Matang Mangrove Forest reserve in Malaysia has been declared as the best managed forest for timber production in the world [6].

3.3.1. Basic Regulation

Fundamentally, seed trees method consists of eight-basic regulations (Inouqe et al. 1985) that are summarized as follows: a) mangrove tree rotation or cutting cycle is 20 years; b) minimum 40 mature well shape (healthy, balanced crown, 17 m distance amongst the trees, with diameter 20 cm up at DBH) of *Rhizophora spp, Ceriop tagal,* and *Bruguera spp* are selected and marked as Seed trees; c) at least 2500 seedling per ha are attainable of established natural regeneration; d) 10 cm at DBH is minimal diameter of trees prior for cutting; e) concessions are divided into forest management unit (FMU) of 100 ha in which forest inventory is conducted 3 years prior for cutting using systematic strip sampling with 5 % intensity for trees, sapling and seedling systematically; f) Green belt areas of 50 m perpendicular to coastal line and 10 m for rivers designed for Riparian area have to be protected without any logging activities; g) maximum of 1% area used for Temporary Stacking Point (TSP); h) thinning is conducted 15-20 years after cutting.

3.3.2. Seed Tree Method in practice

Practices of seed trees method at Bintuni bay is a combination to Indonesian Selective Cutting System (ISCS) of the terrestrial forest in which two activities are adopted preparing infrastructure prior logging, and inventory of logged over areas, respectively. Adjustment is made too in which riparian areas are extended to 200 m and 50 m are for coastal and river areas respectively. Importantly cutting cycle is shifted into 30 years. Field practices of the seed trees method therefore are grouped into three important stages, namely planning, cutting, and re-forestation or rehabilitation stages.

Planning stage consists of mapping forest concession into FMU of 100 ha, forest inventory, marking and numbering the seed trees, and preparing infrastructure for logging. The present stage covers of setting location for logging crew camps, skidding track, and TSP. Re-forestation covers inventory of logged over forest area, establishing nursery, enrichment planting, rehabilitation I - III and thinning. Inventory of the logged over forest area is conducted a year after cutting to examine population and distribution of seedling, sapling and damages of the seed trees. From this inventory, re-plantation or artificial regeneration are recommended to any areas where population of seedling and sapling is less than 2500 plants per hectare with particular empathized at former areas of TSP, skidding tracks, and logging crew camps.

3.4. Research on Evaluation of Seed trees method

Numbers of research have been conducted to examine or evaluate the seed trees method practices at Bintuni bay likes statue or condition of the seed trees at logged over forest area [23], re-establishment of natural regeneration under the seed trees at logged over area two

year after cutting [24], and re-establishment of natural regeneration at former logging infrastructure, logging crew camps, TCP, and skidding tracks, (Beto 2003). The results briefly will be summarized in the following paragraphs.

3.4.1. Statue of the seed trees

When mangrove trees are cut down, the fallen trees could harm the standing trees causing damages or defects of boles, crowns, and buttresses, and consequently propagules production of the seed trees will not be optimum as the healthy ones. The seed trees statue in terms of their well shape (healthy or injury), population per hectare at logged over forest area two years after cutting have been investigated [23]. She reported that population of the seed trees per hectare is 99 at average consisting of four mangrove species of *R. apiculata, B. gymnorrhiza, B. parviflora,* and *C. tagal,* respectively. It is higher than that (40 per hectare) as recommended (MoA 1978) and the seed trees (67% of 99) have diameter of 20 cm up at DBH instead of 10 cm minimum. Damages or defects due to direction of falling trees are low (23 of 99 trees, 23%) and prevalence mostly occurred for crown of 9%, bole or trunk of 9%, and buttresses of 5%. It is also reported that *B. gymnorrhiza* is suffered for the most (10%), followed by *R. apiculata* (9%), and *B. parviflora* is the lowest (1%). It is no argument proposed to explain a tendency for being defects with the mangrove species.

4.2. Establishment of natural re-generation under the seed trees

Mangroves are dynamic, ever-growing and constantly re-established and re-generated themselves, and differ from terrestrial forest because they are special condition and requirement for survival in tidal location [25]. Re-establishment of natural regeneration of mangroves heavily depends on the availability of seedling and sapling. It is because population of natural regeneration represented by seedling and sapling will establish new standing stock of mangrove tree for the next cutting cycle. On seed tree method of silviculture system terms of seedling is an individual plant of young mangrove less than 1 m high, while sapling ranges from 1– 3 m high [21].

This silvicultural system emphasizes that re-establishment of natural re-generation of seedling and sapling is a main indicator for production and germination of propagules of the seed trees. Therefore, examination for re-establishment of population for seedling and sapling under seed trees play key roles in natural re-generation. Investigation on natural re-generation of seedling and sapling under canopy of the seed trees of two species of mangrove, *Rhizophora spp* and *Bruguiera spp*, respectively have been conducted [24], and the results are summarized in Table 2.

Table 2 indicates that regardless of mangroves species and bole class of diameter numbers of natural re-generation of sapling under canopy both for *Rhizophora spp* and *Bruguiera spp* are similar which is 10.3 sapling at average. It means that the seed tree could produce 10 saplings each regardless their bole class of diameter. *Bruguiera spp* produce natural re-generation of seedling is 1.8 higher than that of *Rhizophora spp*, where 944.3 and 539 seedling is for *Bruguiera spp* and *Rhizophora spp*, respectively. This is contrast to the fact that an average of canopy areas of *Bruguiera spp* is lesser (14.6 m^2) than that (21.5 m^2) of *Rhizophora spp*. Nevertheless, small class diameter of bole from *Bruguiera spp* tends to produce higher seedling contrast to *Rhizophora spp* where high class diameter of bole is able to produce much number of seedlings.

Table 2 also indicates that if re-establishment of natural re-generation is expressed in density per hec
seedling and 7871 n/ha for sapling. This population exceeds to the minimum population of seedling and sapling required by the seed tree method system of 2500 n/ha.

Table 2. Population of natural regeneration for seedling and sapling under two seed trees mangrove species

Mangrove species	Diameter		Cover areas of canopy		Clear bole height (m)	Number of natural regenerations produced (n)			Density of natural regeneration (n/ha)		
	Class bole* (cm)	Canopy (m)	(m^2)	(ha)		Seedling	Sapling	Total	Seedling	Sapling	Total
Rhizophora spp	20-29	3.55	9.9	0.001	9.0	359	15	374	359000	15000	374000
	30-39	4.5	16	0.0016	12.6	529	13	542	330625	8125	338750
	40-49	6.41	32	0.0032	10.7	577	6	583	167812	1860	169672
	50 Up	5.95	3.0	0.0030	11.6	691	7	698	246786	2500	249286
Total		20.41	85.8	0.0086	43.9	2156	41	2197	1104223	27485	1131708
Mean		5.10	21.5	0.0021	10.9	539	10.3	549.3	276056	6871	282927
Bruguiera spp	20-29	3.63	10	0.001	8.7	1856	6	1862	1862000	6000	1868000
	30-39	4.45	16	0.0016	9.2	1218	18	1236	761250	11250	772500
	40-49	4.37	15	0.0015	6.9	372	3	375	248000	2000	250000
	50 Up	4.70	17	0.0017	9.8	331	14	345	194705	8235	202940
Total		17.15	58.2	0.0058	34.6	3777	41	3818	3065955	27485	3093440
Mean		4.29	14.6	0.0015	8.6	944.3	10.3	954.5	766488	6871	773360

4.3. Re-establishment of natural regeneration of different site at logged over forest areas

Intensive human labour works of mangrove timber extraction cause significant impact on logged over forest areas such soil compaction, oil polluted, and deteriorated tannin of buried barks. Soil compaction occurred at TSP and logging camps. Skidding tracks are polluted with oil and bark tannin. Oil is used to polish skidding track for slippery. Buried barks on forest floors are inhibited the fallen propagules to penetrate to germinate. Ability of these sites to re-established natural re-generation is undertaken seriously compared to the other sites that are mostly opened and reachable tidal wave.

An investigation on re-establishment of natural re-generation of at temporary stacking place, skidding track, logging crew camps, and unreachable tidal wave was conducted [26], and the results are presented in Figure 6.

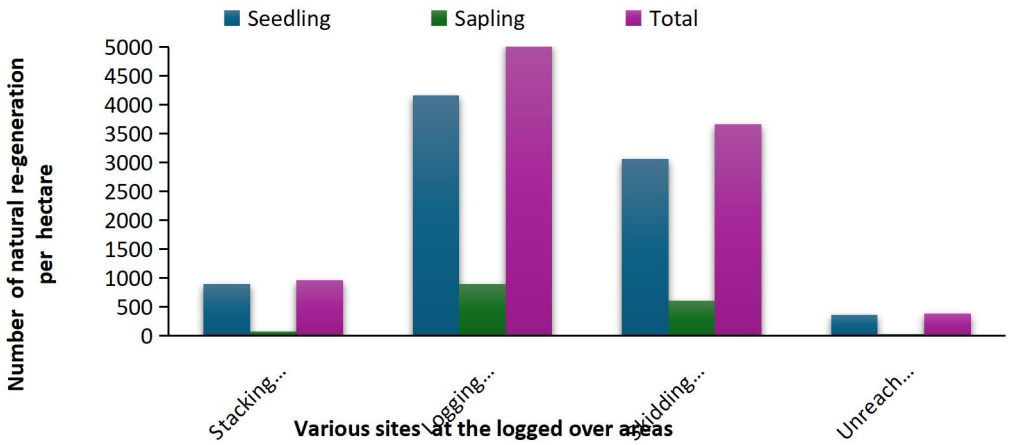

Figure 6. Re-establishment of natural re-generation of seedling and sapling at selected sites of the logged over forest areas

Figure 6 clearly indicates that population of seedling and sapling at logging crew camps and skidding track are higher than number of natural regenerations recommended by the seed tree method, totally 5000 per hectare and 3500 per hectare for logging crew camps and skidding tracts, respectively. Importantly, it is highlighted that replantation is only necessary to the temporary stacking place and unreachable tidal wave areas, where their natural regeneration is lower than recommended by the system.

4. Discussion

Mangrove forest resource at Bintuni bay satisfies necessities of the native people for daily traditional utilization and provides extra income sources of family. Traditional utilization of pole, fuelwood for domestic cooking, vegetables and plant-medicine is principally similar to other coastal communities of the tropical regions [5]; Malaysia [12],[8], Bangladesh [27], Philippines [7], Brazil [28], and East African Region [29]. Utilization of mangrove derived products of charcoal, source of tannin, and body boat are absent at this region and probably due to location of isolated areas in which is no demand for these products. It is also applied for other processed products derivates mangrove [30] , like food, beverage, syrup, dying are not yet developed at Bintuni bay [3]. Those products are mostly developed in the western Indonesia of Java where the population has enough knowledge through training or self-exploration.

Commercial management under forest concession permit, the native people are still tolerable to harvest, utilize, and extract their own mangrove forest to fulfil daily necessities and obtain an extra income of family, which mostly come from the marine products of Crabs, Shrimp, and fishes. The holder permit of forest concession always persuades the native people to develop their potential economically and socially for being self-sufficient and independent community based on the own resources [3], [30], [31].

Regardless of decreasing forest concession permit from 137 000 ha for first concession of 20 years (1988-2008) to 85100 ha for second concession of 35 years (2008 - 2043), the mangrove company is able to manage its concession to produce woodchip continuously as a single product for over 25 years. Its product is mainly from the bole of mangrove trees and the residual logging of buttress, twigs, bark, and branches are disregard. Timber requirement

for woodchip raw-material is not too large in size and diameter, therefore these residual logging have to be processed in the future as well to intemperate forest sustainable utilization.

Timber extraction from mangrove forest for woodchip commercial production is predominantly done by human labours, logging crews, loading crews, and chain saw operator, a using system contract of cubication wage. Chain saw operator is responsible for cutting trees and bucking laid trees to 2 m logs. It is because logs cutting and bucking have to be conducted with skilfully labour, carefully and correctly that they will influence on greater volume and value of timber [9]. Logging and loading crews are responsible for production and movement of logs at the forest site. It is interesting facts that skidding and loading logs with human is still taking today when huge-capital equipment are mostly operated for skidding process at any forest operation worldwide [4], [32]. This intensive human labour for timber extraction probably is only occurred at Bintuni bay and may be adopted to other mangrove forest either for similar or different purposes of utilization.

Even though huge capital investment of heavy equipment is required for skidding of the terrestrial forest, its operational cost of skidding per cubic meter is lesser than that is of the mangrove logs. It is probably related to intensive and skilled human labour in handling mangrove logs. Silviculture is a tool to manage forest resources toward sustainable management and utilization [15]. The seed trees method is a silviculture system developed to manage Indonesian mangrove forest for commercial purposes under forest concession permit [21]. Implementation of this silvicultural system at Bintuni bay is combined with Indonesian selective system cutting in which two principles are adopted and has been working very well or gain successful for over 25 years. Through this system, felling direction of mangrove trees cause a less destructive to the remaining trees including the seed trees as been reported that the seed trees at logged over forest areas two year after cutting are in good statue, well-shape, healthy and more importantly their population per hectare is significantly double, 99 trees per hectare from 40 of minimum requirement [23]. Population of the seed trees per hectare exceeds the recommended population of the seed trees method.

An individual seed tree performs well in producing propagules for initially needed to re-establish natural regeneration regardless of bole diameter and mangrove species. Both mangrove species of *Rhizophora spp* and *Bruguera spp* have comparable capability in producing natural regeneration of seedling and sapling under their canopy. It is highlighted that its population per hectare of seedling and sapling under canopy both seed trees are enormous and it is remarkable exceed the minimum requirement of 2500 of seedling and sapling per hectare [21]. Seed tree is a mature-well shape and commercial species of mangrove selected and un-cut off left at the logged over area aiming to produce propagules. Mangrove is a littoral plant producing enormous quantity of propagules that could drop directly to the forest floor to establish natural regeneration [8], [20], [33]. The seed trees are established with the main purposes to initiate forest regeneration naturally.

Nursery house is established to supply seedling for enrichment planting or reforestation of any logged forest areas sites that are insufficient population of seedling. Stock and house construction of the nursery house is illustrated in Figure 7a-b. As been illustrated in Figure 7, propagules from the two commercial mangrove species of *Bruguera spp* and *Rhizophora spp* are cultivated, seedlings on polybags ready planted (Fig.7.a) and fresh propagules on polybags (Fig.7b). Local made

materials to build nursery house are supplied by the native people of the surrounding woodchip plant.

Figure 7. Nursery house of mangrove at Bintuni Utama Murni Wood Industries, seedlings ready for planting (a), and fresh propagules in nursey polybag (b)

Concentrated work of human labour at skidding track, temporary stacking place and logging camp cause serious impacts of soil compaction particularly at TSP, logging camp and skidding tracks. Oiled used for polishing the skidding track to be slippery is polluted to the forest ground and possibly inhibited to the growth of propagules. Similarly, unreachable tidal wave areas are suffered from the distribution of floated propagules.

5. Conclusion

Both traditional and commercial utilization of mangrove forest at Bintuni bay West Papua Indonesia are happened because of tolerable and understandable relations between the native people and forest concession holders that succeed its operation over 25 years. It is highlighted that traditional utilization of mangrove forest at Bintuni bay is similar to other tropical regions, mainly for daily usages of the native of forest dwellers. Commercial utilization under forest concession permit did not disregard local community dependency on their natural resources. Production of propagules of the seed trees represented into population of seedling and sapling is sufficient enough to establish new mangrove stands of the next rotation of cutting cycle. Enrichment plantings are artificial replanting conducted at any logged over forest areas with un-sufficient population of seedling. Commercial timber extraction managed with appropriate silviculture system could prevent mangrove`s losses and clearly promoting to sustain management and utilization of mangrove forests.

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