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Study on Mangrove Vegetation in Coastal areas of Myanmar: Case study in Kyunsu Township, Tanintharyi Region and Ramree Township, Rakhine State

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Study on Mangrove Vegetation in Coastal areas of Myanmar: Case study in Kyunsu Township, Tanintharyi Region and Ramree Township, Rakhine State

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Abstract

The vegetative composition of mangrove forest and plantations in two coastal areas of Myanmar: Kyuntsu Township and Ramree Township, was investigated in this study. This study focuses species diversity, distribution and regeneration in the study sites, and this presented data was part 1 of this study. Data were collected by using the circle shape of sample plot (0.07 ha), and the distance between the sample plots is 100 m. All vegetation within the sample plot were recorded and measured the diameter at breast height and total height, and the regenerations were enumerated within 5 m radius subplots that laid at the center of the main plot. In Kyuntsu, all study plots located at the natural forest area while both 4 plantations and natural forest areas were included in Ramree. The results demonstrated that Byu Oak Saung (*Bruguiera gymnorhiza*) showed the highest importance value index which followed by Byu (pho) (*Rhizophora apiculata*) and Madama (*Ceriops decandra*) in Kyuntsu. In Ramree, the importance value index revealed that Madama (*C. decandra*) dominated at plantations and natural forest area, followed by Byu (pho) (*R. apiculata*) in natural forest area and Yae-khayar (*Aegiceras corniculatum*) in plantations. Kyuntsu had high diversity index H= 0.83 while Ramree's natural forest site had H= 0.68 and that of plantation sites had H= 0.47. Totally 19 species were recorded in both study sites and, among them 7 species were found in both study sites as the common species. Kyutsu had big sized trees compared with both natural forest area and plantations of the Ramree site. Significant differences were observed in GBH ($p<0.05$, $F = 57.718$) and Ht ($p<0.05$, $F = 390.030$) in among the natural forest sites of both study area. The vegetation regeneration among the study sites indicated different ($p<0.05$) but not significant. Generally, the mangrove forest in the study sites had different vegetation structural formation and species composition which could be attributed to the different agents of degradation i.e. degree of perturbations that greatly depend on human access to the mangrove area. Therefore, understanding the structure and regeneration patterns of the mangrove is critical for developing site specific management strategies that enhances and preserves the ecological functionally of mangrove ecosystem.

Keywords: mangroves, species, regeneration

တနင်္သာရီတိုင်းဒေသကြီး၊ ကျွန်းစုမြို့နယ်နှင့် ရခိုင်ပြည်နယ်၊ ရမ်းဗြဲမြို့နယ်ရှိ ဒီရေတောများတွင် အပင်များပေါက်ရောက်တည်ရှိမှုအား လေ့လာခြင်း

ဒေါက်တာဇာခြည်လှိုင်
လက်ထောက်ညွှန်ကြားရေးမှူး၊ သစ်တောသုတေသနဌာန

ဒီရေတောများကို ထာဝစဉ်ဖွံ့ဖြိုးစေမည့် သစ်တောစီမံအုပ်ချုပ်မှုနည်းလမ်းများဖြင့် ထိရောက် စွာဆောင်ရွက်နိုင်ရန် သဘာဝဒီရေတောပေါက်ပင်များ ပေါက်ရောက်မှု၊ ဖွဲ့စည်း တည်ဆောက် ပုံအားလေ့လာရန်အတွက် ဒီရေတောများပေါက်ရောက်သည့် မြန်မာနိုင်ငံ၏ ကမ်းရိုးတန်း ဒေသများဖြစ်သော တနင်္သာရီတိုင်းဒေသကြီး၊ ကျွန်းစုမြို့နယ်နှင့် ရခိုင် ပြည်နယ်၊ ရမ်းဗြဲမြို့ နယ်တို့တွင် ဤလေ့လာမှုအား ဆောင်ရွက်ထားရှိခဲ့ပါသည်။ ဒီရေတောပေါက်ပင်များ ပါဝင် ပေါက်ရောက်မှုအခြေအနေနှင့် မြေနှင့်ရေတို့၏ ပါဝင်သည့် ဂုဏ်သတ္တိများအားလေ့လာခဲ့ပြီး ဒီရေတောစိုက်ခင်းများနှင့် သဘာဝတောများအတွင်း အပင်များ ရှင်သန်ပေါက်ရောက်မှုနှင့် ပြောင်းလဲမှုတို့အား ဆက်လက်လေ့လာနိုင်ရန် အတွက်လည်း အမြဲတမ်းနမူနာကွက်များ ချမှတ်ခြင်းကို ဆောင်ရွက်ထားရှိခဲ့ပါသည်။ ဒီရေတောများအတွင်း ပါဝင်ပင်များ တည်ရှိမှု၊ မြေဆီလွှာနှင့် ရေတို့၏ ဂုဏ်သတ္တိတို့ကို သိရှိထားခြင်းဖြင့် ဒီရေတောစိုက်ခင်းများ တည်ထောင်ခြင်း၊ သဘာဝအပင်များအား ထိန်းသိမ်းကာကွယ်ခြင်းတို့တွင် အထောက်အကူပြုနိုင် မည်ဖြစ်ပြီး ဒီရေတောဂေဟစနစ် ထိန်းသိမ်းရေးကိုလည်း အထောက်အကူပြုနိုင်ရန် လေ့လာခဲ့ခြင်း ဖြစ်ပါသည်။

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1. Introduction

Mangroves are found along sheltered coastlines in the tropics and sub-tropics where they fulfil important functions in terms of providing wood and non-wood forest products, coastal protection, conservation of biological diversity and provision of habitat, spawning grounds and nutrients for a variety of fish and shellfish (FAO, 2015). In general, geography, coastal topography and tidal regime determine the presence or absence and extent of the mangroves. Structure, physical properties and chemical composition, salinity, acidity of soil and sediments, the nature of the substratum as well as the climate determine the development, growth and productivity of mangrove ecosystem. (Myint et.al., 2008).

Mangrove forests are one of the most productive and biologically diverse wetlands on earth. The mangrove ecosystem does not have as many species of plants and animals as other ecosystems due to the harsh and constantly changing environment (dos Reis-Neto et.al., 2019). Mangrove forests cover approximately 20 million hectares worldwide and are the main vegetation type in protected intertidal areas along tropical and subtropical coastlines (English et.al., 1997) being limited in distribution by the temperature of the sea water and the winter position of the 20°C isotherm (Hogarth, 1999). According to two reputable scientific studies, mangroves include approximately 16-24 families and 54-75 species (Tomlinson, 1986; Field, 1995) respectively. Asia contains most of the world's mangroves with 46 %, followed by America with 35 % and Africa with 17 % (MAP, 1990). Ricklefs and Latham (1993) suggested a number of explanations for the high mangrove diversity in the Southeast Asia region.

In Myanmar, mangrove forests occur in the coastal area of Rakhine State, Tanintharyi Division and delta area of Ayeyawady Division. The estimated area of mangroves in Myanmar is currently 462,954 hectares. (Forest Department, 2015) Nowadays, most of coastal populations have grown over recent decades resulted in an increasing pressure on mangrove resources. Coastal communities have depended on mangrove as one of their sources of income for decades and this dependence has rendered the mangrove forests to severe exploitation (Mchenga and Ali, 2014). Many mangrove areas to other uses and numerous case studies describe mangrove losses over time, but, information on status and trends at the global level is scarce (FAO, 2015). Although many papers have been published on different aspects of mangrove ecology, few publications have focused on mangrove forest structure (Pool et al., 1977; Martinez et al., 1979; Cintron et al., 1980; Cintron & Schaeffer-Novelli, 1983).

Although mangroves cover vast areas of tropical and sub-tropical coasts in many of these areas they are found to be under threat from a variety of anthropogenic activities, Alongi (2002) reports that approximately one-third of the world's mangrove forests have been lost. In Myanmar, large areas of mangrove forests may often be cleared to make way for shrimp aquaculture. They may also face impacts from increase in population pressure, conversion to agriculture, salt production, coastal industrialization and urbanization. Mangrove forests are also being harvested for wood and wood products such as firewood, charcoal, poles and timber. The method most commonly used to acquire the wood is clear-cutting that leads to soil erosion and acidification, which will prevent the forest recovering as re-growth becomes limited (Ellison and Farnsworth, 1996). These activities in many cases has already altered the physical, chemical and biological characteristics of the mangrove

areas. (Tuan et.al., 2003). In order to be able to monitor any changes, a baseline plant dynamics study need to carry out in mangrove forests of Myanmar.

Mangrove forests are usually restored through natural regeneration or artificial restoration using planted seedlings. The major advantage of natural regeneration is that the resulting forest is expected to be more similar to the local mangrove species, but, it may hamper by lack of seeds and propagules, weed competition, pollution, poor soil conditions or disturbed hydrodynamics of the site (Ashton and Macintosh, 2002). On the other hand, increasing awareness of the true value of mangrove ecosystems has led to renewed efforts to protect and restore remaining mangrove stand in Myanmar. It was estimated that about 15,445 ha (38,166 ac) of mangroves was planted since 1981 especially in most degraded areas (Forest Department, 2018), however no regular monitoring and evaluation to indicate how much those efforts are successful. In this study, the status of natural regeneration of mangroves was assessed after a long period based on the mangrove vegetation dynamics and regeneration capacity of existing mangrove species.

Myint and Stanley (2011) recorded 70 species in total of mangrove vegetation and associated salt tolerant species in the whole of the Wunbaik Reserved Forest, Rakhine State. During 2011 to present, deforestation and degradation of mangroves forests have been happening and consequently, plant dynamic and ecological functions have been adversely impacted. Follow up research activities for mangrove vegetation dynamic in the Wunbaik Reserved Forest are urgently needed to conduct.

Currently, Myanmar Government wishes to designate Myeik archipelago as UNESCO site in order to conserve coastal habitats. It is essential to have well understanding of what the present mangrove forest structure and composition, and to monitor the area to see how the forests develop before designation. Therefore, this research will help to contribute the successful sustainable mangrove forest management in Myeik archipelago area.

Moreover, a few published works deal with the community structure of the mangrove forest (Joshi & Ghose 2002; Matilal *et al.* 1986; Saha & Choudhury 1995). In this study, the structure, species distribution and natural regeneration of mangroves in Rakhine State and Tanintharyi were assessed. The main objective of this study was to observe species composition and natural regeneration of mangrove forests that could be supported the information to sustainable mangrove forest management in Myanmar through assessing plant diversity in Tanintharyi Region and Rakhine State.

2. Materials and Methods

2.1 Study Sites

The study was conducted two mangrove areas; the mangrove forest area (natural forest) (11°56′ 11.34″ N – 11° 56′ 48.78″ N and 98° 39′ 50.58″ E – 93° 33′ 33.05″ E) in Kho Kyun Protected Public Forest, near the Mintwin Village, Kyuntsu Township of Myeik coastal, Tanintharyi Region, in September 2019 and the plantation area and natural forest areas in the Wunbaik Reserved Forest (19°07′02″ N–19°23′30″ N and 93°51′0″ E–94°02′30″ E), Ramree Township of Rakhine State in August, 2019. Average annual rainfall in Kyuntsu site was 5,280 mm and the temperature were 33°C to 22°C while 4,860 mm of annual rainfall, and the maximum and minimum temperatures were 33 °C and 27 °C, respectively, in Ramree (http://themimu.info/). The study sites are shown in Figure 1.

In Kyuntsu site, the data collection was only conducted in the natural forest area while the plantations and natural forest areas were in Ramree site. Four plantations such as 2010

and 2011 Madama plantations and 2012 and 2013 Byu (ama) plantations were included in Ramree site' data collection. The condition of study areas was described in Plates 1 to 3.

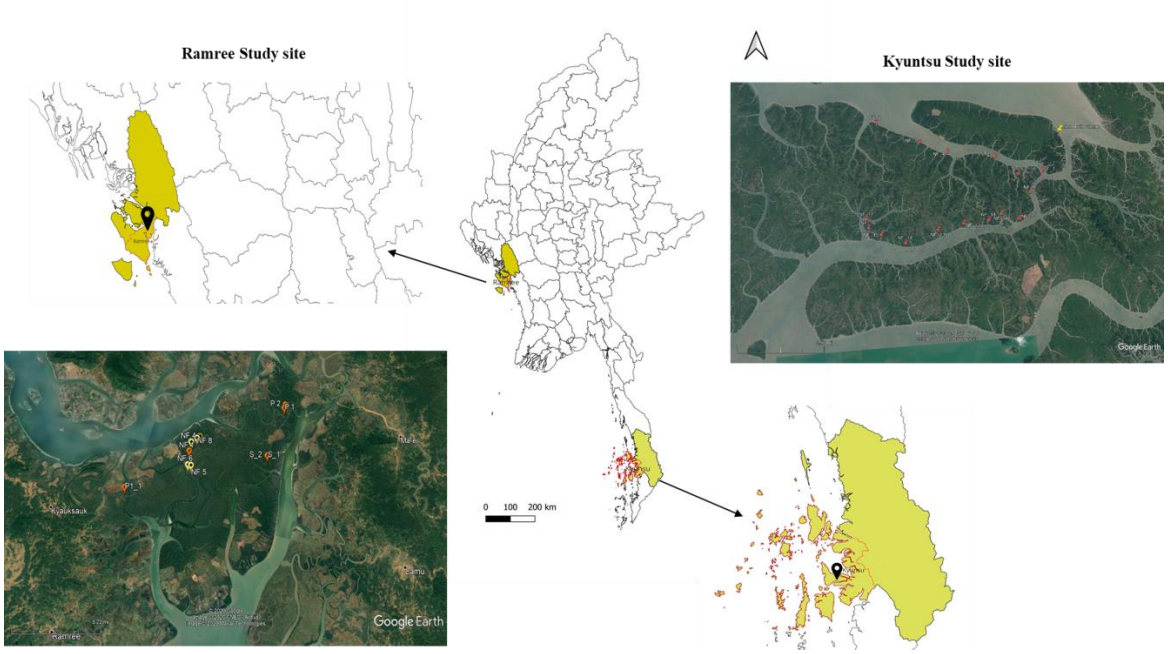


Figure 1. Location map of the study areas (Kyuntsu and Ramree sites)

Plate 1. Condition of natural forest area in Kyuntsu site

Plate 2. Condition of (a) Madama plantation and (b) Byu (ama) plantation in Ramree site

Plate 3. Condition of natural forest area in Ramree site

2.2 Sampling design

Based on the conducting the ground-checking, the sample plots were laid down with the purpose of structural description by using the random sampling. The circular shape sample plot (r = 50 ft) was used to collect the data, and a total of about 1 ha was studied in each study site. The distance between sample plots was about 100 m, and the GPS waypoint of each sample plot was recorded, which was used the permanent sample plots' points.

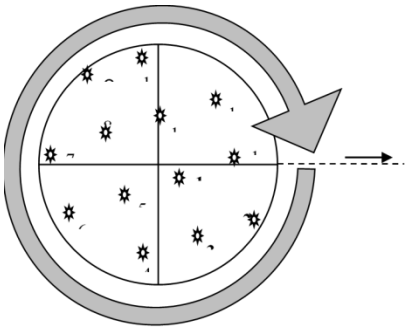


Figure 2. Circular sample plot

2.3 Forest inventory

Within each circle, all trees from larger to occurrence of juveniles of different species were recorded and grouped according to their height classes. Individual tree was identified and counted.

In case of natural regeneration, there are three classifications as follows:

Seedlings - less than 1.5 m in height will be classified as regeneration class I (RCI)

Saplings - up to 1.5 m in height and less and equal to 10 cm in girth as RCII

Small trees - heights greater than 1.5 m but greater than 10 cm in girth as RCIII

Vegetation measurements including tree height, stem diameter and number of individuals (abundance) were recorded from which are derived tree basal area, species density and frequency.

Stem diameter was measured by using diameter tape at 1.3 m from the ground for the trees without buttress and at the height of 0.3 m above the buttress swell for the trees with buttresses. Tree height was measured by using the measuring tape and Sunnto Clinometer.

All living trees and climbers in sample plot were identified by using a guide book of "A Checklist of the Trees, Shrubs, Herbs, and Climbers of Myanmar" at the field. The community members near-by or the surrounding area were asked to participate in the inventory to note the species' local names and their uses. The species local name was recorded by the communities as long as they could identify it, and botanical names will be noted according to "Botanical exploration in Myanmar, 2003" (Kress, DeFilipps, Farr, & Kyi, 2003). Then, the botanical names of the tree species were checked by the experts at the herbarium of Forest Research Institute of Myanmar by collecting the species specimens. If the experts cannot identify the botanical name of the tree species, the plant was listed as "unknown" and the local name was recorded.

To assess the general condition of forest vegetation, the density-diameter histogram was developed. Species richness "S" will be determined by tabulating the number of woody species in each plot according to Whittaker (1976). Shannon-Weiner's diversity index "H" (Shannon and Weiner 1963), species dominance "D" (Simpson 1949), and Hill diversity index number N0, N1, N2 were calculated. Density, frequency, basal area, and importance value index (IVI) will be calculated by Mueller-Dombois and Ellenberg (1974).

Simpson's index (D)

$D = 1 - \Sigma pi\text{^}2$, where *pi* is the relative density.

Shannon-Weiner's index (H)

$H = -\Sigma pi\ Log\ pi$, where *pi* is the proportional abundance of the i^{th} species in the community.

Hill diversity indices were calculated by using the following formula:

N0 = S, where S is the total number of species;

N1 = e^H, where H is the Shannon-Weiner's index; and

N2 = 1/D, where D is Simpson's index.

Importance-Value-Index (IVI)

Importance-Value-Index (IVI) is the sum of relative abundance, relative dominance and relative frequency (Lamprecht, 1989). This index can also permit a comparison of the ecological significance of species in a given forest type. Importance-Value-Index (IVI) can be mathematically expressed as follow;

$$IVI = R.A + R.F + R.D$$

Dominance - considered as an equivalent of the space a plant is occupying in the stand. It can be defined as the horizontal projection of the plant at ground level. The relative dominance is the percentage of a species in the total basal area of a stand.

Abundance - considered as the number of trees per species. The relative abundance is the percentage of each species in total stem number per hectare.

Frequency - considered as the occurrence of absence of a given species in the subplots. The relative frequency is the percentage of the total of the absolute frequencies of all the species.

2.4 Soil and water sample collection

Depending on the different topography and the extent of the marine water reached to the land, the species grown are different in the mangrove forests. Soil samples will be collected at three different depths (0-10 cm, 40-50 cm and 80-90 cm) in each center of sample plots.

Plate 4. Collection of soil sample

Along the transect line, water sample will be collected at three conditions depending on the tidal actions of mangrove forests. Total 14 points in each study site (during the tide rise and after the tide falls) was be collected and analyzed collected water samples at Department of Agricultural Research (DAR) water quality laboratory to explore the water properties.

2.5 Data analysis

After field work, the data was entered into Excel worksheets as the basic format for analysis, thereafter, transformed into other formats according to the software used. The quantitative data from tree inventory was tabulated and put into Microsoft Excel 2019, IBM Statistical Product and Service Solutions (SPSS 26).

3. Results and Discussion

3.1 Vegetation characterization and species composition

In the present study sites, total of 20 species belong to 11 genera from 11 family was scientifically recorded. Totally 22 local species were found in which 13 local species were also noted as the common found local species in both study sites. A total of 18 species were found in Kyuntsu and 17 species were observed in Ramree (Table 1). Byu Shwe War (*Bruguiera sexangular*) was noticed the most dominant species in Kyuntsu while Madama (*Ceriops decandra*) was in Ramree in both plantation and natural forest area. The recorded species were described in Table 1.

Table 1. The recorded species in both Kyuntsu and Ramree study sites

No.	Local Name	Scientific Name	Family	Habit	Kyuntsu	Ramree	IUCN red List
1	Byu Oat Saung (Tut - Rakhine) (Saunggyi -Myeik)	*Bruguiera gymnorrhiza*	Rhizophoraceae	Tree		✔	LC
2	Byu Shwe War (Saung Thay – Myeik)	*Bruguiera sexangular*	Rhizophoraceae	Small tree	✔		Data deficient
3	Byu chedauk apho (Byu – pho) (Byu Saung Yaung – Rakhine) (Pa yone ame – Myeik)	*Rhizophora apiculata*	Rhizophoraceae	Tree	✔	✔	LC
4	Madama (Ka baing – Rakhine)	*Ceriops decandra*	Rhizophoraceae	Shrub	✔	✔	NT
5	Byu chedauk ywetwyne (Byu - ama) (Byu – Rakhine) (Payone aphyu –Myeik)	*Rhizophora mucronata*	Rhizophoraceae	Tree	✔	✔	LC
6	Pinle Ohn (Re ohn – Rakhine)	*Xylocarpus granatum*	Meliaceae	Tree	✔	✔	LC
7	Ye Kanazo (Rezo – Rakhine) (Kanazo – Myeik)	*Heritiera fomes*	Sterculiaceae	Tree	✔	✔	EN
8	Thamegyi (Pyar - Rakhine)	*Avicennia officinalis*	Avicenniaceae	Tree	✔	✔	LC
9	Sar (Sa baung – Rakhine) (Padan – Myeik)	*Aegialitis rotundifolia*	Plumbaginaceae	Shrub	✔	✔	NT
10	La-me (Lan mu – Rakhine)	*Sonneratia alba*	Sonneratiaceae	Tree	✔	✔	LC
11	Thame phyu (Pyar phyu – Rakhine)	*Avicennia marina*	Avicenniaceae	Tree	✔	✔	LC
12	Ye khayar (Jet thalone – Rakhine) (Yet sar khone – Myeik)	*Aegiceras corniculatum*	Myrsinaceae	Shrub	✔	✔	LC
13	Unknown				✔	✔	
14	Kya Na (Pa nan – Rakhine) (Kyat nan – Myeik)	*Xylocarpus moluccensis*	Meliaceae	Tree	✔	✔	LC
15	Madama myaw (Pan lone – Myeik)	*Ceriops tagal*	Rhizophoraceae	Small tree	✔		LC
16	Laba (Lan bae – Myeik)	*Sonneratia griffithii*	Sonneratiaceae	Tree	✔		CR
17	Thame Kyet Tet (Pyar thein – Rakhine) (Lame – Myeik)	*Avicennia alba*	Avicenniaceae	Tree	✔		LC
18	Hnan-phyu (Hnan byu – Rakhine) (Byuboke – Myeik)	*Bruguiera cylindrical*	Rhizophoraceae	Tree	✔	✔	LC
19	War Kyeik Lein (Thila – Rakhine) (Hnget – Myeik)	*Bruguiera parviflora*	Rhizophoraceae	Tree	✔		LC
20	Byaik (Sa lein – Rakhine) (Suk auk – Myeik)	*Dalbergia spinosa*	Fabaceae	Small tree/ Shrub		✔	Data deficient
21	Thilar (Byu Shwe War)	*Bruguiera parviflora*	Rhizophoraceae	Tree	✔	✔	LC
22	Taw Shauk	*Merope*	Rutaceae	Shrub		✔	LC

No.	Local Name	Scientific Name	Family	Habit	Kyuntsu	Ramree	IUCN red List
	(Pyar shauk pin – Rakhine) (Taw shauk – Myeik)	*angulata*					
23	Kant Palar (Pyar zee – Rakhine) (Amayar – Myeik)	*Sonneratia apetala*	Sonneratiaceae	Tree		✔	LC

Symbol (✔) = present

LC = least concern, NT= near threatened, EN = endangered

Based on Myint and Stanley (2011), C. Zockler and C. Aung (2019), Soe Win and Tin Zar Ni Win (2020)

In Kyuntsu site, according to important value index revealed that *Bruguiera gymnorhiza* dominance species followed by *Rhizophora apiculate*, *Ceripos decandra*, and *Bruguiera cylindrical* (Table 2 (a)). In Ramree, *C. decandra*, *Rhizophora apiculate*, *Xylocarpus granatum*, *B. gymnorhiza*, and *Heritiera fomes* exhibited high important value index in natural forest study area while *C. decandra*, *Aegiceras corniculatum*, *R. mucronate*, and *R. apiculate* found in study plantation area as the high important value (Table 2 (b)).

Table 2 (a). The relative dominance, density, frequency and important value of the Kyuntsu study site

Species	Density	Frequency	Dominance	Importance value
Bruguiera sexangular	713	94	2.43	37
Rhizophora apiculata	644	76	3.05	33
Ceriops decandra	599	88	1.19	32
Bruguiera cylindrical	475	82	2.80	29
Bruguiera parviflora	448	71	1.36	25
Rhizophora mucronata	270	82	4.20	24
Xylocarpus moluccensis	27	35	11.18	17
Xylocarpus granatum	24	53	8.44	17
Unknown	19	6	1.79	3
Avicennia officinalis	15	29	10.87	15
Heritiera fomes	14	29	2.41	7
Aegialitis rotundifolia	6	12	2.36	4
Sonneratia alba	5	12	13.81	16
Ceriops tagal	4	18	5.43	8
Sonneratia griffithii	3	6	9.12	10
Avicennia alba	3	6	7.24	8
Avicennia marina	2	12	9.93	12
Aegiceras corniculatum	2	6	2.18	3

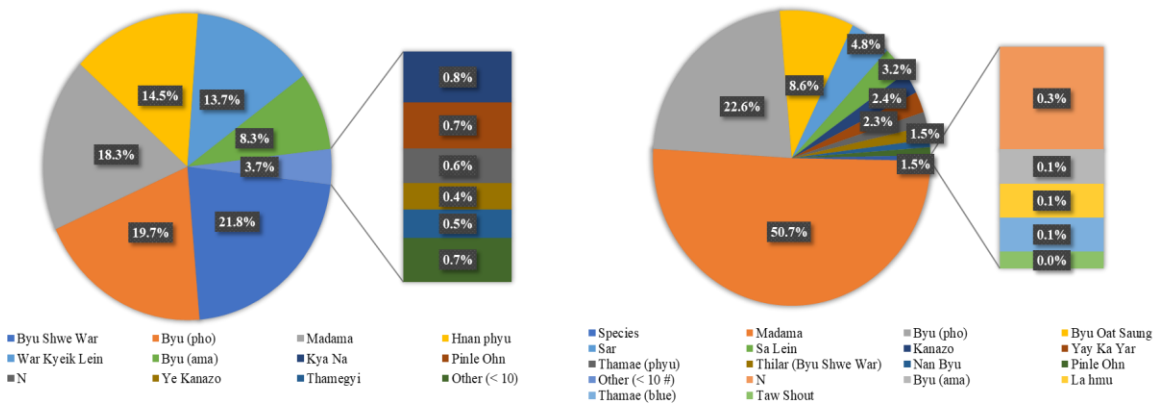
Table 2 (b). The relative dominance, density, frequency and important value of the Ramree study site

Species	Density	Frequency	Dominance	Importance value
Ceriops decandra	1898	100	4.13	68
Rhizophora apiculata	846	88	9.19	43
Bruguiera gymnorhiza	323	75	15.36	25
Aegialitis rotundifolia	180	50	6.36	15

Species	Density	Frequency	Dominance	Importance value
Dalbergia spinosa	120	25	10.35	8
Heritiera fomes	91	75	8.40	22
Aegialitis corniculatum	86	75	14.92	16
Avicennia marina	57	25	4.11	12
Bruguiera parviflora	55	63	3.91	18
Xylocarpus granatum	32	88	6.80	27
Bruguiera cylindrical	32	38	5.02	11
Unknown	11	25	1.51	5
Sonneratia alba	4	13	4.87	17
Avicennia officinalis	4	13	2.92	7
Rhizophora mucronata	4	25	1.45	6
Merope angulata	2	13	1.22	3

The species composition of natural forest in both Kyuntsu and Ramree sites was described in Figure 3. In Kyuntsu site, Byu Shwe War (*B. sexangular*) was found 21.8% that was followed by Byu Chedauk Apho (*R. apiculata*) and Madama (*C. decandra*) with 19.6 % and 18.3%, respectively. 50.7 % of Madama (*C. decandra*) was followed by Byu Chedauk Apho (*R. apiculata*) of 22.6% were also observed in Ramree' natural forest area (Figure 3). In the plantation areas, the other species besides the main plantation species, were found as 18.3 % and 54% at the 2010 and 2011 of Madama plantations, respectively. But, at the 2012 and 2013 Buy (ama) plantations, other species were only found less than 10 % (Figure 4). It seems that the other species' seeds or seedlings were carried by tidal.

Species richness differed across the study sites among which Kyuntsu had higher diversity index of H' =0.83 than natural forest area and plantation area of Ramree with H' =0.68 and H' =0.47, respectively. Moreover, the Simpson's index of natural forest area in Kyuntsu was found 17.83 while that of Ramree was 15.68 and 12.61 in the plantation area of Ramree. The diversity parameters of both study sites were shown in Table 3. Two IUCN near threatened species, Madama (*Ceriops decandra*) and Sar (*Aegialitis rotundifolia*), and one endangered species, Ye Kanazo (*Heritiera fomes*) were observed in both study sites while one critically endangered species, Laba (*Sonneratia griffithii*), was found in Kyuntsu site. Floredel *et. al*., (2015) mentioned that the present or absence of vegetations may be related not only to natural and anthropogenic disturbances but also site's geomorphology and hydrology. Observing found that tidal inundation, substrate composition and properties of water and soil could be the major influences on structure and composition of the study sites.



(a) (b)

Figure 3. Species composition of natural forest area in (a) Kyuntsu site and (b) Ramreee Sites

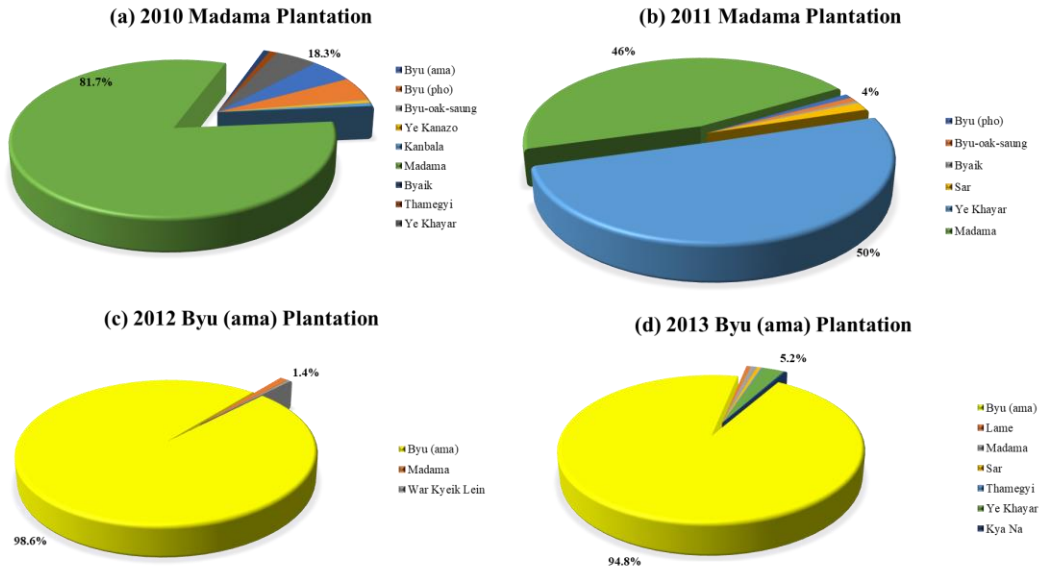


Figure 4. Species composition of (a) 2010 Madama Plantation (b) 2011 Madama Plantation, (c) 2012 Byu (ama) Plantation and (d) 2013 Byu (ama) Plantation at Ramree site

Table 3. Diversity parameter of both study sites

	Kyuntsu's natural forest area	Ramree's natural forest area	Ramree's plantation area
Number of trees per hectare	3,270	3,745	7,196
Ave. Individual per species	182	234	554
SHANNON index (H)	0.83	0.68	0.47
SHANNON evenness (E%)	0.66	0.57	0.42
SIMPSON's index (D)	17.83	15.68	12.61
Hill diversity index			
N0	18	16	13
N1	2.29	1.97	1.60
N2	0.06	0.06	0.08

3.2 Mangrove forest structure

The average DBH of the natural forest area in Kyuntsu was 7.12 cm and average height was 7.79 m while 4.09 cm in DBH and 3.85 m in height were observed in natural forest of Ramree (Table 4). There was significant difference in DBH ($p<0.05$, $F = 57.718$) and height ($p<0.05$, $F = 390.030$) in among the natural forest sites of both study area. Generally, Kyuntsu' natural forest area had higher DBH trees than that of Ramree, and hence the average basal area was high in Kyuntsu' natural forest area followed by Ramree's natural forest and plantations area. Even though Kyuntsu had bigger DBH trees among the study sites, all of the study sites' forest were exhibited with not big sized trees.

The density-diameter histogram of the study sites was shown in Figure 5 (a) and (b). According to the histogram, the mangrove vegetation of both study sites was observed the general condition as high small diameter (regeneration) number of trees, but the number of trees in Ramree site were small than Kyuntsu site.

Significance differences existed in stem density among the different mangrove species of all the sites. *C. decandra* had the highest stem density in Kyuntsu (1,347 ± 2.34) followed by *B. gymnorhiza* (1,289 ± 1.67). Ramree's natural forest described with highest stem density with *C. decandra* (2,867 ± 3.93) which is followed by *R. apiculate* (550 ± 0.75) while *C. decandra* (1,838 ± 4.43) was found as the highest stem density followed by *A. corniculatum* (1,640 ± 8.52) in the plantation area of Ramree study site. Figure 6 and 7 were described the average girth and height of the observed species in study sites.

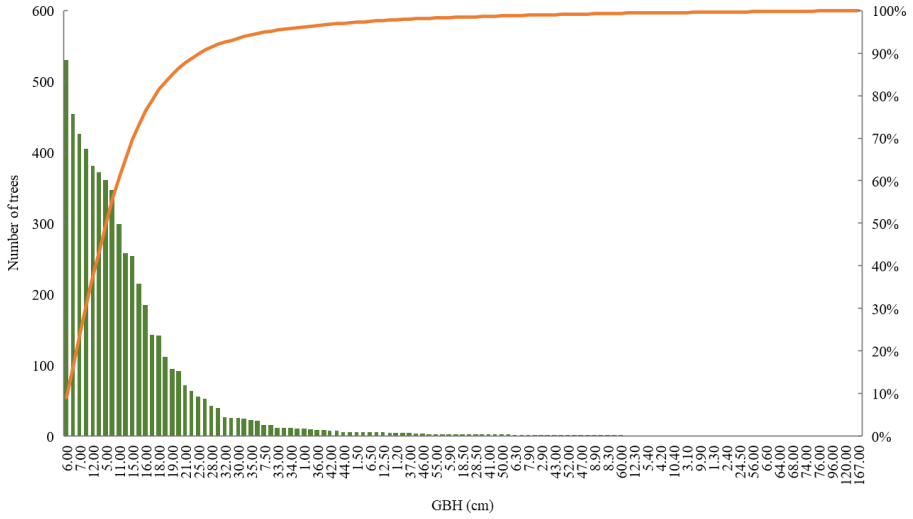


Figure 5(a). The histogram of the density and girth of the collected trees in Kyuntsu site

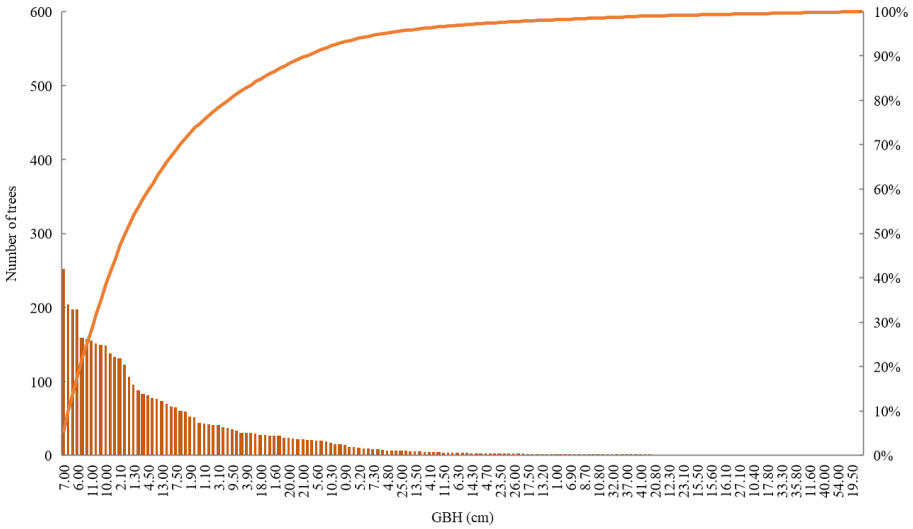


Figure 5(b). The histogram of the density and girth of the collected trees in Ramree site

Table 4. Average diameter at breast height (DBH) (cm), average height (ft), stem density (per hectare) and average basal area (m^2 per hectare) of Kyuntsu and Ramree sites

Study sites	Ave DBH (cm)	Ave Ht (m)	Stem density (stems/ha)	Ave BA (m^2/ha)
Kyuntsu (NF)	7.12 (±2.77)	7.79 (±2.82)	182 (±264)	0.004 (±0.003)
Ramree (NF)	4.09 (±1.50)	3.85 (±1.41)	234 (±491)	0.003 (±0.002)
Ramree (plantations)	2.64 (±1.10)	2.54 (±1.12)	554 (±1165)	0.001 (±0.001)

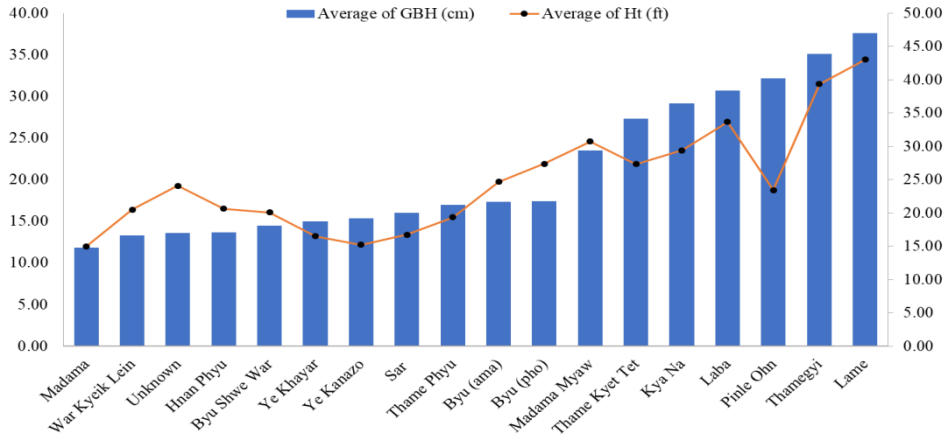


Figure 6. Average girth at breast height (GBH) (cm) and average total height (ft) of the natural forest area in Kyuntsu site

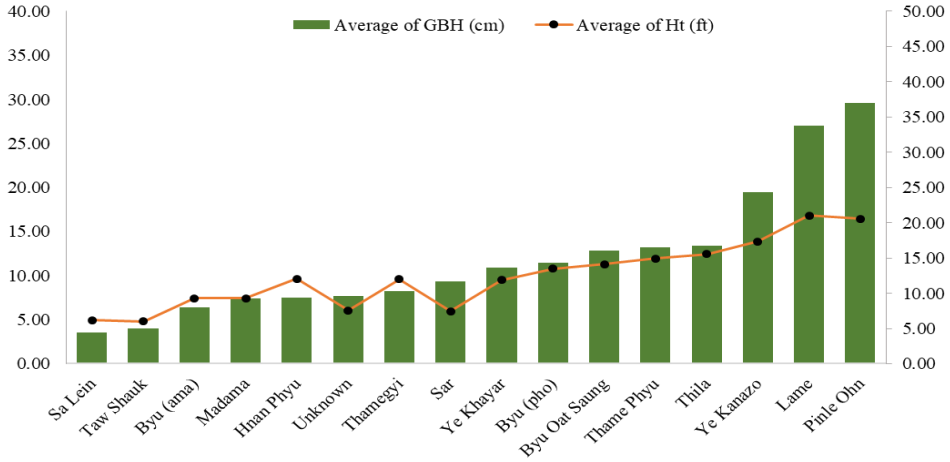


Figure 7. Average girth at breast height (GBH) (cm) and average total height (ft) of the natural forest area in Ramree site

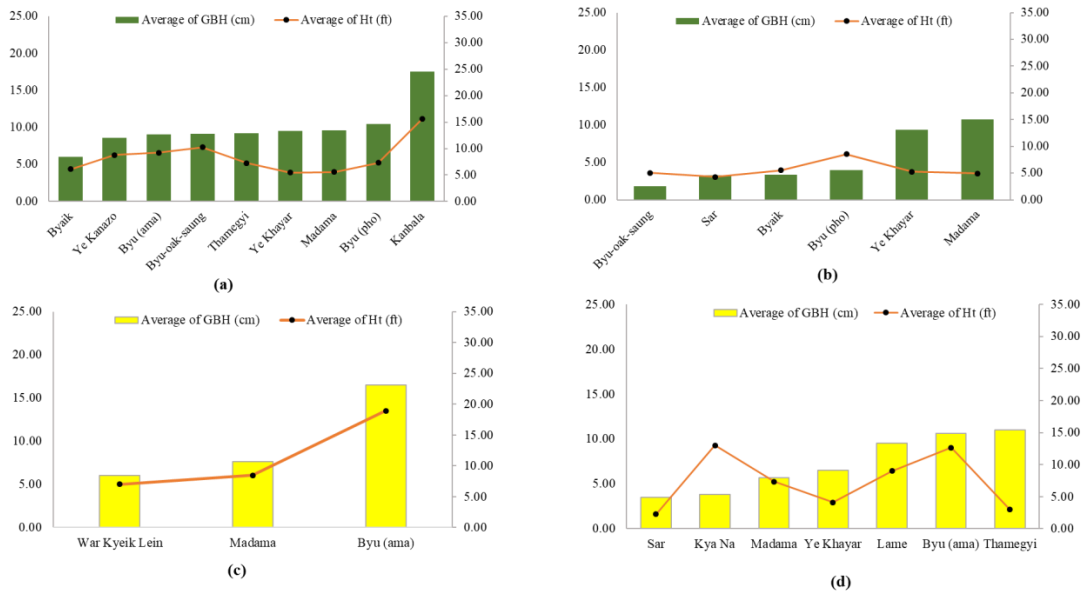


Figure 8. Average girth at breast height (GBH) (cm) and average total height (ft) of (a) 2010 Madama Plantation (b) 2011 Madama Plantation, (c) 2012 Byu (ama) Plantation and (d) 2013 Byu (ama) Plantation at Ramree site

3.3 Natural regeneration conditions

Generally, the regeneration of the mangrove forest was observed as the seedlings stage (less than 1.5 m in height and less than 5 cm in GBH) in both study sites (Figure 4). There was no significantly different among the height class of the regeneration ($p<0.05$) in both study sites. But, significantly differences ($p<0.05$) among the species of both study sites were found. A large number of natural regenerations of Thila (*Bruguiera parviflora*) was observed in the study area of Kyuntsu site while Madama (*C. decandra*) was high number in the regenerations in Ramree site (Figure 9). a few numbers *C. decandra* and *Bruguiera gymnorhiza* were found as the sapling stage in Kyuntsu sties, and only *R. mucronate* had a sapling in Ramree sties. In term of regeneration, Ramree exhibited higher seedling density (5,810 seedlings per hectare) than that of Kyuntsu site (3,526 seedlings per hectare).

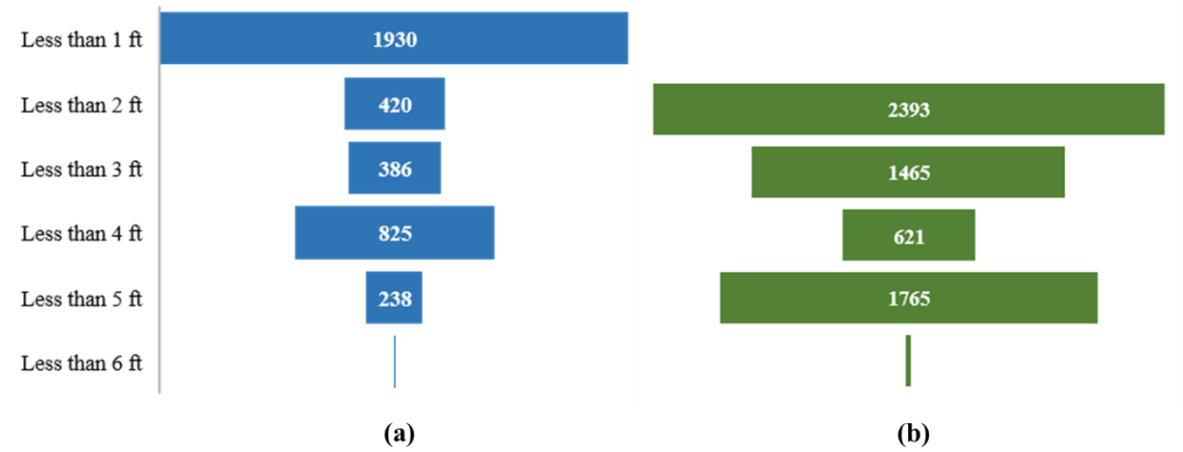


Figure 9. The observed number of regeneration (seedling classes) in (a) Kyuntsu site and (b) Ramree site

Plate 5. natural regeneration condition in (a) Kyuntsu and (b) Ramree sites

Mchenga and Ali (2014) described that Zanzibra Island exhibited human induced pressure in the mangrove forest resulted into presence of open spaces which allowed the high regeneration of mangrove trees. And also, Alemayehu and Wekesa (2017) observed that the high regeneration of mangroves in Mwache creek in Kenya as the result of selective wood harvesting. The study showed that the high seedling density is an indication of degradation that has showed up an area leading to system response to recover as revealed by high regeneration in Ramree site of both natural forest and plantation areas. Nevertheless, a

minimum of 2,500 well distributed seedlings are enough for natural regeneration of mangrove forest that was stated in FAO (1994) as the presence of sufficient regeneration as encouraging for natural regeneration of the mangrove forest. Thus, both study sites demonstrated high potential for natural regeneration.

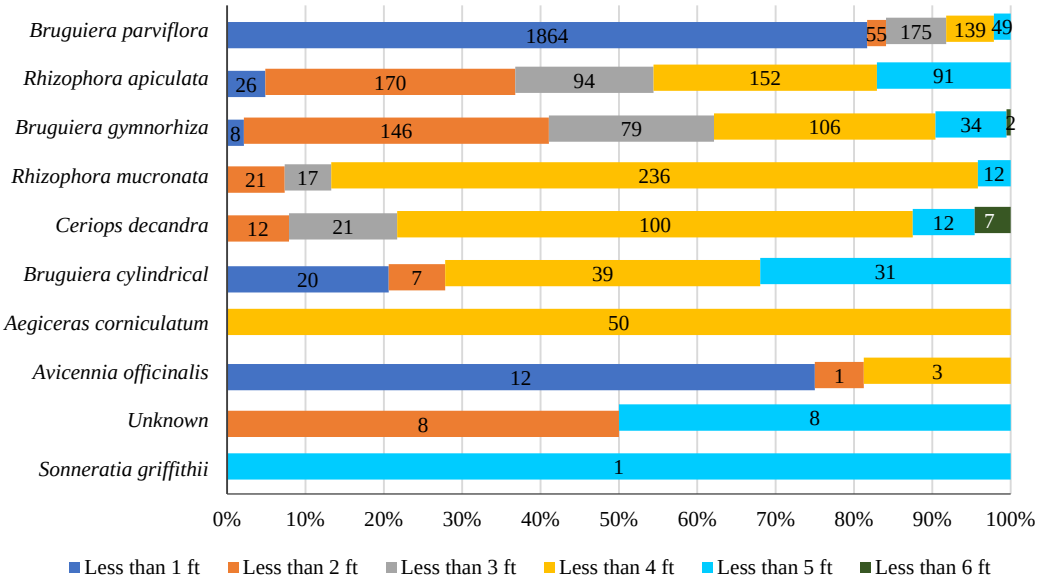


Figure 10 (a). The regeneration condition of recorded species in Kyuntsu site

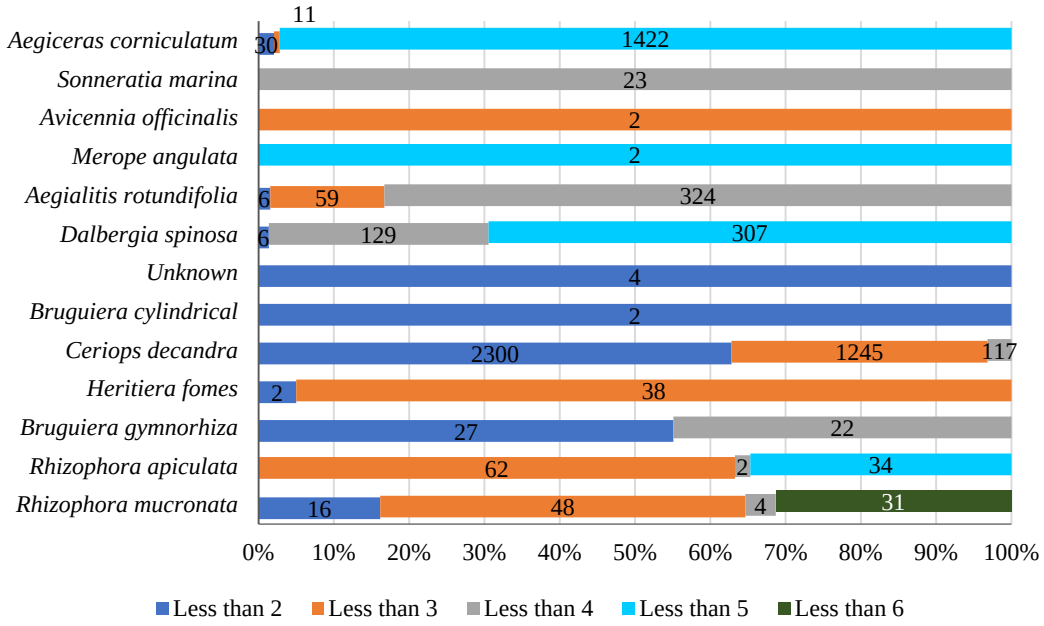


Figure 10 (b). The regeneration condition of recorded species in Ramree site

3.4 Soil and Water conditions

In this present study, Table 5 revealed the environmental parameters such as water pH, and soil condition of study sites. The water pH measurements indicate that the optimum value for mangrove growth exist (7.0 – 8.5) (Puspaningrum and Titah, 2020). In both study sites, the higher pH value is found in Kyuntsu site which is 7.24 – 7.90 than that of in Ramree site which is 6.99 – 7.58. Thus, the more carbonate ions are contributed than Ramree site.

Overall the measured water pH value is still fairly normal and productive for mangrove growth. Soil pH of both study sites were found 2.45 - 7.10 and 2.67 – 6.74, Kyuntsu and Ramree, respectively. Usually, soil pH values ranging from 6.7 to 7.3 are the most optimum values for the growth of mangrove trees (Palufi, Gita Endang *et al*., 2019). So, both study sites seem to be not good for mangrove growth. But the salinity and temperature of water and soil of both study sites are needed to be further observed.

The distribution of mangrove species was subjected to various concentration of salinity and nutrient levels (Cunha-Lignon *et al*., 2011). Moreover, Tin Zar Ni Win *et al*., (2019) mentioned that the environmental parameter changes in hydrology and water quality were important indicator. Thus, the water salinity, temperature of seawater and temperature and pH of soil are needed to observed and recorded to construct the strategy for the sustainable yield and reforestation including the conservation of mangrove ecosystem.

Table 5. Environmental parameters (Soil and water) of Kyuntsu and Ramerre Townships

Parameters	Kyuntsu	Ramree
Water pH	7.50 (7.24 – 7.90)	7.33 (6.99 – 7.58)
Soil pH	5.06 (2.45 – 7.10)	4.54 (2.67 – 6.74)
Soil Texture	Silty Caly_Loam	Silty Caly_Loam
Sand (%)	9	15
Silt (%)	50	50
Clay (%)	38	32

3.5 Permanent sample plots establishment

Three permanent sample plots in Ramree site only, were established by setting up limestone pillar at the center of each permanent sample plot along the transect lines in order to re-survey forest conditions in the future and to monitor any future impacts. GPS waypoints were recorded at the center of permanent sample plot (Table 6), and also the (number) label cards (3 to 5 trees per each sample plots) were tagged. The permanent sample plots were chosen among the sample plots that the measurements did conduct.

Table 6. Location (GPS points) of permanent sample plots in Ramree site

No.	Natural Forest/ Plantation	GPS point
1.	Plantation area	19° 19′ 52.58″ N 94° 0′ 58.79″ E
2.	Natural forest area	19° 16′ 47.57″ N 93° 56′ 20.79″ E
3.	Natural forest area	19° 16′ 40.54″ N 93° 56′ 9.69″ E

Plate 6. The record of permanent sample plots in Ramree site

Plate 7. Making (number) label card tag

4. Conclusion

The present study has been carried out in Wunbaik Reserved Forest, Ramree Township, Rakhine State and Khyo Kyun Public Protected Forest, Kyuntsu Township, Tanintharyi Region. The study sites were selected and measured the vegetative structure and recorded the species composition so as to estimate the forest value. The forest type is inner mangrove formation which based on the tidal creeks. A total of 22 mangrove species were recorded in the study areas. Byu Shwe War (*Bruguiera sexangular*) was noticed the most dominant species in Kyuntsu while Madama (*Ceriops decandra*) was in Ramree in both plantation and natural forest area. *C. decandra* had the highest stem density in Kyuntsu (1,347 ± 2.34) followed by *B. gymnorhiza* (1,289 ± 1.67). Ramree's natural forest described with highest stem density with *C. decandra* (2,867 ± 3.93) which is followed by *R. apiculate* (550 ± 0.75) while *C. decandra* (1,838 ± 4.43) was found as the highest stem density followed by *A. corniculatum* (1,640 ± 8.52) in the plantation area of Ramree study site.

The average DBH of the natural forest area in Kyuntsu was 7.12 cm and average height was 7.79 m while 4.09 cm in DBH and 3.85 m in height were observed in natural forest of Ramree. the regeneration of the mangrove forest was observed as the seedlings stage (less than 1.5 m in height and less than 5 cm in GBH) in both study sites. In term of

regeneration, Ramree exhibited higher seedling density (5,810 seedlings per hectare) than that of Kyuntsu site (3,526 seedlings per hectare).

Overall the measured water pH value is still fairly normal and productive for mangrove growth. But, both study sites seem to be not good for mangrove growth. But the salinity and temperature of water and soil of both study sites are needed to be further observed.

Three permanent sample plots in Ramree site only, were established by setting up limestone pillar at the center of each permanent sample plot along the transect lines in order to re-survey forest conditions in the future and to monitor any future impacts.

According to the recorded data, the estimation of mangrove forest can be implemented. Based on the observation and collected data, the mangrove forest area in Kyuntsu site is in good condition in term of species density and composition but some of the area in Ramree site is not because of the several human impacts and activities, such as the accessibility is better than Kyuntsu site. Nowadays, mangrove forests are being degraded and destroyed on globally through the natural disturbances and anthropogenic activities. Many scientists and researchers are studying about the mangroves and mangrove ecosystems which have been studied extensively, but still remain poorly to be understood. Thus, there is a critical need to better understanding them.

Based on the present study, many baseline data on the mangroves of Kyuntsu and Ramree are still needed, and also mangrove areas of Myanmar, towards the proper conservation activities. For further study in the study sites, the mangrove forest degradation and sea awater and soil salinity could be conducted. Among the study sites, the mangrove area of the Ramree site is seemed to be more degraded because of urban development, although both study sites' mangrove areas are being degraded. The mangrove forest in the study sites had different vegetation structural formation and species composition which could be attributed to the different agents of degradation i.e. degree of perturbations that greatly depend on human access to the mangrove area. Therefore, this is a need to maintain and manage areas. The results of this study suggest that the contribution of knowledge to local people for awareness on values of mangroves and mangrove ecosystem is still needed to maintain the sustainability of both water and terrestrial resources and livelihoods of local communities.

5. Acknowledgement

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