CARBON STOCK ESTIMATION IN THE MANGROVE PLANTATION AREA BY USING MULTI-TEMPORAL SATELLITE DATA AND THE SELF-THINNING MODEL

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1. INTRODUCTION

A mangrove plantation as a Clean Development Mechanism (CDM) project is expected as a sink of greenhouse gases, because of their large CO_2 sequestration ability of high primary productivity. The method for estimating the amount of carbon stock after plantation was essential for a planning of a mangrove CDM project. However, there is often no information about tree planting year and planting region in the mangrove plantation area. We has been developed the planted year estimation method using multi-temporal images [1]. This method worked effectively in the controlled low-density plantation trees, such as *Rhizophora apiculata* stands in Thailand. The self-thinning process was known in crowded *Kandelia candel* stands [2]. Self-thinning is considered as one of the most important plant demographic processes. The 3/2 power law of self-thinning is perhaps the most widely applicable principle in plant population dynamics. Much interest on self-thinning studies has been focused on terrestrial plant populations. In contrast, little information is known about the self-thinning process for mangroves. In this study, the self-thinning model was applied to estimate the carbon stock of the uncontrolled high density *Kandelia candel* stands in Vietnam.

2. METHODOLOGY

In order to obtain useful information for mangrove plantation project, the practical utilization of multi-temporal satellite data and field survey data was investigated. The study sites were located in Nam Dinh Province and Tanh Hoa Province, northern part of Vietnam. The relationship between stand age and biomass was investigated based on field survey (tree height, diameter, etc.) at near mangrove forest, in order to calculate carbon stock after plantation by the internationally recognized method. The self-thinning process was monitored in crowded *Kandelia candel* stands in Nam Dinh Province. Thus, the self-thinning model was applied to estimate the carbon stock of the uncontrolled high density plantation trees.

3. RESULTS

3.1 Plantation year estimation using multi-temporal images

In this study area, the sites for which planting year data were available were limited. Therefore, plantation year was estimated using satellite data. Multi-temporal satellite images obtained in 1986-2007 were used to estimate plantation year on the basis of the expansion of the area. This study used 20 sets of satellite data in Nam Dinh Province, and 16 sets of satellite data in Tanh Hoa Province. A moving average NDVI of three years was conducted to decrease the dispersion of data and interpolate no-data year. To estimate stand ages, the judgment rule of NDVI threshold value was applied to three year's average of NDVI. Plantation year was determined as follows. Threshold or minimum and maximum NDVI were determined for several stand age. These determinations were carried out on multi-temporal NDVI images. It confirms whether or not the forest age is the same as a known site. The confirmation was repeated until all correct stand ages were obtained. Then, the plantation year map was estimated by applying this judgment rule to the entire plantation area. This method worked effectively in the region where accurate tree planting year of the mangrove plantation were not recorded.

3.2 The self-thinning model in mangrove *Kanderia candel* stands

The self-thinning model [3] was applied to estimate tree density and tree volume of *Kandelia candel* stands. This model must decide five parameters, such as the self-thinning exponent, initial density, final density, and two parameters for growth rate. These parameters were determined based on the field survey data in Nam Dinh Province and Tanh Hoa Province. Fig. 1

shows the relationship between tree density and tree volume. The tree density and tree volume in the growing process are well represented in comparison with the field survey data.

3.3 Carbon stock estimation on the basis of IPCC methodology

The IPCC methodology can be applied to estimate the carbon stock in this area using predicted value of tree density and tree volume. Carbon stocks were calculated using the following equation, on the basis of Intergovernmental Panel on Climate Change (IPCC) Guidelines [4] and IPCC Good Practice Guidance [5].

$$\text{Carbon Stocks [tC/ha]} = Sv * D * BEF * (1+R) * CF \quad (1)$$

where Sv = stand volume [m3/ha], D = 0.49 basic wood density [tDW/m3], BEF = 1.5 biomass expansion factor, R = 0.73 root-shoot ratio, CF = 0.5 Carbon fraction of dry matter [tC/tDW].

Fig. 2 shows the relationship between carbon stock and stand age. The carbon stock map can be estimated using the plantation year map and carbon stocks curve. By this method, we can determine the carbon stocks in a specific year after plantation, and also estimate the amount of carbon credit in the first promised period in 2008-2012 of Kyoto Protocol. Even in the area where the forest information has not been prepared, these methods are effective for the planning of CDM project, and will be able to apply to monitor the carbon stock under the operation of CDM project.

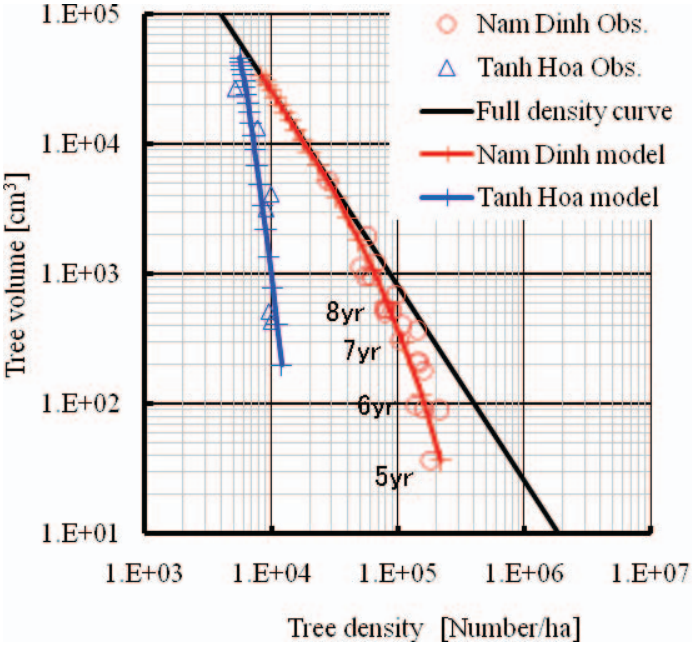

Figure 1. Self-thinning of *Kanderia candel* stands.

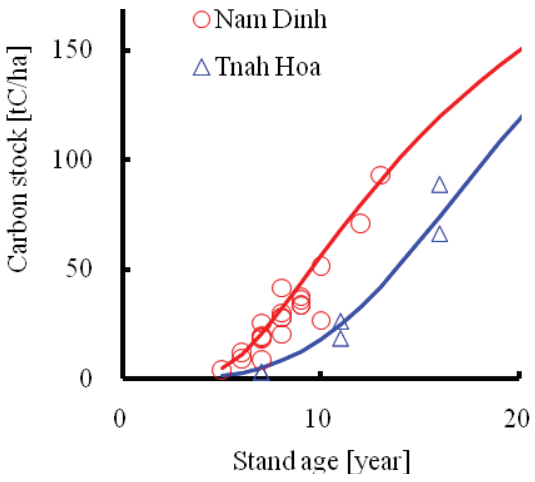

Figure 2. Relationship between carbon stock and stand age.

4. REFERENCES

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