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Assessment of the Growth and Carbon Storage of Teak Plantations and Secondary Forests

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Abstract

The world has been facing the consequences and impacts of climate change which has been significantly shown during the recent decades. To reduce the negative consequences and impacts, nature-based solutions are the most acceptable solutions around the world. The trees and forests have capacity to store carbon and at the same time to remit carbon by destroying the forests. And thus, there is no doubt that the nature-based solutions are useful and effective among different solutions. As one of the nature-based solutions, restoration and rehabilitation activities especially teak plantations have been done in Myanmar while forest conservation activities have been emphasizing at the same time. However, there is still an argument of plantation establishment and leaving that area as natural without establishing the plantation in terms of carbon storage capacity. Hence, it is necessary to know the growth of carbon storage capacity of teak plantation and secondary forests. This study finds the gap of information to express the carbon storage capacity of teak plantations and the secondary forests. To reduce error and get acceptable results, the secondary forests are selected in degraded area where their locations are right beside of the plantations. The study sites are located Ottarathiri township in Bago Yoma area. As the results of the study, the carbon storage capacity of young teak plantations is lower than the capacity of secondary forests until the age of three years. At the age of four to five years, it is comparable to the secondary forests. The diversity is significantly lower in the plantation than that of the secondary forests. The findings from this study support the sustainable forest management, Reducing Emission from Deforestation and Forest Degradation, Nature-based Solutions in Myanmar.

Key words: Climate change, diversity, nature-based solutions, restoration, rehabilitation, Reducing emission from deforestation and forest degradation, sustainable forest management.

စိုက်ခင်းနှင့် ပြန်လည်ပေါက်ရောက်သည့်တော (secondary forests) များ၏ ရှင်သန် ကြီးထွားမှုနှင့် ကာဗွန်သိုလှောင်နိုင်မှုကို လေ့လာခြင်း

စာတမ်းအကျဉ်း

ကမ္ဘာ့နိုင်ငံများတွင် ရာသီဥတုပြောင်းလဲမှု၏ ဆိုးရွားလှသည့်အကျိုးဆက်နှင့် အန္တရာယ်များကို ရာစုနှစ်များအတွင်း သိသိသာ ရင်ဆိုင်နေကြရပါသည်။ ထို့အတွက်ကြောင့်လည်း ရာသီဥတုပြောင်းလဲမှု၏ အကျိုးဆက်နှင့် အန္တရာယ်များကို ကာကွယ်နိုင်ရန် နည်းလမ်းများကို အစဉ်တစ်စိုက် ရှာဖွေလျက်ရှိကြပြီး အဆိုပါ နည်းလမ်းများအနက် သဘာဝကို အခြေခံသော ဖြေရှင်းနည်းလမ်းများ (nature-based solutions) သည် အများလက်ခံနိုင်သည့် အကောင်းဆုံးနည်းလမ်းများအနက် တစ်ခုအပါအဝင်ဖြစ်ပါသည်။ သစ်တော သစ်ပင်များသည် ကာဗွန်ကို စုပ်ယူစုဆောင်းနိုင်သကဲ့သို့ သစ်တောသစ်ပင်များ ပျက်စီးဆုံးရှုံးပါက သစ်တော သစ်ပင်မှ ကာဗွန်ထုတ်လွှတ်နိုင်သည်ကို အားလုံးသိရှိပြီး ဖြစ်ပါသည်။ ထို့အတွက်ကြောင့် ရာသီဥတု ပြောင်းလဲမှု လျှော့ချစေရေး ဆောင်ရွက်ရာတွင် သဘာဝကို အခြေခံသော ဖြေရှင်းနည်းလမ်းများ (nature–based solutions) ဖြင့် ဆောင်ရွက်ခြင်းသည် ရာသီဥတုပြောင်းလဲမှုကို ဖြစ်စေသည့် သစ်တောပြုန်းတီးမှု အကြောင်းတရားကို ကာကွယ်တားဆီးနိုင်သကဲ့သို့ သစ်တောများ တိုးပွားလာခြင်းဖြင့် လေထုထဲရှိ ကာဗွန်ပမာဏကို လျှော့ချနိုင်သောကြောင့် အသုံးအဝင်ဆုံးနှင့် အကျိုးအရှိဆုံး နည်းလမ်းပင်ဖြစ်ပါသည်။ မြန်မာနိုင်ငံတွင် သစ်တောပြုန်းတီးသည့်နေရာများ၌ စိုက်ခင်းပြန်လည်ထူထောင်ခြင်း လုပ်ငန်းများနှင့်အတူ သစ်တော ပြုစုထိန်းသိမ်းခြင်း လုပ်ငန်းများကို အားသွန်ခွန်စိုက် ဆောင်ရွက်လျက်ရှိပါသည်။ သို့ရာတွင် ရာသီဥတုပြောင်းလဲမှု လျှော့ချရေးနှင့် ပတ်သက်၍ စိုက်ခင်း တည်ထောင်ခြင်းနှင့် တောပျက်များကို စိုက်ခင်းတည်ထောင်ခြင်းမပြုဘဲ နဂိုအတိုင်းထားရှိခြင်း တို့အနက် မည်သည်က ကာဗွန်သိုလှောင်နိုင်စွမ်း ပိုမိုများပြားသည်ကို ဆွေးနွေးရာတွင် လက်ကိုင်ပြုပြောကြားရန် လေ့လာထားသော သုတေသနမှာ မြန်မာနိုင်ငံတွင် မရှိသေးပါ။ သို့ဖြစ်ပါ၍ ဤသုတေသနတွင် စိုက်ခင်းနှင့် ပြန်လည် ပေါက်ရောက်သည့်တော (တောပျက်) များ၏ သစ်မျိုးစုံကွဲပြားမှုနှင့် ကာဗွန်သိုလှောင်နိုင်မှု ကို နှိုင်းယှဉ် လေ့လာခြင်းဖြစ်ပါသည်။ သုတေသန ရလဒ်ဆိုင်ရာ လက်ခံနိုင်မှု အားကောင်းစေရန် ပြန်လည်ပေါက်ရောက်သည့်တော (တောပျက်) အား ရွေးချယ်ရာတွင် ပဲခူးရိုးမအတွင်း ကျွန်းစိုက်ခင်း နှင့် တဆက်တစပ်တည်းရှိသည့် နေရာအား ရွေးချယ်ခဲ့ပါသည်။ သုတေသန ရလဒ်များအရ ကျွန်း စိုက်ခင်း၏ ကာဗွန်သိုလှောင်နိုင်စွမ်းသည် ပထမ သုံးနှစ်အတွင်း ပြန်လည်ပေါက်ရောက်သည့်တော (တောပျက်)၏ ကာဗွန်သိုလှောင်နိုင်စွမ်း အောက် လျော့နည်းသည်ကို တွေ့ရှိရပါသည်။ စိုက်ခင်းသက် လေးနှစ်ကျော် ၅ နှစ်အတွင်းတွင် စိုက်ခင်း၏ ကာဗွန်သိုလှောင်နိုင်စွမ်းသည် ပြန်လည်ပေါက်ရောက်သည့်တော (တောပျက်)၏ ကာဗွန်သိုလှောင်နိုင်စွမ်း နီးပါး ရရှိလာကြောင်း တွေ့ရှိရပါသည်။ အပင်မျိုးကွဲပြားမှုမှာ ပြန်လည်ပေါက်ရောက်သည့်တော (တောပျက်)တွင် ပိုမိုများပြားသည်ကို တွေ့ရှိရပါသည်။ ဤသုတေသန ရလဒ်များသည် သစ်တောစီမံအုပ်ချုပ်ခြင်း၊ သစ်တောပြုန်းတီးခြင်း နှင့် သစ်တောအတန်းအစား ကျဆင်းခြင်းမှ ကာဗွန်ထုတ်လုပ်မှု လျှော့ချခြင်းနှင့် သဘာဝကို အခြေခံသော ဖြေရှင်းနည်းလမ်းများ (nature–based solutions) ကို ဖော်ဆောင်ရာတွင် အထောက် အကူပြုနိုင်သည့် ရလဒ်များ ဖြစ်ပါကြောင်း တင်ပြအပ်ပါသည်။

Assessment of the Growth and Carbon Storage of Teak Plantations and Secondary Forests

1. Introduction

The forests cover about one third of the land area of the world, and it is very precious to human beings and environment in terms of supporting, provision, regulation and protection services. In terms of regulation services, the forest could be considered as a sink of carbon (Köhl et al. 2015). Globally, the forests stored 650 Pg of carbon (Khaine and Woo 2015). Tropical forests alone cover about half of the global forest areas and their contribution significantly takes part in the overall amount (Keenan et al. 2015).

Because of wide variations in forest carbon storage have been found throughout different climatic regions worldwide, researchers are now striving to study each country or region for site-specific information (Toledo et al. 2011; Thompson et al. 2014; Castro-Izaguirre et al. 2016; Chheng et al. 2016).

The carbon storage of tropical forests in Asia and Oceania regions was about 89 ~ 180 Mg C ha^{-1} whereas the carbon storage of tropical forests in Latin America was 84 ~ 160 Mg C ha^{-1} and those in Sub-Saharan Africa was 44 ~ 165 Mg C ha^{-1} (Saatchi et al. 2011). On average, the tropical teak dominant forests stored 112.19 Mg C ha^{-1} of above-ground carbon (Juwarkar et al. 2011). In temperate forests, the amount of carbon storage showed a range of 42.63 ~ 181.88 Mg C ha^{-1} while the amount of carbon storage in temperate grassland showed 3.74 ~ 9.83 Mg C ha^{-1} (Mendoza-Ponce and Galicia 2010). Therefore, it can be clearly understood that the global forests have a considerable amount of carbon storage potential, although capacity will vary among regions. Tropical teak dominant forest in Myanmar stored 185.2 ~ 227.7 Mg C ha^{-1} of above-ground carbon (Oo 2009; Khaine 2018).

Myanmar is a tropical country that is located between the latitudes of 9° 28' and 28° 29' North and the longitudes of 92° 10' and 101° 10' East. The total land area is 67.66 M ha. East-to-west Myanmar is 936 km long, and north-to-south the country is 2,051 km long. Forests cover about 42.19% of the land, making Myanmar one of the countries with the highest forest coverage in the Asia-Pacific region (FAO 2020; Ministry of Natural Resources and Environmental Conservation 2020).

Six types of forests are mainly found throughout the country: tropical evergreen forests, tropical deciduous forests, mangrove forests, dry forests, deciduous dipterocarp forest, and hill and temperate evergreen forests. Over 2,000 of floristic species are distributing in various forest types. Among the six forest types, tropical deciduous forests have the largest forest coverage of the country. About 38.26% of the total forest areas is covered by tropical deciduous forests. The Bago Yoma region represents the tropical deciduous forests of Myanmar. Nearly all species adapted to tropical deciduous forests in Myanmar are found in this region. The Bago Yoma region is located between the latitudes of 16º 50' and 19º 29' North, the longitude of 94º 41' and 97º 13' East. It has been separated into two regions called Eastern Bago Yoma and Western Bago Yoma. These regions have been known as ideal place for teak, covering 3.87 M ha. Therefore, the carbon storage of forests in the Bago Yoma region should be explored in Myanmar.

To reduce the negative consequences and impacts of climate change, nature-based solutions are the most acceptable solutions around the world. The trees and forests have capacity to store carbon and at the same time to remit carbon by destroying the forests. And thus, there is no doubt that the nature-based solutions are useful and effective among different solutions. As one of the nature-based solutions, restoration and rehabilitation activities especially teak plantations have been done in Myanmar while forest conservation activities have been emphasizing at the same time. However, there are still an argument of plantation establishment and leaving that area as natural without establishing the plantation in terms of carbon storage capacity. Hence, it is necessary to know the growth of carbon storage capacity of teak plantation and secondary forests. This study finds the gap of information to express the carbon storage capacity of teak plantations and the secondary forests.

Therefore, the following research questions were addressed in this study:

(1) How much carbon can the secondary forests in Bago Yoma Region store?

(2) Are species diversity, growth and carbon storage of secondary forests greater than those in teak plantations?

(3) If so, how significantly do these factors varied between secondary forests and teak plantations?

2. Objectives

Based on the research questions, the following main objectives have been explored in this study:

(1) To explore the carbon storage of secondary forests in Bago Yoma Region

(2) To investigate species diversity, growth and carbon storage of secondary forests and teak plantations in a comparative way

3. Materials and Methods

3.1 Study sites

The study was conducted in Ottarathiri Township and Paukkaung Township of Bago Yoma Region of Myanmar. The research survey was taken in compartment No. 2 and 28 in Ngalike reserve forests in Ottarathiri Township and South Nawing, middle Nawing and Phyukun reserve forests in Paukkaung Township of Bago Region. The sample plots were situated between the latitudes and longitudes of of 19° 55′52″ N and 95° 59′57″ E, and 18° 58′51″ N and 95° 37′20″ E in Ottarathiri and Paukkaung Townships, respectively. Tropical savanna climate was found in this region within an average annual precipitation range of

1482 mm to 1528 mm (Department of Meteorology and Hydrology of Myanmar). The average annual temperature is ranging from to 25.5°C to 26.1°C. The forests are tropical deciduous forests and they are protected as reserve forests. The altitude of study sites ranges from 34 m to 125 m.

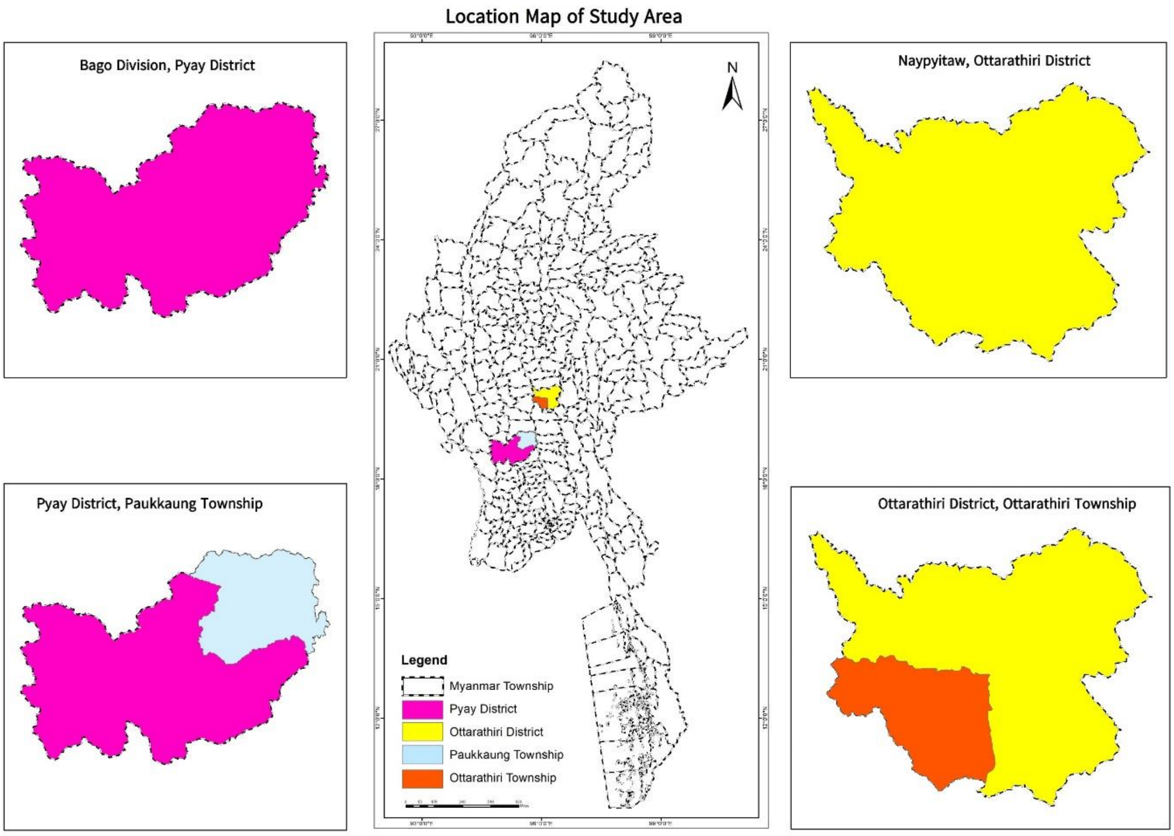

Figure 1. Location map of the study area of Bago Yoma Region in Myanmar

3.2 Sampling procedure, data collection and analysis

Sampling plots were laid down at each study site using the stratified sampling. A preliminary survey was performed in each site before establishing the sample plots. Then the forests and plantation sites were stratified for the collection of sample plots depending on the apparent density of forests and the occurrence of minor disturbance (Khaine et al. 2017). In each stratum, the sample plots were laid out randomly so that the sample plots covered and represented the individual sites. The size of each sample plot was 2,500 m^2 (50 m × 50 m). The species area curve was performed to be representative of the population by the samples (Cain 1938; Cencini et al. 2012). A total of 20 sample plots were set up in the study area.

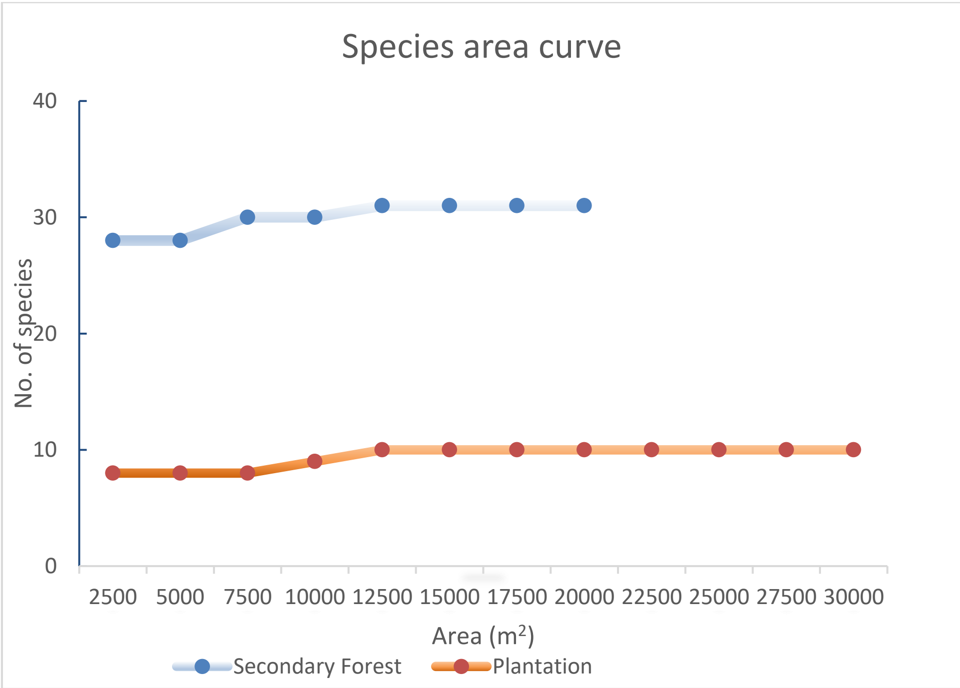

Figure 2. Species-area curve of forests

In each plot, the diameter and height of all trees greater than 5 cm in diameter at breast height (dbh) were measured.

In case of species diversity, two commonly accepted diversity indices, namely, Shannon index (Shannon and Weaver 1949) and Simpson index (Simpson 1949) were calculated. The diversity index could be defined as a mathematical measure of species diversity of a forest. The Shannon diversity index give a favor for rare species, while the Simpson diversity index give a more outweigh to the common species (Heip et al. 1998; Oo 2009; Hakkenberg et al. 2016). Both indices are the products of the richness of species and the abundance of individual species in a forest. Duncan's multiple range tests was used to express the differences among indices.

The formula for Shannon's diversity index is as follows:

$$H' = \sum_{i=1}^{s} (Pi)(\ln Pi),$$

where, H' = Shannon's diversity index

s = the number of species in the sample

Pi = the proportion of the total sample belonging to the i^{th} species

ln = the natural logarithm

The formula for the Shannon evenness index is as follows:

$$E\ (\%) = 100\ (H^{'}/\ln H_{max})$$

where, E = the Shannon evenness index in percentage

H' = Shannon's diversity index

H_{max} = the number of total species

The formula for Simpson's diversity index is as follows:

$$D = \sum_{i=1}^{s} \{n_i (n_i - 1)/N (N - 1)\}$$

where, $(1 - D)$ = Simpson's index of diversity

n_i = the number of individuals of species i

s = the number of species in the sample

N = the total number of individuals in the sample.

The above-ground carbon storage was calculated using formulas recommended by Brown (Revised version) and FAO:

$$Y = \exp \{-2.134 + 2.530 \times \ln(D)\}$$

where, Y = above-ground biomass of forest

D = diameter of tree

The carbon conversion factor, 0.47, (IPCC 2006) was used for calculating the carbon storage of forests.

The statistical analyses were performed using the R program (Version 3.4.2, R Foundation for Statistical Computing, Vienna, Austria, 2017) and SPSS statistical software (Version 24, International Business Machines Corporation (IBM), United States, 2016).

4. Results and Discussions

4.1 Species richness and diversity

Occurrence of species in the secondary forests of Bago Yoma region is good in in comparison with dry forest area. A total of 31 species were found in the secondary forests and 11 species were found in young plantations in the study sites of the Bago Yoma region. The plantation ages of the study sites ranged from 1 year to 5 years. Shannon diversity index ranged from 0.10 ± 0.01 in young plantations to 3.36 ± 0.27 in secondary forests. Simpson diversity index ranged from 0.99 ± 0.02 in young plantations to 0.98 ± 0.04 in secondary forests. The richer species diversity was found in the secondary forests than that of the young plantation in the Bago Yoma region. The Shannon evenness showed 4.22 ± 2.13 in young plantations and 97.92 ± 1.76 in the secondary forests. The result was also higher in comparison with *Terminalia* forest (1.13), *Acacia* forest (0.43), *Diospyros* forest (1.71) and *Dipterocarpus* forest (1.18) by Khaing (2014).

Table 1. Species diversity of forests in the study areas

Description	Shannon diversity index	Simpson diversity index	Shannon evenness	Species richness
Secondary Forest	3.36 ± 0.27 [a]	0.98 ± 0.04 [a]	97.92 ± 1.76 [a]	31
Plantation	0.10 ± 0.01 [b]	0.99 ± 0.02 [a]	4.22 ± 2.13 [b]	11

Mean value ± standard deviation. Different lowercase letters indicate the differences among the sites was significant by t tests (DMRT) at $p < 0.05$.

A total of thirty-one species including *Tectona grandis*, *Dalbergia obovata*, *Millettia pendula*, *Millettia brandisiana*, *Erythrina suberosa*, *Anogeissus acuminata* and *Dalbergia cultrata* are found in the secondary forests and a total of eleven species including *Tectona grandis*, *Vitex canescens*, *Flacourtia cataphracta* and *Oroxylum indicum* were found in the young plantation area. The accumulation pattern of the diversity of forests can be seen in the following Figure 3.

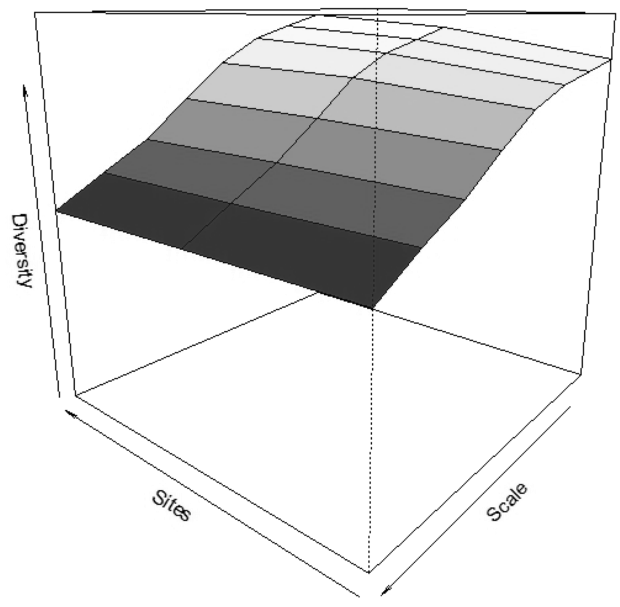

Figure 3. Accumulation pattern of diversity of forests

4.2 Stand structure

Maintenance of the diversity and stand structure of living ecosystem is crucial for functional ecology (Chiarucci et al. 2011). Therefore, analysis of forest structure plays an important role. Based on the results, the basal areas of forests were 11.89 ± 1.23 m^2 ha^{-1} in secondary forests, 0.55 ± 0.03 m^2 ha^{-1} in one year old plantation, 2.46 ± 0.16 m^2 ha^{-1} in two years old plantation, 3.84 ± 0.05, 6.10 ± 1.40, 10.22 ± 2.11, 12.03 ± 4.16 m^2 ha^{-1} in four to six years old plantations, respectively. The densities ranged from 1494.35 ± 1.18 to 3002.70 ± 1.03 trees ha^{-1} in young plantations and 164.29 ± 5.31 trees ha^{-1} in secondary forests, respectively.

Table 2. Density and basal area of forests in the study area

Description	Parameter	Value
Secondary forest	Average density per ha	164.29 ± 5.31 [c]
	Average diameter (cm)	24.52 ± 18.63 [a]
	Average BA per ha (m^2)	11.89 ± 1.23 [a]
Plantation (1yr)	Average density per ha	2988.70 ± 3.28 [a]
	Average diameter (cm)	1.54 ± 0.66 [f]
	Average BA per ha (m^2)	0.55 ± 0.03 [e]
Plantation (2yr)	Average density per ha	3000.70 ± 2.21 [a]
	Average diameter (cm)	3.01 ± 0.27 [e]
	Average BA per ha (m^2)	2.46 ± 0.16 [d]
Plantation (3yr)	Average density per ha	2998.70 ± 1.11 [a]
	Average diameter (cm)	4.03 ± 0.18 [d]
	Average BA per ha (m^2)	3.84 ± 0.05 [d]
Plantation (4yr)	Average density per ha	3002.70 ± 1.03 [a]
	Average diameter (cm)	5.10 ± 1.01 [c]
	Average BA per ha (m^2)	6.10 ± 1.40 [c]
Plantation (5yr)	Average density per ha	3000.70 ± 1.05 [a]
	Average diameter (cm)	6.60 ± 0.92 [c]
	Average BA per ha (m^2)	10.22 ± 2.11 [b]
Plantation (6yr)	Average density per ha	1494.35 ± 1.18 [b]
	Average diameter (cm)	9.85 ± 1.61 [b]
	Average BA per ha (m^2)	12.03 ± 4.16 [a]

Different letters indicate significant differences by Duncan's multiple range test at $p < 0.05$.

4.3 Structural diversity

In case of structural diversity, a regular distribution showed that there will be the maximum growing spaces and environment for every tree and species while cluster distribution showed a reduction in diameter increment of each tree because of competition among individuals (Neumann and Starlinger 2001). In this study, individual species in each forest seemed to have enough growing spaces and conditions for their growth since all study sites showed distributions with an index of 0.93 to 0.54. The distribution pattern is different between secondary forest and plantation. The vertical structure of secondary forests has more vibration and show multiple structure and wide range in distribution while the plantation has a positive trend and with very little variations. Figure 4 and 5 show the distribution pattern of secondary forest and plantation of the study area.

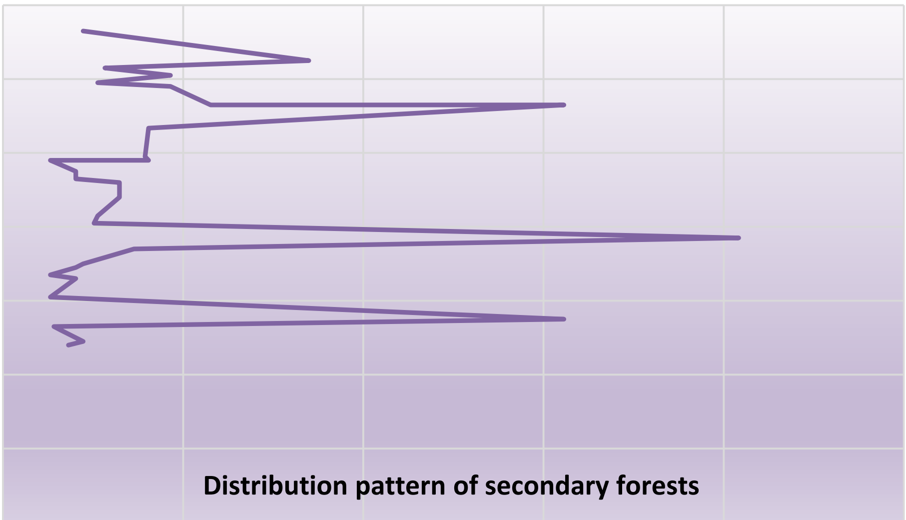

Figure 4. Distribution pattern of secondary forests

Figure 5. Distribution pattern of plantations

4.4 Aboveground carbon storage of forests

Based on the results, the forests in the study sites had a carbon storage showing 3.04 ± 0.3 Mg C ha^{-1} of above-ground carbon in one year old teak plantation. The carbon storage was increased to 5.76 ± 0.72 Mg C ha^{-1} of above-ground carbon in the two years old plantation. The carbon storage was increased time to time showing 9.40 ± 1.03, 14.35 ± 0.33, 21.99 ± 3.20, 23.84 ± 2.11 Mg C ha^{-1}. The carbon storage of secondary forest is higher than those of plantations showing 23.01 Mg C ha^{-1} to 28.78 Mg C ha^{-1}. Until one to three years of plantation, the carbon storage was significantly lower than those of the secondary forest. Starting from age of four years old, the carbon storage of plantation was significantly increased to 14.35 Mg C ha^{-1}, and reached 21.99 Mg C ha^{-1} at the age of 5 years old plantation which is a comparable amount of secondary forest. However, if the secondary forest is well managed without any destroy, it could be higher carbon storage than the young plantation. According to Oo's (2009) study, the forests in Bago Yoma region stored 227.7 Mg C ha^{-1}. Therefore, the secondary forest showed a lower carbon storage than the finding in Bago Yoma area because the secondary forest we targeted is the degraded site adjacent with the plantation establishment.

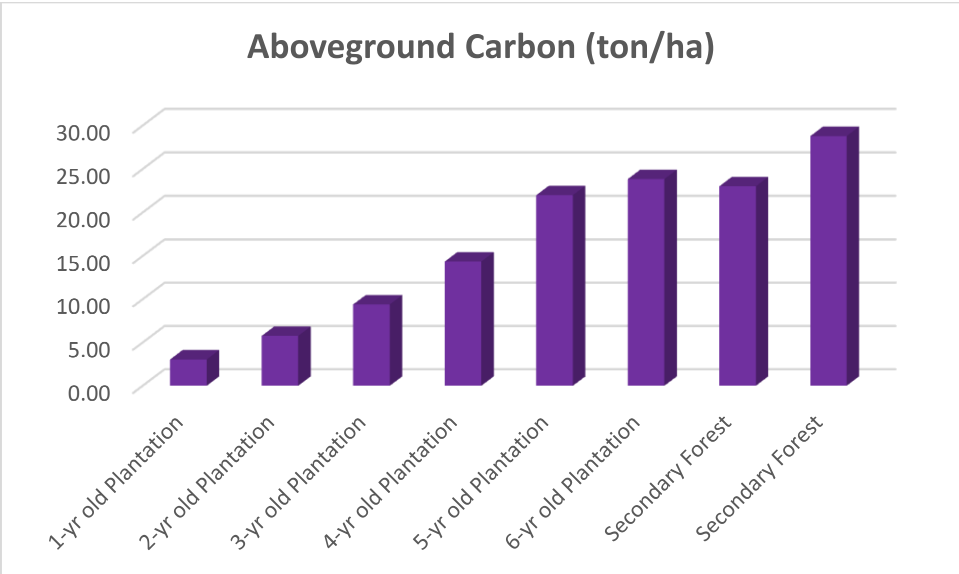

Figure 6. Aboveground carbon storage of plantation and secondary forests in the study areas

Based on a network chain analysis, not only the growth but also the condense of forests overwhelmed the carbon storage of forest and the regeneration of forests should not be neglected in the management of carbon storage. The regeneration in plantation is lower than that of the secondary forests. Likewise, the composition of species is lower in the plantation than the secondary forests. Figure 7 shows the network of the factors in plantation and secondary forests.

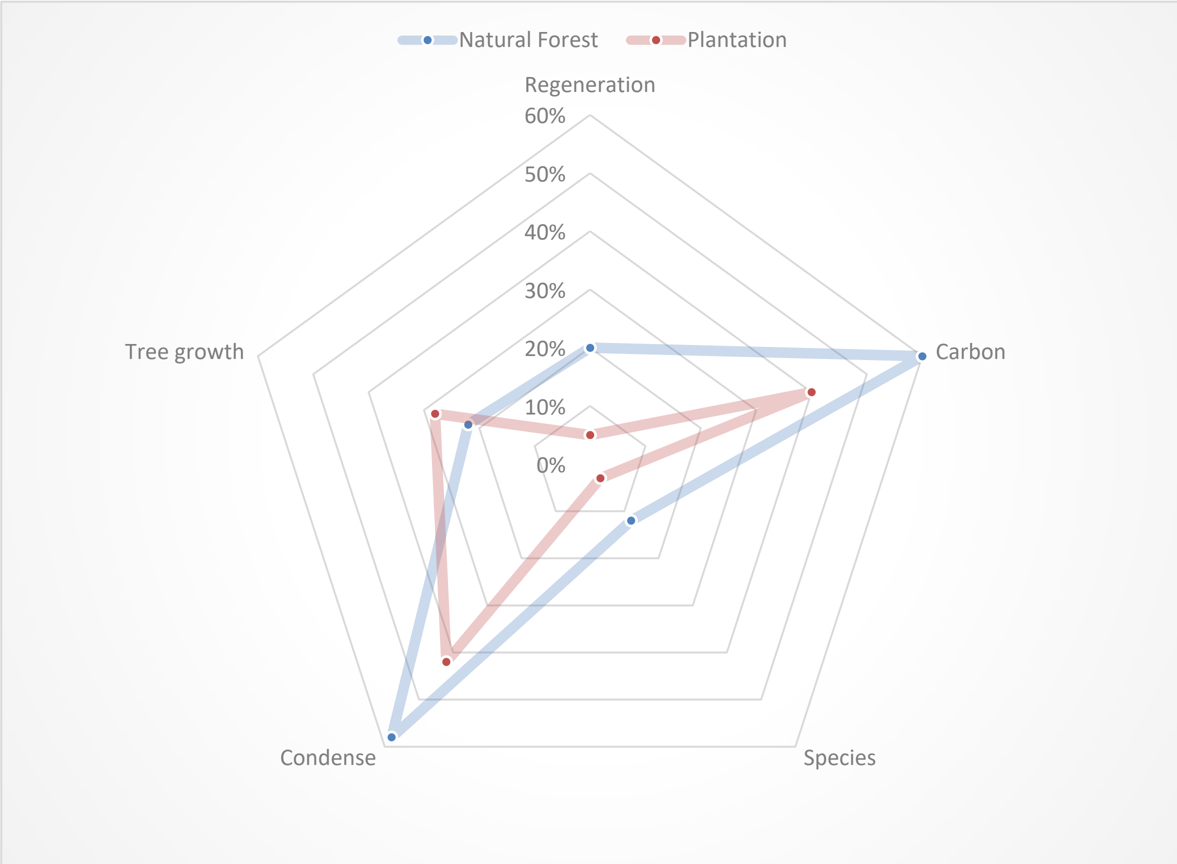

Figure 7. Network analysis of plantation and secondary forest in the study areas

5. Conclusion

The composition species in the secondary forests of Bago Yoma region is good in in comparison with dry forest area. A total of thirty-one species including *Tectona grandis, Dalbergia obovata, Millettia pendula, Millettia brandisiana, Erythrina suberosa, Anogeissus acuminata* and *Dalbergia cultrata* are found in the secondary forests and a total of eleven species including *Tectona grandis, Vitex canescens, Flacourtia cataphracta* and *Oroxylum indicum* were found in the young plantation area. Shannon diversity index ranged from 0.10 ± 0.01 in young plantations to 3.36 ± 0.27 in secondary forests.

The distribution pattern is different between secondary forest and plantation. The vertical structure of secondary forests has more vibration and show multiple structure and wide range in distribution while the plantation has a positive trend and with very little variations. The carbon storage in one year old plantation was 3.04 ± 0.3 Mg C ha^{-1} and it was increased to 5.76 ± 0.72 Mg C ha^{-1} of above-ground carbon in the two years old plantation. The carbon storage was increased time to time showing 9.40 ± 1.03, 14.35 ± 0.33, 21.99 ± 3.20, 23.84 ± 2.11 Mg C ha^{-1}. The carbon storage of secondary forest is higher than those of plantations showing 23.01 Mg C ha^{-1} to 28.78 Mg C ha^{-1}. As the results of the study, the carbon storage capacity of young teak plantations is lower than the capacity of secondary forests until the age of three years. At the age of four to five years, it is comparable to the secondary forests. The findings from this study support the sustainable forest management, Reducing Emission from Deforestation and Forest Degradation, Nature-based Solutions in Myanmar.

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Appendix

List of species found in the secondary forests

No.	Species	Family Name	Scientific Names
1	Daunt-Ta-Laung	Fabaceae	*Dalbergia rimosa*
2	Didu	Bombacaceae	*Bombax insigne*
3	Hin-Ngoke	Bignoniaceae	*Stereospermum neurant*
4	Htauk-Sha	Verbenaceae	Vitex conescens
5	Ka-Thit	Fabaceae	*Erythrina suberosa*
6	Khat-Cho	Liliaceae	Similax macrophylla
7	Kyat-Tat	Flacourtiaceae	*Flacourtia cataphracta*
8	Kyaung-Sha	Bignoniaceae	Oroxylum indicum
9	Kyot-Chay-Htauk	Sapindaceae	Schleichera oleasa
10	Kyun	Lamiaceae	*Tectona grandis*
11	Lat-Htoke	Apocynaceae	*Holarrhena pubescens*
12	Lein	Combretaceae	*Terminalia pyrifalia*
13	Ma-Da-Ma	Fabaceae	*Dalbergia obovata*
14	Myauk-Chaw	Salicaceae	*Homanlium tomentosum*
15	Nabe	Anarcadiaceae	*Lannea coromandelica*
16	Ngu-Shwe	Caesalpinaceae	*Casia fistula*
17	Phan-Khar	Combretaceae	*Terminalia chebula*
18	Sein-Na-Phaw	Smilacaceae	*SImilax prolifera*
19	Sit-Si	Rubiaceae	*Ixora sp.*
20	Swa-Ni	Malvaceae	*Eriolaena candollei*
21	Taw-Kyat-Mauk	Euphorbiaceae	*Euphoria dimocarpus*
22	Thabut	Annocaceae	*Polyalthia simiarum*
23	Thet-Yin-Gyi	Euphorbiaceae	*Croton roxburghianus*
24	Thin-Win	Fabaceae	*Millettia pendula*
25	Thit-Bagan	Euphorbiaceae	*Croton roxburghianus*
26	Unknown species		
27	Unknown species		
28	Wet-Shaw	Sterculiaceae	*Firmiana colorata*
29	Yin-Htaik	Fabaceae	*Dalbergia cultrata*
30	Yone	Combretaceae	*Anogeissus acuminata*
31	Zaung-Palway	Lythraceae	*Lagrostroemia villosa*

List of species found in plantations

No.	Species	Family Name	Scientific Names
1	Htauk-Sha	Verbenaceae	Vitex conescens
2	Ka-thit	Fabaceae	*Erythrina suberosa*
3	Khat-Cho	Liliaceae	Similax macrophylla
4	Khat-Cho	Liliaceae	Similax macrophylla
5	Kyat-Tat	Flacourtiaceae	*Flacourtia cataphracta*
6	Kyaung-Sha	Bignoniaceae	Oroxylum indicum
7	Kyot-Chay-Htauk	Sapindaceae	Schleichera oleasa
8	Sein-Na-Phaw	Smilacaceae	*SImilax prolifera*
9	Taw-Kyat-Mauk	Euphorbiaceae	*Euphoria dimocarpus*
10	Teak	Lamiaceae	Tectona gradis
11	Wet-Shaw	Sterculiaceae	*Firmiana colorata*