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Land Use and Biomass Monitoring to Achieve Sustainability of Peat Swamp Area

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Introduction

Approximately 30 to 45 million hectares are covered in peat swamp in Indonesia, comprising roughly 10% of that throughout the world. In particular, 4 million hectares of peat swamp (the second-largest in Indonesia), exist in the Riau region (WWF, 2008).

Giam Siak Kecil-Bukit Batu (GSK-BB), Riau, Indonesia was registered as a Biosphere Reserve by UNESCO in 2009 (UNESCO, 2009). In this area, achieving harmony between the profit of large-scale plantation companies, the activities of peasants, environmental conservation and protection, and development is an issue of great importance. The actual achievement of such harmony is, however, extremely difficult because land conflicts, forest fires, and illegal logging occur frequently. The rapid expansion of plantation and agricultural land has also released a great deal of carbon dioxide into the atmosphere, because of drainage and burning for land preparation.

This paper presents the results of a field survey in the peasants' residential area, farmland and large-scale acacia plantation area, the GSK-BB Biosphere Reserve, in order to determine the carbon stock for the different kinds of Land Use and Land Covers (LULC). We focus on House Land, Rubber, and Oil Palm gardens in residential areas and clarify that 1) The amount of above-ground biomass in a 1-ha Rubber garden is larger than that in an Oil Palm garden. 2) There are six different LULC and Acacia Plantation and Burnt Areas.

Study Area

The GSK-BB Biosphere Reserve consists of three different kinds of socioecological regions (i.e., Core Zone, Buffer Zone, and Transition Area) of 179,000 ha, 222,000 ha, and 304,000 ha, respectively. Natural and secondary forest spreads in the Core Zone and large-scale acacia plantations are located in the Buffer Zone. Residential area, which also contains farmland, exists in the Transition Area. The ecological conditions in these areas are quite different, and the people's utilization of the land varies in each area.

Materials and Methods

Field Survey

In this study, 1) the above-ground biomass of Oil Palm and Rubber trees and 2) the LULC in the buffer and transition zones were surveyed. To estimate the above-ground biomass volume of Rubber and Oil Palm trees, the height of the tree and the diameter at breast height (DBH) were measured using a Laser ACE 3D. Recognizing the LULC in this study area, a Phased Array type L-band Synthetic Aperture Radar (PALSAR) image of the *Advanced Land Observation Satellite* (ALOS) was utilized. This satellite image can penetrate clouds and is thus very efficient at monitoring tropical rainforest areas, which always have cloud cover. In this survey, 30 ground survey points with six different LULC (i.e., Dense Forest, Scarce Forest, Grass Land, Water Body, Wet Land, and Bare Land) were collected using a global positioning system (GPS).

Estimation of Above-Ground Biomass Volume

The above-ground biomass (ABG) volume was estimated by the following equations (Janssens *et al.*, 2002):

$$\text{Rubber (kg/tree)} = 0.11 * p * D^{2.62}$$

$$\text{Oil Palm (kg/tree)} = 0.3747 * H + 3.6334$$

P = Wood density (0.61 kg/m³), D = Diameter, H = Stem Height

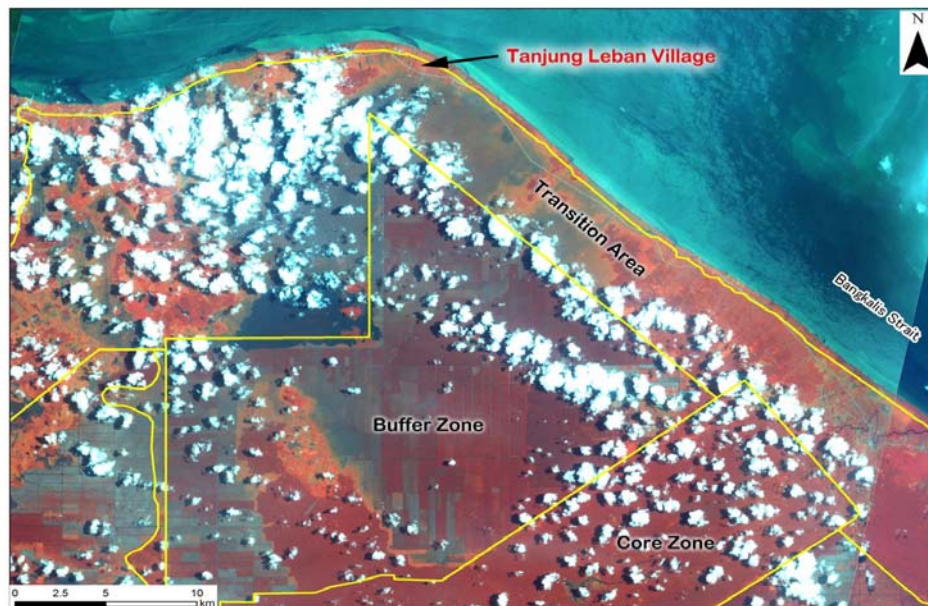


Fig. 1 Study Area

Results and Discussion

Relationships between Diameter and Stem Height

Figure 2 presents the relationships between the diameter at 120 cm and the height of Rubber and Oil Palm trees with age. For rubber trees, the stem height increases with increasing diameter. The average stem height for trees that are 3, 4, 5, and 7 years old is 689, 886, 973, and 1,251 cm and the diameter is 10.3, 11.6, 13.8, and 17.2 cm, respectively. In contrast, stem height is not correlated with diameter in Oil Palm trees. In Oil Palm trees, once the DBH becomes fixed, only the stem height increases. The average stem height for trees that are 6, 8, and 12 years old is 156, 260, and 560 cm and the DBH is 60, 70, and 70 cm, respectively.

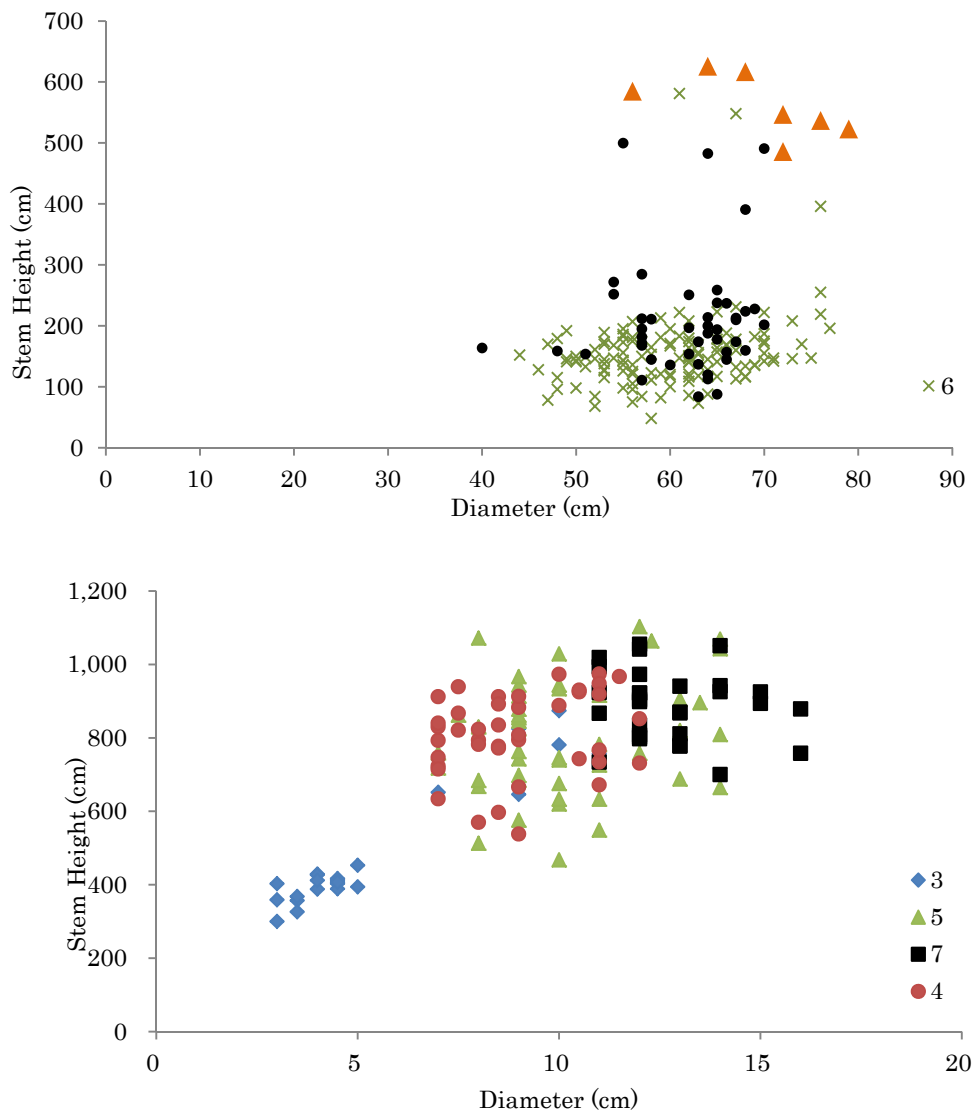


Fig. 2 Relationship between Diameter and Stem Height with Age (Above: Rubber, Below: Oil Palm)

Biomass Volume

Figure 3 depicts the estimated above-ground biomass by age. There are two ages that can be compared in terms of biomass (6 and 8 years). At both of these ages, Oil Palm is larger than Rubber: at 6 years, Rubber is 33 kg/tree and Oil Palm is 62 kg/tree and at 8 years it is 68 kg/tree and 101 kg/tree, respectively. According to the interview with the farmer, because the number of Rubber and Oil Palm trees per hectare is approximately 500 and 150, respectively, Rubber's biomass volume per hectare is larger than Oil Palm (Rubber is 16,500 kg/ha and Oil Palm is 9300 kg/ha in 6 years). It is thus evident that the biomass stock in the Rubber garden is greater than that of Oil Palm within the same area.

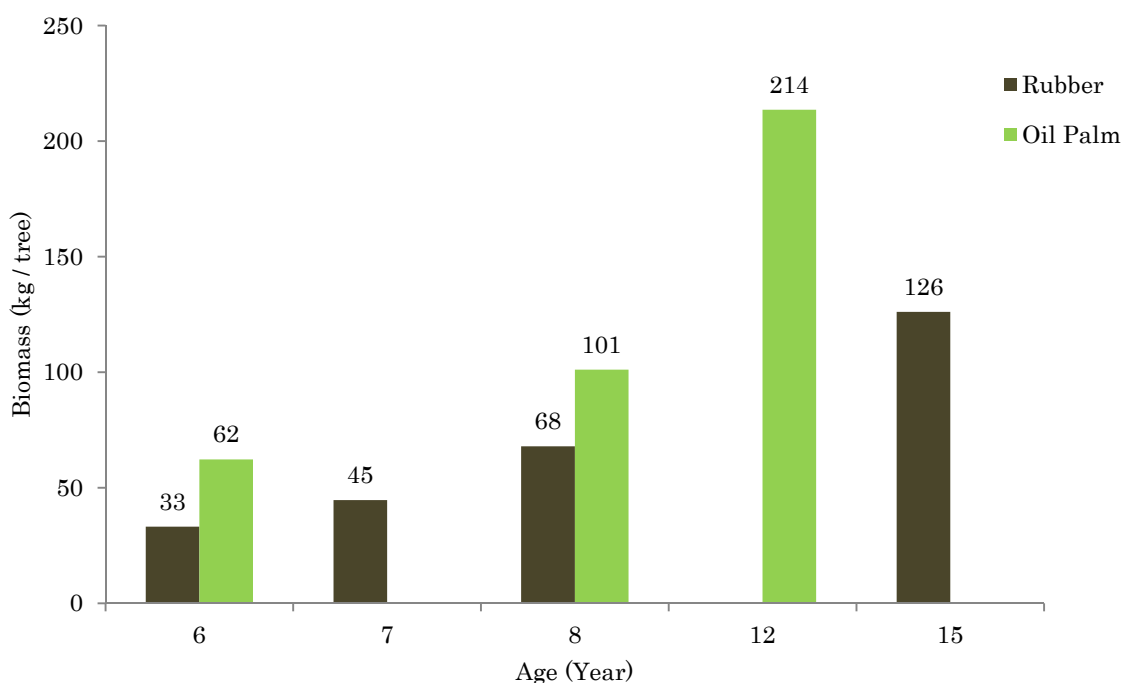


Fig. 3 Estimated Above-Ground Biomass of Rubber and Oil Palm with Age

Land Use and Land Cover

Figure 4 depicts LULC in the study area. The light green color, which represents sparse growth, comprises the majority of the acacia plantation area and the brown color, which represents burnt areas affected by forest fires, spreads to the residential area.

This figure shows that forest fires are a severe problem in residential areas. In addition to emitting CO₂ into the atmosphere, forest fires damage small holders' income.

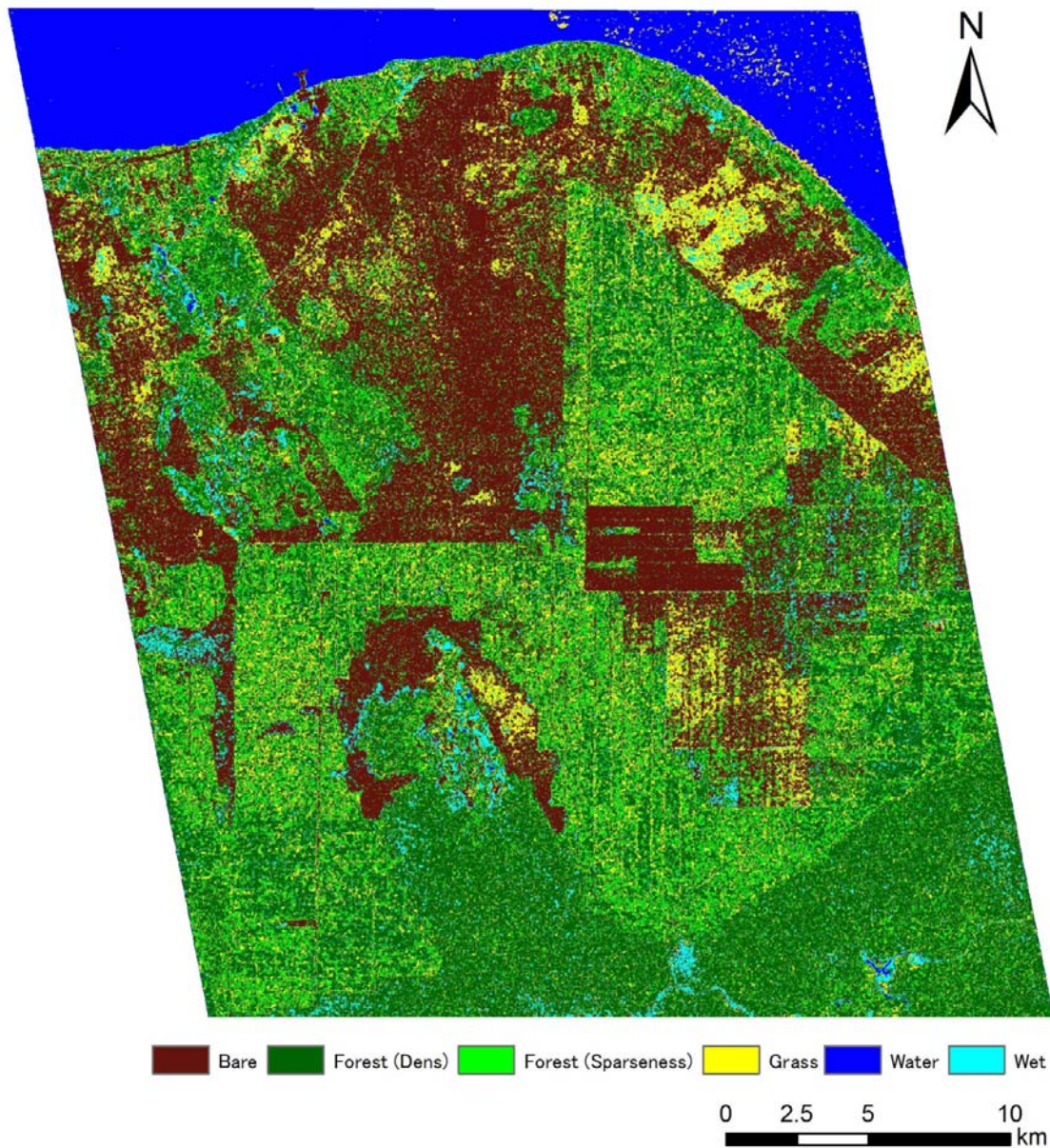


Fig. 4 LULC in the Study Area

Conclusion

In this study, the carbon stock and LULC in the BB-GSK Biosphere Reserve were examined. In the Rubber and Oil Palm gardens that are managed by small holders, the carbon stock of Rubber gardens is higher than that in Oil Palm gardens within the same area.

The LULC in the study area was revealed by the ALOS PALSAR satellite image. Acacia plantations and burnt area occupy the majority of the area. It is of note that burnt areas are spread widely and emit huge amounts of CO₂ so rehabilitation of this area is very important.

More data sampling with different places and ages are required to estimate the carbon stock in this study area. By merging with Remote Sensing data and ground surveyed data, widespread and temporary biomass stock will be clarified.

References

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