THE DYNAMICS OF CARBON DIOXIDE SEQUESTRATION RELATED TO THE STOCKED STANDS OF TROPICAL FOREST IN CENTRAL KALIMANTAN

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ABSTRACT

The purpose of the research is to measure the dynamics of biomass, carbon and CO_2 sequestration related to the stocked stands with liberation and non-liberation treatment on the permanent sample plot of PT. Indexim Utama's IUPHHK-HA year 2011 - 2015. The estimation of stocked stands biomass storage above and below ground biomass/roots used Brown's allometric equation (1997) and Indonesian National Standard or SNI 7724 (2011). Meanwhile, the estimation of carbon storage and CO_2 sequestration used the equation of SNI 7724 (2011) dan IPCC (2006). These dynamics are calculated by using Stock-Difference method (IPCC, 2006). The result of the observation shows the average biomass, carbon, and CO_2 of the stocked stands with liberation treatment during 4 years were about 13.28 ton/ha/year; 6.24 tonC/ha/year; 22.91 tonCO_2/ha/year. Meanwhile the biomass storage rate, carbon, and CO_2 sequestration of the stocked stands observed with non-liberation treatment were about 10.75 ton/ha/years; 5.04 tonC/ha, and 18.49 tonCO_2/ha/year.

Keywords: *carbon dioxyde, stocked stand, tropical forest*

INTRODUCTION

Tropical forest ecosystem has an important role in climate change mitigation to surpress the increasing carbon dioxide or CO_2 emission in the atmosphere through forest component stands. The forest component stands use the CO_2 in the atmosphere for photosyntetic process. The photosyntetic results in oxygen and carbohydrate accumulating to cellulose and lignin as carbon stocks (Climate Change Team at Forest Research and Development Agency, 2010). In other side, tropical forest is also the source of CO_2 gas emission under deforestation and degradation by human activities (*anthropogenic*). One cause of the tropical forest degradation in Indonesia is as the effect of the utilization of wood forest product by the company under the Licence for Utilization of Timber in Natural Forest or IUPHHK-HA. The utilization of the wood forest product is obliged to orientate on the principle of sustainable forest management according to relevant rules and regulations. Despite of the regulation, the process of forest degradation caused by

those activities is unavoidable, which enables the role of tropical forest in surpressing CO_2 gas emission to low down.

IUPHHK-HA of PT. Indexim Utama is one of the companies that using wood forest product in Central Kalimantan in extent of 52.480 hectares. This utilization uses Indonesian Selective Cutting and Planting or TPTI silviculture system. In TPTI silviculture system guidelines, the utilization of wood forest product in natural forest is conducted on commercial type of trees with 40 centimeters diameter limit (Regulation by Directorate General of Forest Production of Indonesia Republic No. P.9/VI/BPHA/2009). The implementation of silviculture system will leave some areas of stocked stands in logged-over areas with different composition and structure compared to previous condition (before logging). The stands left in the logged-over areas (LOA) based on growth level vary in seedling, sapling, pole and trees stage. The observation toward the growth and the development of the stacks in the logged-over areas particularly at trees stage (diameter of >10 centimeters) is compulsory for every IUPHHK-HA company on permanent sample plot (PSP), which measured continuously every year (Decree of the Forestry Minister of Indonesian Republic No.237/Kpts-II/1995). The habitation of the stocked stands in logged-over areas has the ability to live and grow dynamically, and gradually develop in long succession process. The dynamic growth and development process of the present stocked stands, especially those in LOA stage (diameter >10 centimeters) in LOA take effect toward biomasses storage, carbon and CO_2 sequestration. To understand about how significant the impact of the sawtimber-stage stocked stands in their growth and development toward the dynamics of biomasses storage, carbon, CO_2 sequestration, a study was conducted by research.

The objective of the research is to measure the dynamic of biomasses storage, carbon, and CO_2 sequestration of stocked stands with liberation and non-liberation treatment on the PSP under the Licence of Utilization of Timber in Natural Forest or IUPHHK-HA at PT. Indexim Utama during 2011 - 2015.

METHODOLOGY

Location and Time

The research was conducted on the permanent sample plot (PSP) under the Licence of Utilization of Timber in Natural Forest or IUPHHK-HA at PT. Indexim Utama since year 2011 until 2015.

Target and Instruments

The target of research was the present stocked stands at sawtimber stage (diameter >10 centimeters) on the permanent grid areas or PSP which was divided into 6 PSPs with 1 (100 m x 100 m) each at LOA in 2008. The treatment on each PSP serial number is horizontal (PSP Serial No. 01, 02, 03) and non-liberation with PSP Serial No. 04, 05, 06. The instruments used were Suunto compass, GPS, *phiband*, 50 meters gauge, hagameter, clinometer, altimeter, machetes, permanent-ink marker, stationeries, and *tally sheet*.

Research Procedure

The data measurement on sawtimber-stage stands on each PSP serial was conducted on August annually from 2011 - 2015. Meanwhile, the PSP location at IUPHHK-HA of PT Indexim Utama was a logged-over area since 2008.

Data variable of the stocked stands which was measured covering the tree varieties and trunk diameters measured at the height of 1.3 meters above the ground. The stands measurement at sawtimber stage was conducted on every PSP serial and 10 m x 10 m sized sub plots were framed therefore each measured sub-plots in all PSP series were 600 units in total.

The biomass storages in every PSP serial measured were the biomass storage above and those under the ground level. The biomass storage above the ground level was measured with Brown's *allometric* equation (1997) and the under ground one was measured with Indonesian National Standard or SNI equation No. 7724 (2011). The total biomass storage in every PSP serial was the summation between the biomass storage above and under the ground (roots) levels. The estimation of the biomass storage in the stocked stands was measured by using the SNI equation No. 7724 (2011), and the CO_2 sequestration of the stocked stands was measured with IPCC formula (2006). Meanwhile, the dynamic of biomass storage, carbon, and CO_2 sequestration was measured by using *Stock-Difference* method (IPCC, 2006).

RESULTS AND DISCUSSION

The Dynamic of the Stocked Stands Biomass Storage

The dynamic of above and below ground biomass (root) with liberation and non-liberation treatment on permanent sample plot (PSP) under IUPHHK-HA at PT Indexim Utama from 2011 to 2015 is presented on Figure 1.

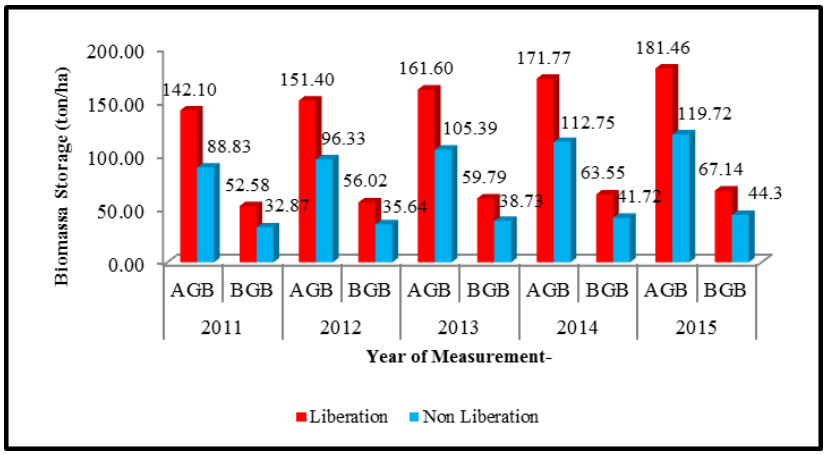

Figure 1. *The Dynamic of Above Ground Biomass (AGB) and Below Ground Biomass/root (BGB) with liberation and non-liberation treatment on PSP under IUPHHK-HA of PT. Indexim Utama from 2011 until 2015.*

Figure 1 shows the dynamic of the stocked stands biomass storage (above and below ground biomass/root) with liberation and non-liberation treatment on

PSP location has the tendency to increase along with the aging of the logged-over areas. The increase of the stocked stands biomass storage on logged-over areas underwent the process of development, growth, and change in the stand composition and structure, therefore impacting to the biomass storage quantity. Dharmawan and Ismayadi (2012) stated that the longer years the forest at logged-over areas, the more it would contribute to the increase of the biomass or the forest carbon substance.

The rate of the stocked stand biomass storage with the liberation treatment during 4 years was 13.28 ton/ha/year and the non-liberation treatment was 10.75 ton/ha/year in average. The peaking rate of the stocked stand biomass treatment was influenced by the diameter and the density of the composition stands. The average diameter of the stocked stands with liberation treatment was as much as 28.50 centimeters with stand density for about 178 individual/ha. Meanwhile, the non-liberationled stocked stands had the average 27.60 centrimeters and stand density as much as 147 individual/ha. Kusmana (1993), the biomass of forest stands was influenced by the age of the stands, the vegetation growth history, composition, and stand structures.

In general, this research indicates the increase rate of the stocked stand biomass storage on PSP location (liberation and non-liberation treatment) under IUPHHK-HA at PT. Indexim Utama ranges around 11.50 – 12.28 ton/ha/year with the average of 12 ton/ha/year. The biomass storage rate of the stocked stands will keep increasing along with the ongoing development and growth process of the stocked stands.

The Dynamic of the Stocked Stand Carbon Storage

The dynamic of total carbon storage (above and below ground carbon/root) with liberation and non-liberation treatment on permanent sample plot or PSP under IUPHHK-HA at PT. Indexim Utama is presented as Figure 2.

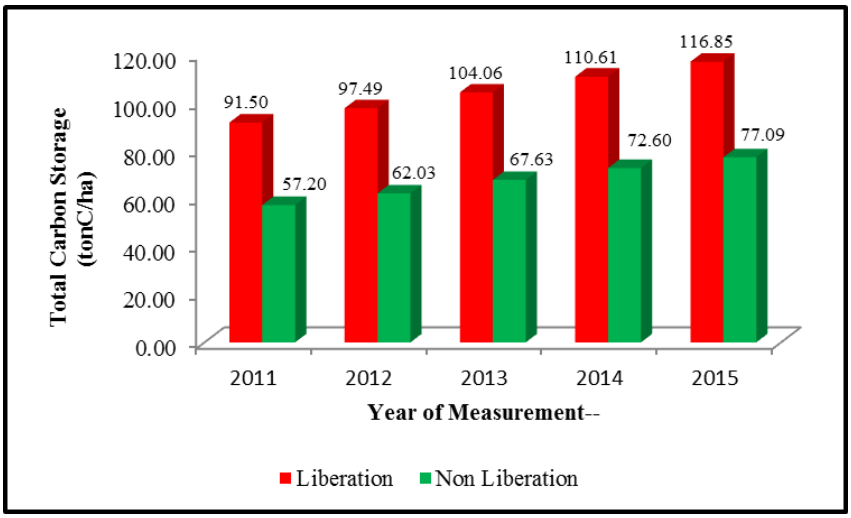

Figure 2. *The dynamic of the biomass storage (above and below ground biomass/root) with liberation and non-liberation treatment on PSP under IUPHHK-HA at PT. Indexim Utama from 2011 to 2015.*

Figure 2 indicates the dynamic of the carbon storage of the stocked stands with liberation and non-liberation treatment showing the same pattern with the pattern of increasing biomass storage. It points out that the carbon stock quantity of the stocked stands is proportional to the biomass storage. The average of the carbon stock of the stocked stands with liberation treatment on PSP serial areas during 4 years was 6.24 tonC/ha/year and on non-liberationled PSP serial areas was 5.04 tonC/ha/year. The treatment to the stocked stands brings good impact to the increase rate of carbon stock with difference as much as 1.20 tonC/ha/year on non-liberation stocked stands. The fluctuation of the increase rate of carbon stock with liberation and non-liberation treatment in each measurement period is depicted in Figure 3.

The Figure 3, shows how the fluctuation of the increase rate of the carbon stock on the stocked stands in PSP serial areas with liberation treatment tends to more stable; kept increasing starting at the 2nd measurement period until the 3rd period and only decreased at the 4th observation period (7 years after logging) compared to the stocked stands at the non-liberationled PSP serial areas. Meanwhile, the rate of carbon stock on the stocked stands at the non-liberationled PSP serial areas tend to fluctuate; it increased at the 2nd measurement period (5 years after logging) and decreased at the 4th measurement period (7 years after logging). Therefore the liberation treatment to the stocked stands caused the fluctuation on the increasing rate of carbon stock to be more stable compared to the non-liberation one on the PSP under IUPHHK-HA at PT. Indexim Utama. The liberation treatment was estimated to bring positive impact to the physiological growth of the stocked stands whereas the speed of the physiologic process of the stocked stand growth would get much slower along with the age of the stocked stands of trees. Campbell *et. al* (2002) in Dharmawan and Ismayadi (2012) stated that the older the trees would cause the slower physiologic process in its growth and development process and influences the carbon stock rate.

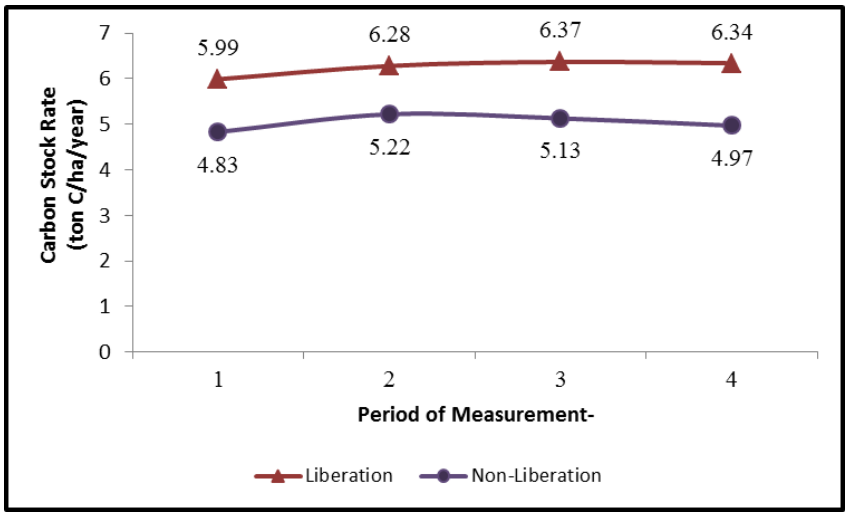

Figure 3. *The fluctuation of the carbon stock rate of the stocked stands with liberation and non-liberation treatment each period on PSP under IUPHHK-HA at PT. Indexim Utama.*

The Dynamic of Carbon Dioxide Sequestration of the Stocked Stand

Naturally the forest composition stocked stands use CO_2 from the atmosphere as the material to produce carbohydrate for its growth through photosyntetic process. The carbohydrated resulted from the photosyntetic process will be distributed and stocked to all components of the stocked stands (leaves, twigs, branches, stems, roots, fruits, and flower) in the form of biomass. The biomass of the stocked stands is a total living organic material with organic carbon content about 47 % (Indonesian National Standard 7724, 2011). The organic carbon storage of living stocked stands can be used to depict how much CO_2 from the atmosphere that can be sequestrated by the stocked stands (Hairiah *et. al*, 2011). The dynamic of the CO_2 sequestration of the stocked stands on the PSP serial areas with silviculture liberation and non-liberation treatment from 2011 until 2015 is on Figure 4.

The dynamic of the CO_2 sequestration of the stocked stands on all PSP serial areal with liberation and non-liberation treatment increased along with the more years the logged-over areas were (Figure 4). The increase of CO_2 sequestration indicates the continuous growth of the stocked stands along with the time so the need of CO_2 from the atmosphere also increases. The average of the CO_2 sequestration rate from the stocked stands with liberation treatment was higher (22.91 tonCO_2/ha/year) compared to the non-liberation ones (18.49 tonCO_2/ha/year). The height of the increasing CO_2 sequestration rate on the stocked stands with liberation treatment was affected by the higher biomass and carbon stock compared to the non-liberation.

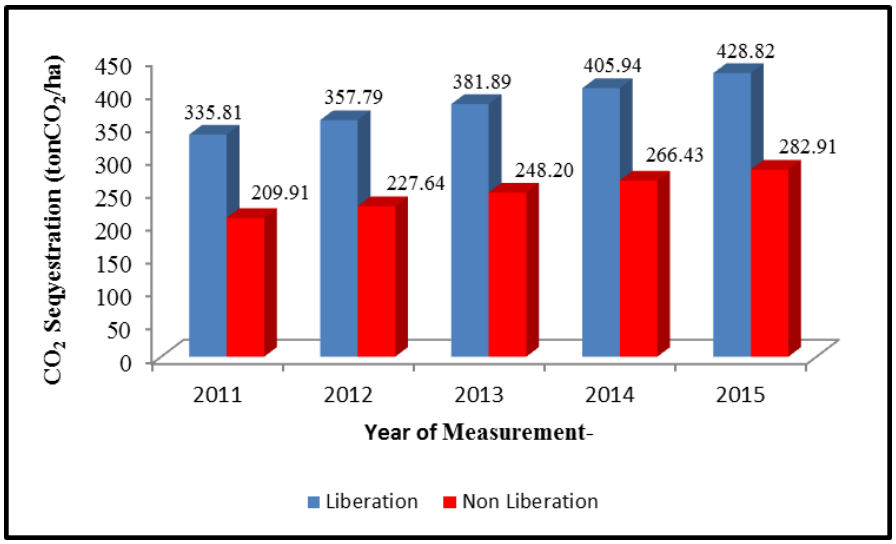

Figure 4. *The dynamic of CO_2 sequestration on the stocked stands with liberation and non-liberation treatment on PSP under IUPHHK-HA at PT. Indexim Utama from 2011 to 2015.*

The fluctuation of CO_2 sequestration rate of the stocked stands with liberation and non-liberation treatment on each PSP serial based on measurement period is illustrated in Figure 5.

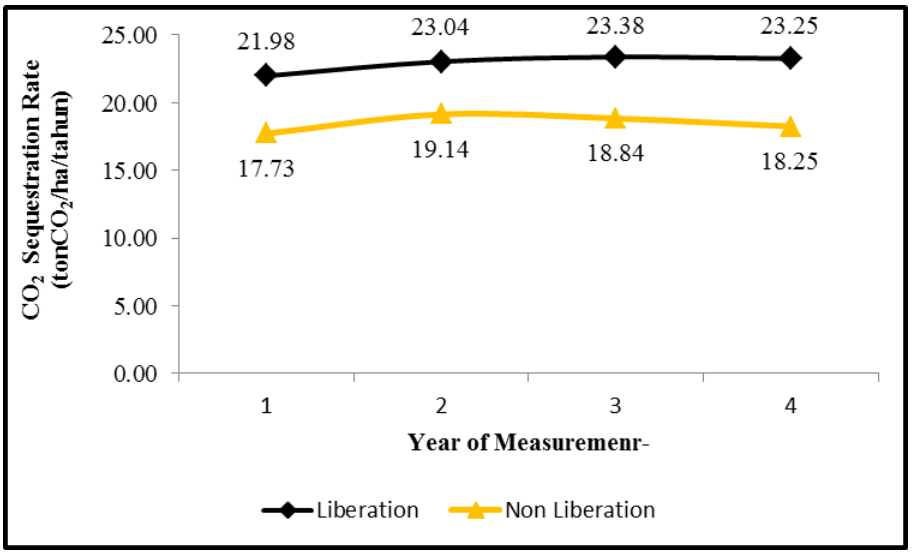

Figure 5. *The fluctuation of CO_2 sequestration rate of the stocked stands with liberation and non-liberation treatment each period on PSP under IUPHHK-HA at PT. Indexim Utama.*

Figure 5 indicates the fluctuation of CO_2 sequestration rate of the stocked stands with liberation and non-liberation treatment each period was at the same pattern with the fluctuation of carbon stock on the stocked stands. The increase of CO_2 sequestration of the stocked stands with liberation treatment occurred at the 2nd and the 3rd period of measurement as was much as 0.34 tonCO_2/ha/year and 0.13 tonCO_2/ha/year each. Meanwhile, the fluctuation pattern of CO_2 sequestration rate of the stocked stands increased at the 2nd period of measurement as much as 1.41 tonCO_2/ha/year and decreased at the 3rd and the 4th period of measurement as much as 0,30 tonCO_2/ha/year and 0,59 tonCO_2/ha/year each. The fluctuation of the CO_2 sequestration rate of the stocked stands on PSP under IUPHHK-HA at PT Indexim Utama tends to be influenced by the treatment given (liberation and non-liberation) therefore impacted to the physiologic speed process carried on its growth. It can be seen on Figure 5 which presents the fluctuation of CO_2 sequestration increase of the stocked stands with liberation treatment to be more stable that the non-liberation.

The fluctuation of the total CO_2 sequestration rate of the stocked (liberation and non-liberation treatment) on all PSP serial locations under IUPHHK-HA at PT. Indexim Utama per period of measurement is depicted on Figure 6.

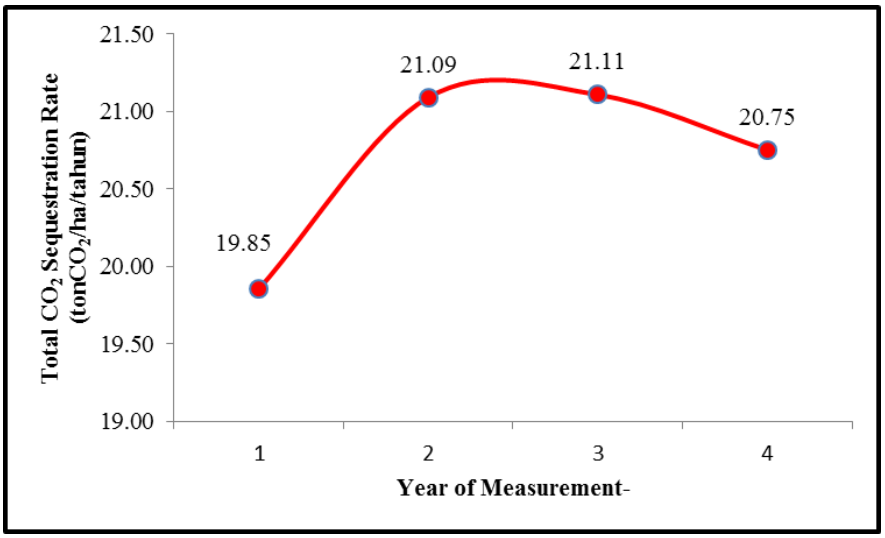

Figure 6. *The total CO_2 sequestration rate of the stocked on all PSP serial locations under IUPHHK-HA at PT. Indexim Utama per period of measurement.*

Figure 6 indicates that the pattern of the total CO_2 sequestration rate of the stocked stands on PSP under IUPHHK-HA at PT. Indexim Utama tends to fluctuate. The fluctuation of increase can be seen at the 2nd and the 3rd measurement of period as much as 1.24 tonCO_2/ha/year and 0.02 tonCO_2/ha/year each and decreased at the 4th period of measurement as much 0,36 tonCO_2/ha/year (Figure 6). Nevertheless, the total CO_2 sequestration rate of the stocked stands during 4 years in all PSP locations under IUPHHK-HA at PT. Indexim Utama increased in the average rate of 20.70 tonCO_2/ha/year. The CO_2 sequestration of the stocked stands on would keep increase along with the more years the stocked stands on the PSP (logged-over areas) in varied increase rate. The variation of CO_2 sequestration rate of the stocked stands depends on the speed of the physiologic process in the development and the growth of the stocked stands.

CONCLUSION AND SUGGESTION

Conclusion

a. The dynamic of the biomass storage and carbon stock of the stocked stands (above and below ground) on the PSP under IUPHHK-HA at PT. Indexim Utama with liberation and non-liberation treatment tends to increase along with the more years the logged-over areas have.
b. The average rate of the biomass storage and carbon stocks of the stocked stands (liberation and non-liberation) on the PSP under IUPHHK-HA at PT. Indexim Utama is as much as 12 ton/ha/year and 5.64 tonC/ha/year each.
c. The dynamic of CO_2 sequestration rate increase of the stocked stands at the PSP under IUPHHK-HA at PT. Indexim Utama with liberation treatment is higher than the non-liberation.

d. The average rate of CO_2 sequestration increase of the stocked stands on the PSP under IUPHHK-HA at PT. Indexim Utama is as much as 20.70 ton CO_2/ha/year.

Suggestion

An advanced research on the same PSP location is necessary with longer measurement period including the measurement on the dynamic of the biomass storage at the sapling, seedling, and roots stage.

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