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IMPACT OF LAND COVER CHANGES ON ACTUAL EVAPOTRANSPIRATION

DAMPAK PERUBAHAN PENUTUPAN LAHAN TERHADAP EVAPOTRANSPIRASI AKTUAL

Eleonora Runtunuwu
Indonesian Agroclimate and Hydrology Research Institute
Jln. Tentara Pelajar No. 1 A Bogor 16111
runtunuwu2001@yahoo.com

ABSTRACT

This paper presents an attempt to investigate the changes on land cover that have occurred due to human activities and its impact on actual evapotranspiration, E_a , in Monsoon Asia. Comparison between current and potential vegetation classifications has been done to identify the impact of human activities on land cover distribution. The current vegetation was obtained from satellite data, while the potential vegetation was defined from climatic data. As a result of comparison of the both vegetation maps, we realized that India, and China were as the center of land cover changes. This also appears in tropics region, such as Indonesia and Malaysia. In general, the type of changes is from forest to non-forest such as, paddy field, cropland and grassland. These anthropogenic changes caused the decreased up to 180mm or 12% per year. The 0 value indicates such area where the has no changed, while the positive value indicates the of current condition has been decreased from potential one. The lower value (less than 5%) was happened when evergreen broadleaf forest (seasonal) changed to rice paddy such as in Shandong (China). It also occurred in Punjab and Uttar Pradesh (India) when the subtropical rain forest has been changed to cropland. In addition, when the sub tropical rain forest changed to rice paddy, such as in Assam (India) and Guangxi, and Guangdong (China), thewas decreased by 9%. The highest decreased value (12%) was occurred when the tropical rain forest was changed to rice paddy such as in Kalimantan Selatan (Indonesia) and Pahang (Malaysia).

Keywords : land cover changes, actual evapotranspiration, Monsoon Asia.

ABSTRAK

Tulisan ini memaparkan perubahan penutupan lahan akibat kegiatan manusia serta dampaknya terhadap perubahan evapotranspirasi actual,, di Monsun Asia. Perbandingan antara vegetasi aktual dan potensial menjadi indikator dampak perubahan lahan akibat kegiatan manusia. Kondisi vegetasi akual diidentifikasi dengan menggunakan citra satelit, sedangkan vegetasi potensial ditentukan dengan menggunakan data iklim. Dengan membandingkan distribusi vegetasi potensial dan aktual, perubahan banyak terjadi di India, China, Indonesia dan Malaysia dengan perubahan dominan dari hutan ke non hutan. Perubahan ini ternyata mengakibatkan penurunan sampai 180mm atau 12% per tahun. Penurunan sebesar kurang dari 5% teridentifikasi di daerah yang mengalami perubahan dari *evergreen broadleaf forest* ke padi sawah ataupun dari hutan subtropikal menjadi lahan pertanian, seperti yang terjadi di Shandong (China), Uttar Pradesh (India). Penurunan mencapai 9% teridentifikasi pada saat hutan sub tropis berubah menjadi padi sawah, seperti yang terjadi di Assam (India), serta Guangdong dan Guangxi (China). Penurunan tertinggi sebesar 12% terjadi pada saat hutan tropis berubah menjadi padi sawah seperti yang terjadi di Kalimantan Selatan (Indonesia) and Pahang (Malaysia).

Kata kunci : perubahan penutupan lahan, evapotranspirasi aktual, Monsun Asia.

INTRODUCTION

Knowledge of the impact of anthropogenic activities on evapotranspiration is important in global change research since this parameter is essential to the hydrological and climatic processes between the earth and atmosphere, which are performed by heat and water balance equations. Relating to study of the land cover change and its impact on hydrologic changes especially for evapotranspiration parameter has been seriously observed, as reported by Running *et al*. (1996): Dickinson and Henderson-Sellers in 1988 simulated the Amazon basin with full forest cover, and then replaced with grasslands. The degraded grasslands reduced evapotranspiration so much that surface temperatures were predicted to increase by 3-5 °C; Walker *et al*. *in* 1995 found that precipitation had been reduced by 1.2 mm day^{-1} due to reductions in evapotranspiration of 18% by land cover changes.

Following those research evidences, the purpose of this study is to investigate the land cover changes that have occurred due to human activities and its impact on actual evapotranspiration in Monsoon Asia (-20 °S -60 °N, 60 °E-160 °E).

METHODOLOGY

To allow for land cover and E_a comparisons, the method was defined in two ways (Figure 1). The first is the current vegetation procedure that indicates the current vegetated surfaced determined with satellite data. The second way is potential vegetation that exists the vegetation distribution without human disturbance determined with climatic data.

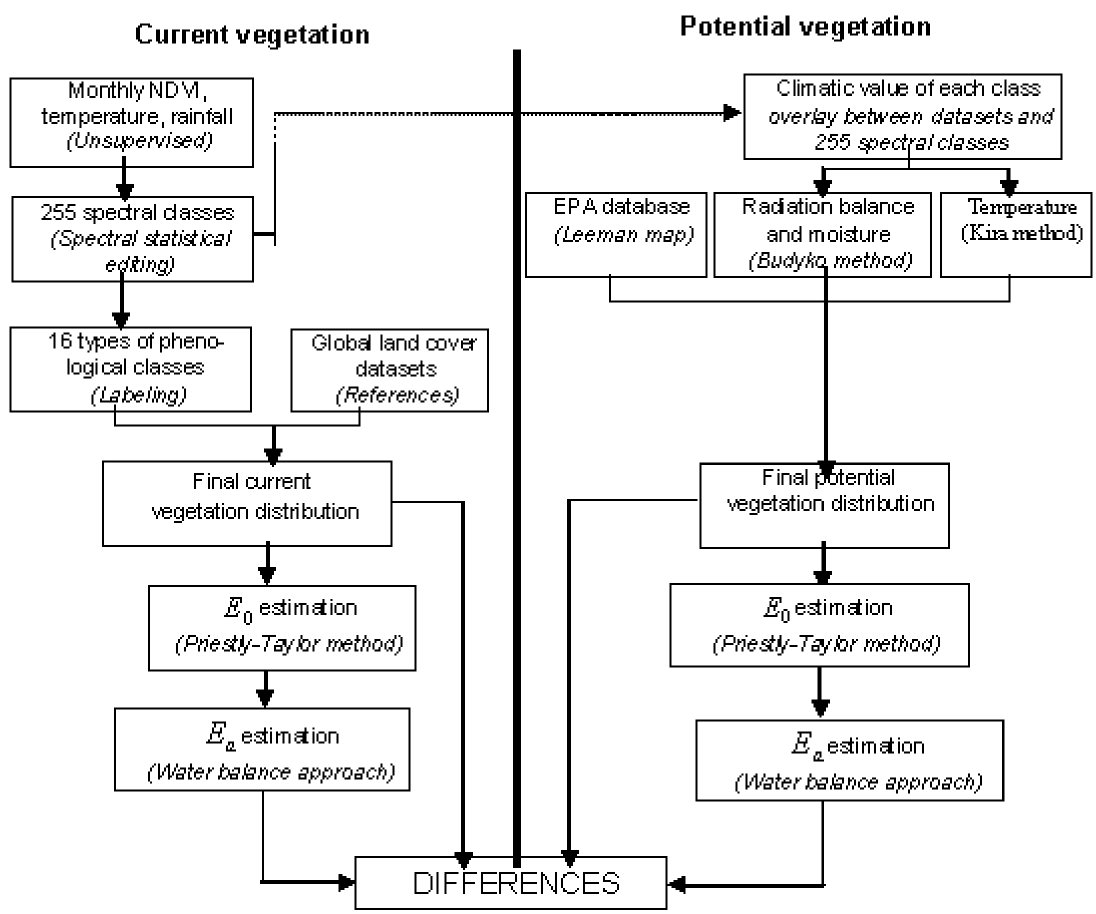

Figure 1. Schematic procedures used on this study

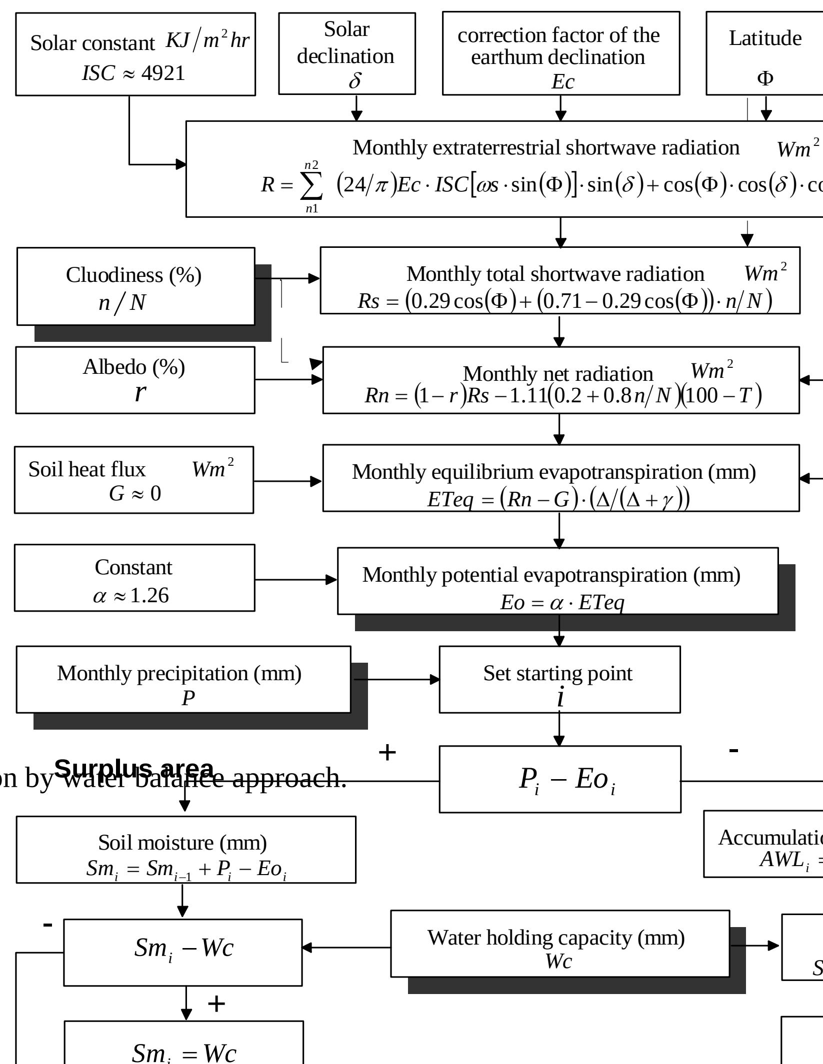

Figure 2. A flow chart for monthly E_a computation by water balance approach.

Solar radiation in the visible and near-infra red wave bands reflected by the Earth's surface and collected by remote sensing, can be combined into a spectral vegetation index such as the Normalized Difference Vegetation Index (NDVI) and related to the physical properties of the vegetation (Runtunuwu and Syahbuddin, 2005, and Runtunuwu, 2006). However, in this study, the NDVI combined with the climatic data, since the differences in climatic condition are able to show either the latitudinal or longitudinal variations associated with the distribution of vegetation. Detail procedure of the current vegetation classification could be referred to Runtunuwu, *et al*, (2000), and Runtunuwu (2005).

Potential vegetation classification

By assuming the same phenology class resulted from previous step will have the same hydrological function, the temperature, cloudiness, precipitation, radiation, humidity index, as well as elevation of each class have been extracted from available ground-based global datasets. These extracted climatic data were applied to determine the distribution of potential vegetation by using Kira (1945) and Budyko (1974) methods. The two maps resulted were then compared with Leemans (1990) map to conclude the potential vegetation.

Actual evapotranspiration estimation

Because of the limited of available spatial climatic data, the monthly potential evapotranspiration, E_0, in this study was calculated by using Priestly-Taylor method (1972). The result of monthly E_0 analysis has been used together with monthly precipitation and soil water holding capacity (W_c) on the next step to calculate E_a as shown in Figure 2 and the detail could be referred to Thornthwaite and Mather (1957) and Kondoh *et al.* (2004).

Datasets

To achieve the goal, the data used in this study as following: (a) NDVI data: Time Series of 0.144^o Global Monthly Vegetation Cover from NOAA/AVHRR CD-ROM Ver. 1.0. The NOAA reflectance measured from Channel 1 (visible: 0.58 - 0.68 microns) and Channel 2 (near infrared: 0.725 - 1.0 microns) are used to calculate the NDVI: NDVI = (Ch2-Ch1)/(Ch2+Ch1); (b) Climatic data: CRU05 0.5 Degree 1901-1990 Mean Monthly Climatology and CRU05 0.5 Degree Monthly Climate Time-Series (1901-1995), Ver.1. April 1999; (c) Albedo: Global Ecosystem Database, NOAA/NGDC and EPA, Disc A, 1992; (d) Elevation: Global Land One-Kilometer Base Elevation (GLOBE) Digital Elevation Data, NOAA/NGDC, Ver. 1.0 1998; and (e) Bowman soil water holding capacity: UNEP/GRID-Geneva (http:www-cger.nies.go.jp/grid-e).

RESULTS AND DISCUSION

Land cover changes

Figure 3a and Figure 3b show the distribution of current vegetation and potential vegetation respectively, that could be divided into 16 vegetation types. Areal estimates of current and potential vegetation on the same class have been compared in Figure 4 to indicate which ecosystems have been modified by human activities. The largest focus of the alteration as was expected to be in almost the whole area of India and some parts of China. This also appeared in Myanmar, Indonesia, Kazakhstan, and Pakistan. In other countries such as Papua New Guinea, Philippines, Korea, and Japan, also denoted a little modification.

Estimation of actual evapotranspiration

By applied the water balance approach (Figure 2) into 255 classes which resulted from unsupervised classification in Figure 1, the twelve monthly datasets of actual evapotranspiration maps were produced to obtain the annual value for before and after human activities. The E_a value is distributed following the distribution of vegetation type. The lowest values (around 150 mm per year) are distributed in wide desert area of Russia, China, Mongolia, and Kazakhstan. The equatorial zones are bounded tropical regions such as Indonesia, Malaysia, Philippines, Papua New Guinea were associated with the tropical forest with the highest values per year (more than 1600 mm per year).

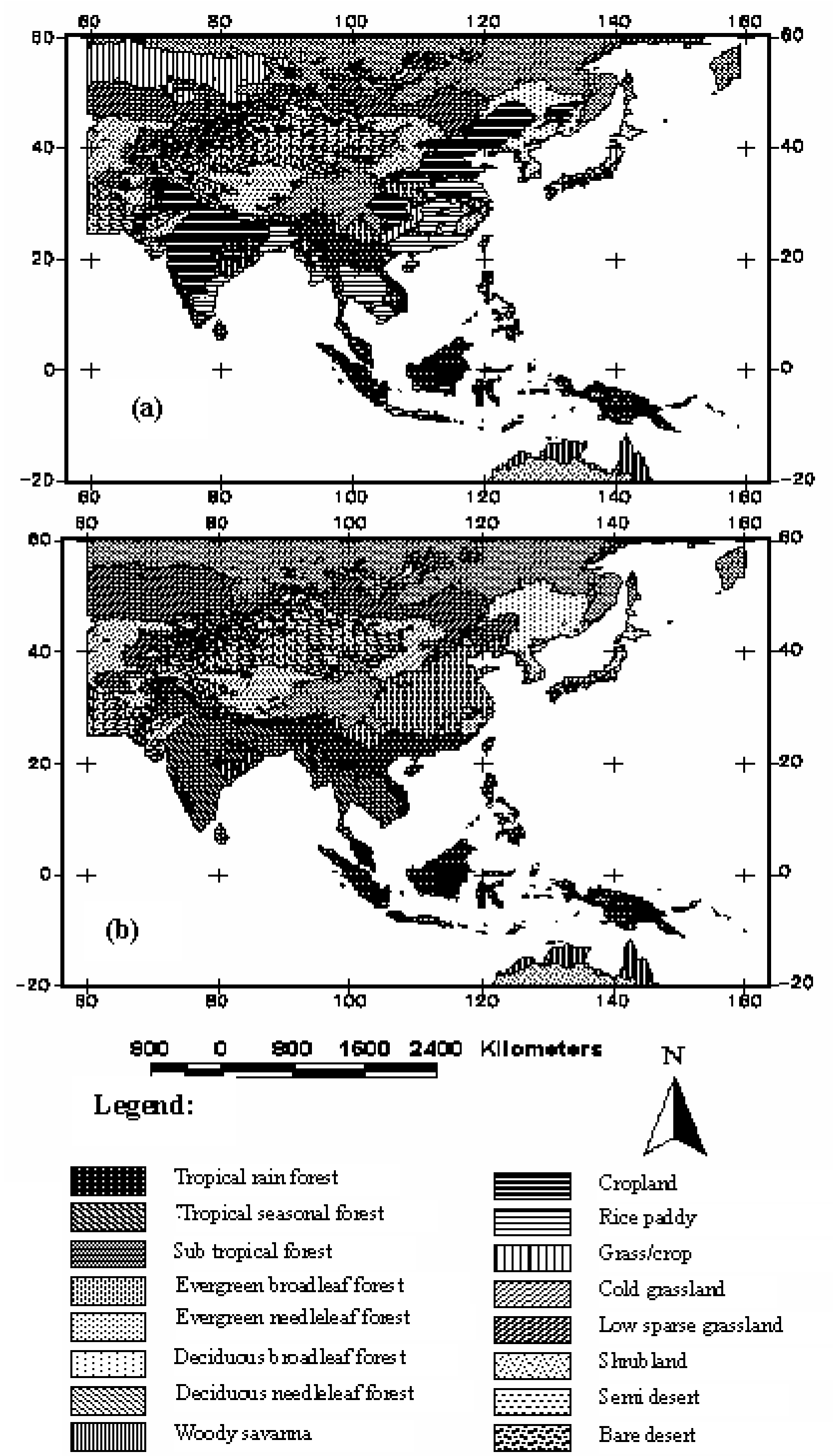

Figure 3. Distributions of (a) current and (b) potential vegetation in monsoon Asia.

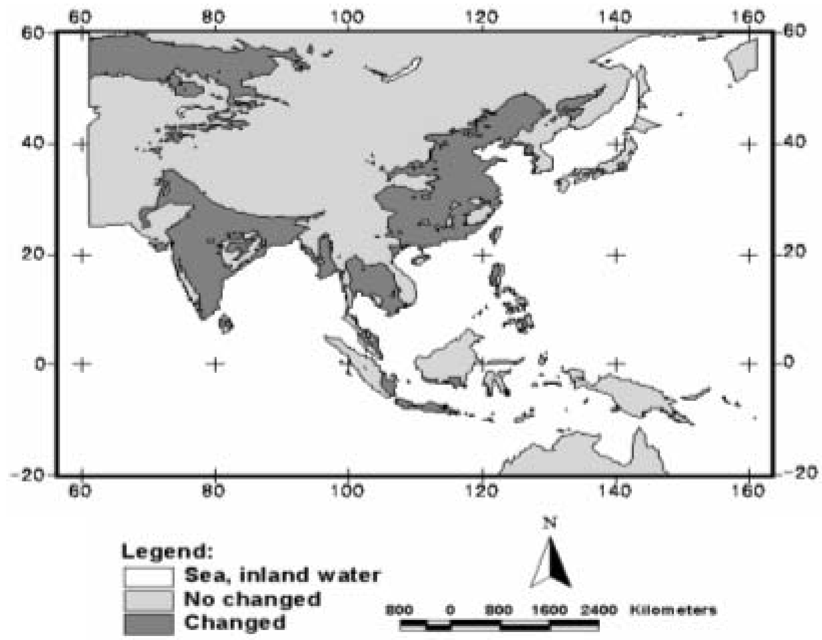

Figure 4. Land cover changes distribution

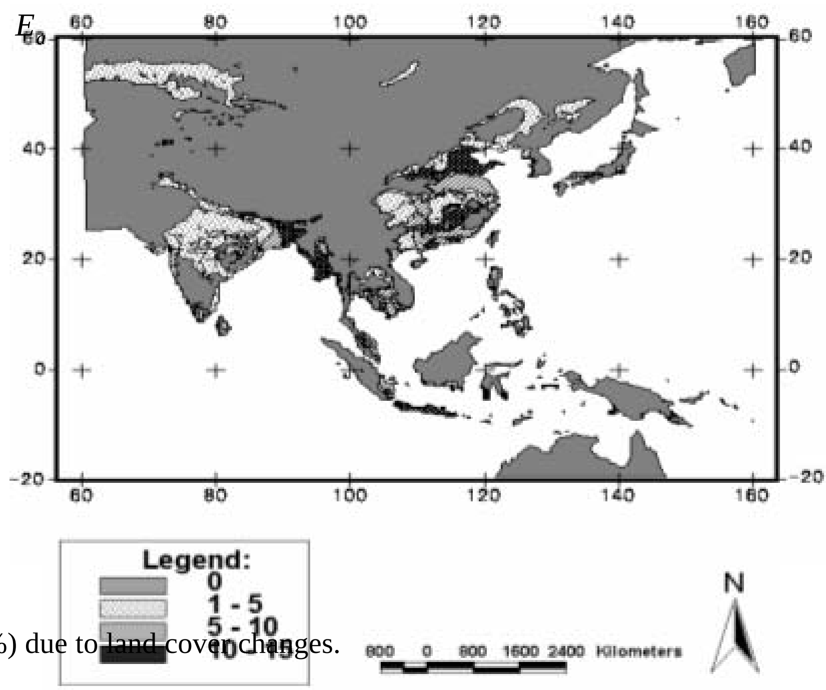

Figure 5. Changes of annual E_o (%) due to land cover changes.

Actual evapotranspiration changes

The amount of E_a changes between potential and current vegetations is 0 to 180 mm per year or 0 to 12% per year, as shown in Figure 5. The 0 value indicates such area where the has no changed, while the positive value indicates the of current condition has been decreased from potential one. The highest value (12%) was occurred when the tropical rain forest was changed to rice paddy. The decreased by 9% was happened when the sub tropical rain forest changed to rice paddy. The tropical rain forest which has been changed to cropland caused the decreased by 7% as well as the changed from tropical seasonal forest to rice paddy. The lower value (less than 5%) was happened when evergreen broadleaf forest (seasonal) changed to rice paddy. It also occurred when the subtropical rain forest has been changed to cropland.

Conclusion

This paper investigated the land cover changes over the Monsoon Asian region, which has indicated by comparing current vegetation as imaged by current phenology satellite against a hydroclimatic defined potential vegetation that would theoretically exist without human disturbance. By comparing those two yielded maps, we realized that India and China as the center of land cover changes. It also appears in tropics such as Indonesia, Kazakhstan, and Thailand. Some places in Japan, Korea and Mongolia were denoted that the cover changes also occurred but in a relative small area.

Based on E_a calculation, the changes of between current and potential vegetation is around 0 to 12% (180mm) per year. The 0 value indicates the area where the and land cover has no changed. The lower value (less than 5%) was happened when evergreen broadleaf forest (seasonal) changed to rice paddy. It also occurred when the subtropical rain forest has been changed to cropland. In addition, when the sub tropical rain forest changed to rice paddy, thewas decreased by 9%. The highest decreased value (12%) was occurred when the tropical rain forest was changed to rice paddy.

I consider that further research maybe necessary to improve the outcome of this research by using more accurate datasets and research methods in order to obtain better understanding concerning the anthropogenic land cover changes and its influences on water balance.

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