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# Length of the growth period derived from remote sensed and climate data for different vegetation types in Monsoon Asia

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## Abstract

The length of the growth period (LGP) for diverse vegetation types in Monsoon Asia has been estimated using remote sensed-derived Normalized Differential Vegetation Index (NDVI) and climate data. Over the study area, sixteen-selected vegetation types were used, which include tropical rain forest, tropical seasonal forest, sub tropical forest, evergreen broadleaf forest, evergreen needleleaf forest, deciduous broadleaf forest, deciduous needleleaf forest (conifer forest), woody savanna, cropland, rice paddy, grass/crop, cold grassland, low sparse grassland, shrubland, semi desert, and desert. From the remote sensed perspective, the LGP applied here was defined as the longest consecutive period in one year when the monthly NDVI values are greater than 0.09, 0.099, 0.1, 0.17, and 0.2, where as climatic approach, it is determined when the monthly precipitation is greater than 50% potential evapotranspiration. The results show that they have different LGP values, but in general the longest LGP is distributed in dense canopy such as tropical rain forest and the shortest in rare canopies such as semi desert and desert. This study found that the remote sensed-derived NDVI data clearly demonstrated the difference LGP for the diverse vegetation types in Monsoon Asia.

**Keywords:** length of the growth period; vegetation types; NDVI; Monsoon Asia

## Introduction

LGP, also referred to as vegetation period, growing period, growing season, vegetative period, is defined as the time of the year when certain plants grow. The LGP is particularly important for grain and fruit crops that need a minimum period to complete a reproductive cycle. It is a most frequently limiting factor in the northern latitudes or at high altitude, and extremely depends on the environmental factors such as climate, soil and the vegetation type. White *et al.* (1999) found out that the variability of LGP from year to year has a strong relationship to carbon assimilation and evapotranspiration.

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Traditionally, researcher used climatic data to estimate this parameter by using potential evapotranspiration and precipitation data (Wood and Dent, 1983). However, remote sensed derived NDVI data being recently used to estimate the LGP (Henricksen and Durkin, 1986; Lloyd, 1990; Reed *et al.* 1994; Fischer, 1994; Markon *et al.* 1995; etc.). Henricksen and Durkin (1986) suggested that there is a strong correlation between estimates of the start of the growing period made using climatic data and NDVI values. It seems that the growth period is unlikely to begin when the NDVI values are below 0.10. Lloyd (1990) analyzed the LGP by using NDVI data between July 1985 and December 1986 as one of phytophenological variables in land cover classification. The onset and offset of LGP were determined by using 0.099 as threshold NDVI value, as noted by Justice *et al.* (1985). Reed *et al.* (1994) utilized the divergence of smoothed curve from

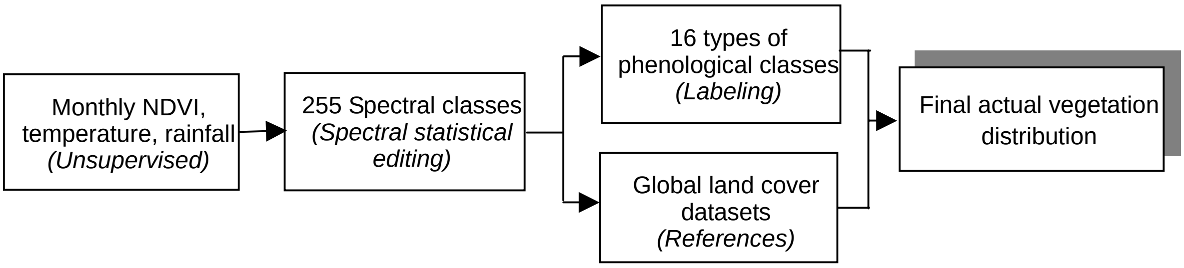


**Figure 1**. Schematic procedure of land cover classifications

autoregressive moving average of each pixels. Fischer (1994) and Markon *et al.* (1995) applied 0.09 and 0.17 as threshold NDVI value, respectively.

In this paper, we investigated the variability of LGP for diverse vegetation types in Monsoon Asia by using the remote sensed and climatic data. We expected that the variability of LGP enable to show the various types of vegetation.

## Methods and Data

### *Vegetation map*

The vegetation types were obtained from Runtunuwu and Kondoh (2001), which is a modification from Runtunuwu *et al.* (2000) classifications. The method is briefly described here, as shown in Figure 1. The map not only utilized remote sensed-NDVI data, but also the climatic data, since we considered the differences in climatic condition are capable of showing either the latitudinal or longitudinal variations associated with the distribution of vegetation. The isoclass program was used to generate spectral classes for the unsupervised classification utilizing twelve monthly NDVI, precipitation, and air temperature. Through classification trials, a number of 255 spectral classes over the study area were obtained. Actually, by using the statistical editing procedure, the distance matrix created from unsupervised classification processes could be modified to produce only for about 70 spectral classes. This procedure allowed the editing of classes by merging, pooling or deleting classes based on hierarchical classification system. However, for this study, we considered using the all-255 classes to defend the homogeneous climatic value of each class. Finally, the vegetation formation of each class was identified based on phenological pattern of NDVI and the global land cover maps.

### *LGP estimations*

a. Remote sensed data: The criterion used to calculate the LGP here is adopted from Henricksen and Durkin (1986), Lloyd (1990) and Justice *et al.* (1985), Fischer (1994) and Markon *et al.* (1995) which is the longest consecutive period in a year when NDVI value (x) is greater than 0.1, 0.099, 0.17, and 0.09 respectively (Figure 2a).

b. Climate data: The criterion used here is referred to Wood and Dent (1983), which is the longest consecutive period in a year when precipitation, $P$ value is greater than 50% potential evapotranspiration, 0.5 $E_0$ (Figure 2b). The

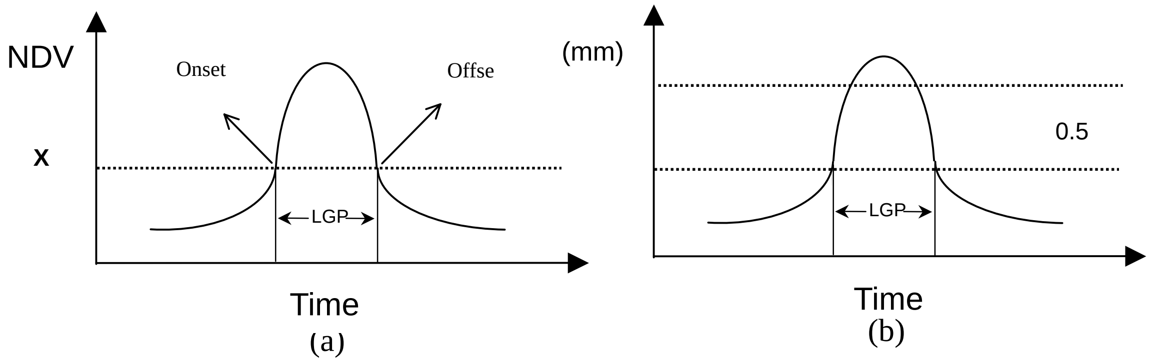


**Figure 2.** Schematic illustration of LGP estimation, by (a) remote sensed and (b) climate data

$E_0$ data was derived from Runtunuwu and Kondoh (2001) utilizing Priestly and Taylor method (1972) that used albedo (%), cloudiness (%), air temperature (ºC), and elevation (m) as input data. Detailed procedure of this method could be referred to Ahn and Tateishi (1994).

These simple criterions were applied in all 255 classes considered in order to obtain the LGP of each vegetation type in Monsoon Asia.

## Results and Discussion

*Seasonal trend of monthly NDVI and climate data*

Before calculating the LGP, the profiles of monthly NDVI over a one-year period have been plotted versus time (month), as well as $P$ , $E_0$ , and 0.5 $E_0$ . For instance, Figure 3 shows the distributions for some selected vegetation types. Plot A represents a curve of tropical rain forest showing high NDVI and the climate value throughout the year. Based on the NDVI value, this class has twelve months for the LGP value since all the NDVI data are more than the all references threshold value. It resembles in conclusion with the climate approach, because in one year the $P$ is higher than 0.5 $E_0$ value.

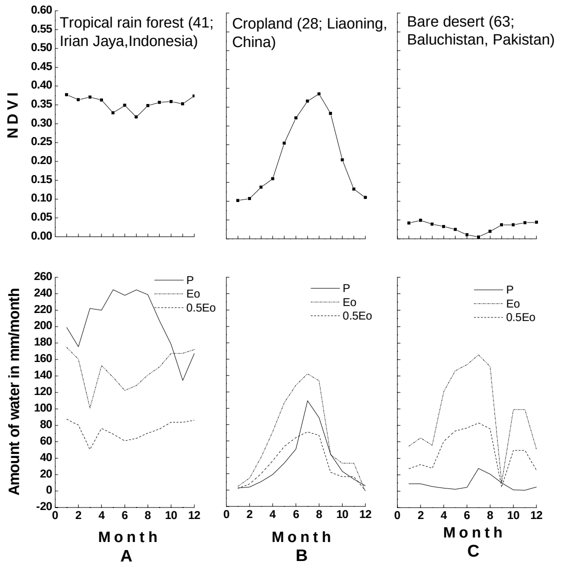


**Figure 3**. The distribution of NDVI and $P$ , $E_0$ and 0.5 $E_0$ for some vegetation types: (A) tropical rain forest, (B) cropland, and (C) bare desert

In addition, Plot B shows irrigation agriculture patterns, which has only one peak distribution throughout the year. This is similar with climate distribution, as shown in plot B (below). Hence, the sites with lower vegetation indices are associated

**Table 1**. The LGP estimations based on (a) Henricksen and Durkin (1986), (b) Lloyd (1990) and Justice *et al.* (1985), (c) Fischer (1994), (d) Markon (1995), and (e) climate data. The *m* and *s* indicate the mean and standard deviation.

| No | Vegetation type | a | | b | | c | | d | | e | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *m* | *s* | *m* | *s* | *m* | *s* | *m* | *S* | *m* | *s* |
| 1 | Tropical rain forest | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 1 |
| 2 | Tropical seasonal forest | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 7 | 1 |
| 3 | Sub tropical forest | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 7 | 2 |
| 4 | Evergreen broadleaf forest | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 7 | 3 |
| 5 | Evergreen needleleaf forest | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 11 | 0 |
| 6 | Deciduous broadleaf forest | 12 | 0 | 12 | 1 | 11 | 1 | 8 | 1 | 10 | 2 |
| 7 | Deciduous needleleaf forest | 10 | 3 | 9 | 3 | 9 | 3 | 7 | 1 | 8 | 1 |
| 8 | Wood savanna | 12 | 0 | 12 | 0 | 12 | 0 | 12 | 0 | 4 | 1 |
| 9 | Cropland | 12 | 1 | 12 | 1 | 12 | 1 | 9 | 3 | 6 | 4 |
| 10 | Rice paddy | 12 | 0 | 12 | 0 | 12 | 0 | 11 | 2 | 7 | 2 |
| 11 | Grass/crop | 10 | 2 | 11 | 2 | 10 | 2 | 8 | 3 | 8 | 2 |
| 12 | Cold grassland | 12 | 0 | 12 | 0 | 12 | 0 | 8 | 3 | 4 | 1 |
| 13 | Low sparse grassland | 9 | 3 | 9 | 3 | 9 | 3 | 4 | 2 | 6 | 2 |
| 14 | Shrubland | 7 | 2 | 6 | 2 | 5 | 3 | 1 | 1 | 3 | 1 |
| 15 | Semi desert | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 0 |
| 16 | Bare desert | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |

with lower biomass; for example, plot C represents low NDVI values throughout the year demonstrating the locations of desert forms, which have a low precipitation value but high evapotranspiration value.

*LGP estimations*

The mean LGP estimations for diverse vegetation types in Monsoon Asia by using remote sensing and climate approach are shown in Table 1. They have a different conclusion of the LGP value among the methods. However, in general the dense canopy, such as tropical rain forest has the longest result (12 months), while the rare canopy on the other hand, such as bare desert has the shortest. It is easy to recognize that the LGP is longest when the canopy is green along the year, and vice versa.

From Table 1, the LGP value from Henricksen and Durkin (1986), Lloyd (1990) and Justice *et al.* (1985) and Fischer (1994) show an over estimated value since there is no differences between dense and rare canopies.

In addition, the estimation by using climate data, the LGP found here principally used only the climate data without the vegetation information; therefore the result is an under estimation for forests region, but an over estimation for un-vegetated area. Based on that reasoning, the threshold value of Markon *et al.* (1995) was used to determine the LGP over Monsoon Asia region.

## Conclusions

This study has estimated the LGP for various vegetation types in Monsoon Asia based on satellite and climate data. We found that the LGP for each vegetation types are as follows: the longest LGP (12 months) is distributed in dense canopy such as tropical rain forest, tropical seasonal forest, sub tropical, and evergreen forest. In spite of this, the deciduous forest has LGP less than 12 months, due to the influences of the winter season. For cropland, the LGP ranged from 6 to 12 months. The rice paddy has 8 to 12 months in a year because of the irrigation supplement. For the other rare canopies like shrubland and grassland, we noted that its LGP ranged 2 to 7 months. And the desert area showed no LGP throughout the year.

This study has attempted to clearly demonstrate that the LGP differ for the diverse vegetation types in Monsoon Asia. However, we believe that further research could be necessary to improve the outcome of this research by using a shorter period (7 or 10 days) of remote sensed and climate data.

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