Identifying prevalent landcover conversion patterns in regions of different major developments

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Abstract
Landcover types in a region characterize the natural processes and anthropogenic activities of the region. Landcover types in a well-evolved region are expected to reach a stabilized prevalent landcover conversion pattern whereas landcover conversions in evolving regions are either random or fast changing. Understanding the prevalent landcover conversion pattern of a region is essential for landuse planning and resources management. In this study the ALOS images will be used to identify and compare prevalent landcover conversion patterns in three regions of different major developments (well-developed urban, developing urban, and agriculture) in Taiwan and two cities (Kyoto and Tokyo) in Japan. Major components of the proposed study include: (1) Landcover classification, (2) Determining an appropriate scale (or cell size) for landcover conversion evaluation, (3) Determining the characteristic variable which summarizes the landcover information in individual cells, (4) Identifying the prevalent landcover conversion patterns using the characteristic variable and distribution of cells in a multidimensional landcover space, and (5) Comparing and assessing the prevalent landcover conversion patterns in different regions..

Keywords: Landcover classification, remote sensing, landcover pattern.

1. INTRODUCTION

Rice cultivation through paddy irrigation has had a long history in eastern and southeastern Asia. Despite of its long history and relevant cultural aspect, such practices have been criticized for inefficiency of water utilization. However, in addition to rice production, there are also concerns about multifunctionality of paddy cultivation. An important and apparent function of paddy field is its capability of flood retention during the typhoon and monsoon seasons (Nakanishi, 2004; Unami and Kawachi, 2005). Other functions of paddy culture include recharge of groundwater (Greppi, 2004), air temperature cooling (Saptomo et al., 2004; Yokohari, et al., 1997 and 2001), removal of pollutants in irrigation water (Ishikawa et al., 2003; Nakasone, 2003), providing habitat for inhabitants (Fukuda et al., 2006), aesthetic landscape, and facilitating religious/cultural activities. However, quantitative evaluations of individual functions are difficult and rare due to lack of data and, in some cases, difficulty in determining what to measure.

Many major cities in Eastern Asia still have paddy fields within their close vicinities. Existence of such paddy fields provides many functions in urban areas. Yokohari et al. (1994, 1997 and 2001) conducted a series of studies on the temperature cooling effect of paddy fields in urban fringe areas of Tokyo using field measured land surface and air temperatures. For large study areas, it would be labor and time consuming to conduct field measurements. With the availability of many images from weather and land observation satellites, it seems beneficial and feasible to use remote sensing images to aid in similar studies. Therefore, the objectives of this study are to identify major landcover types in regions of different major developments and to compare their conversion patterns using remote sensing images of different study areas in Taiwan and Japan.

2. STUDY AREA AND DATA

2.1. Study area

Three areas in Taiwan and two cities in Japan of different development styles were chosen for this study. The three study areas in Taiwan include: (1) well-developed urban area – Taipei, (2) developing urban area – Chu-Bei, and (3) agriculture area – Chang-Hua county. The two cities in Japan are Tokyo and Kyoto. The former is a modern metropolitan area while the latter is a historical ancient city with many cultural heritages.

2.2. Data

Until present, only ALOS images of the two study areas in Japan are available. Five image sets acquired for this study are listed in Table 1.

3. METHODOLOGY

3.1. LULC classification

In order to identify landcover conversion patterns of individual study areas, it is necessary to conduct land-use/landcover (LULC) classification for each study area. This is done by applying the maximum likelihood classification and indicator kriging classification methods. Four major landcover types including (1) built-up area, (2) vegetated area, (3) water bodies, and (4) paddy fields are specified for LULC classification.

Table 1. Acquired Images

	Date of image acquisition	Sensor
Tokyo	May 21, 2006 November 21, 2006 Jan. 11, 2007 March 1, 2007	AVNIR-2
Kyoto	Oct. 9, 2006	AVNIR-2

3.2. Calculation of landcover coverage ratios

ALOS AVNIR-2 images have a spatial resolution of 10m. Identification of the landcover pattern in a region should be based on a scale much larger than the image resolution. In this study we adopt a base-cell of 1-km by 1-km as the basis of landcover pattern identification. The whole study area is thus divided into a group of 1 km^2 cells. Each base-cell may be composed of several different landcover types and the coverage ratios (CR) of individual landcover types within a base-cell were calculated.

3.3. Calculation of base-cell average NDVI

In order to demonstrate the effect of landcover changes, the average NDVI values within the spatial coverage of individual base-cells were calculated by the following equations:

$$NDVI(i) = \frac{IR - R}{IR + R} \qquad (1)$$

$$\overline{NDVI} = \sum_{i=1}^{K} NDVI(i) \qquad (2)$$

where *IR* and *R* are respectively image digital numbers of the near infrared channel and red channel, *i* is an index for pixels in ALOS AVNIR images, and *K* is the total number of pixels within a base-cell.

Samples of the study area in Tokyo and Kyoto are respectively shown in Figures 1 and 2.

4. DISCUSSION AND CONCLUSIONS

The LULC classification results of the Tokyo and Kyoto study areas are shown in Figure 3. Unlike the Kyoto study area, no paddy fields are present in the Tokyo study area and thus only three landcover types are specified. The variation of base-cell average NDVI with respect to coverage ratios of individual landcover types are demonstrated in Figures 4 and 5. It can be seen clearly that the base-cell average NDVI increases almost linearly with increase of coverage ratio of vegetated area, while it decreases with increase of coverage ratio of built-up area for both study areas.

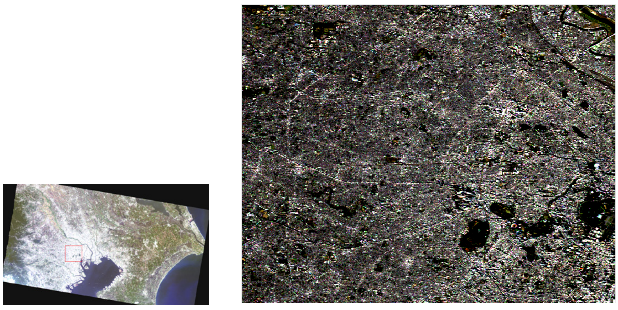

Figure 1. Image of the Tokyo study area.

Figure 2. Image of the Kyoto study area.

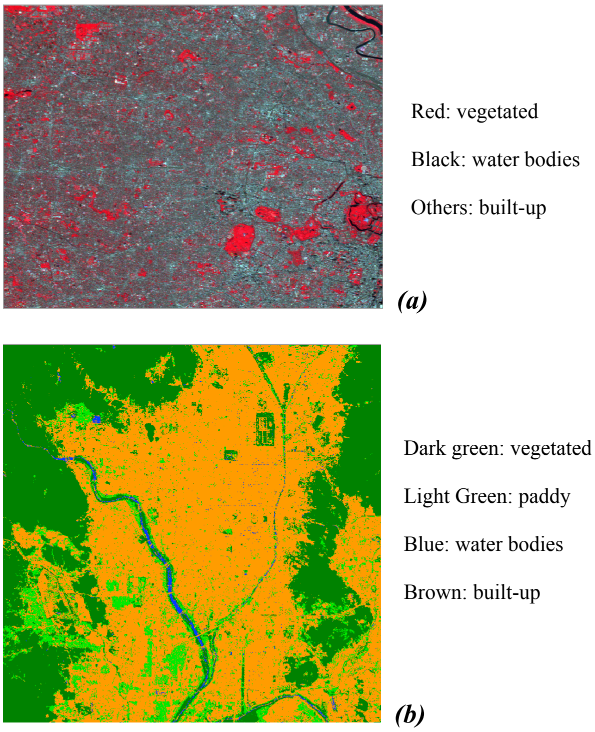

Figure 3. Results of LULC classification (a) Tokyo, (b) Kyoto.

It can also be observed that correlation coefficients of the linear relationships between the base-cell average NDVI and the coverage ratios of individual landcover types are much higher in the Tokyo study area (with $r^2 > 0.83$). It reflects the relatively low variability of coverage ratios for both built and vegetation classes, with respect to a fixed base-cell average NDVI value. Such result suggests a relatively homogeneous landcover condition in the City of Tokyo. In contrast, the lower correlation coefficients of the linear relationships (or the relatively higher variability of coverage ratios for both built and vegetation classes with respect to a fixed NDVI) in the Kyoto area suggest that landcover conditions in Kyoto are more diversified, as compared to Tokyo. The landcover conversions in the chosen study area in Tokyo are almost exclusively between the built-up and vegetated landcover types. However, the landcover conversions in Kyoto study area are more diversified. The conversion between vegetation and paddy fields seems to occur in the urban fringe of the city.

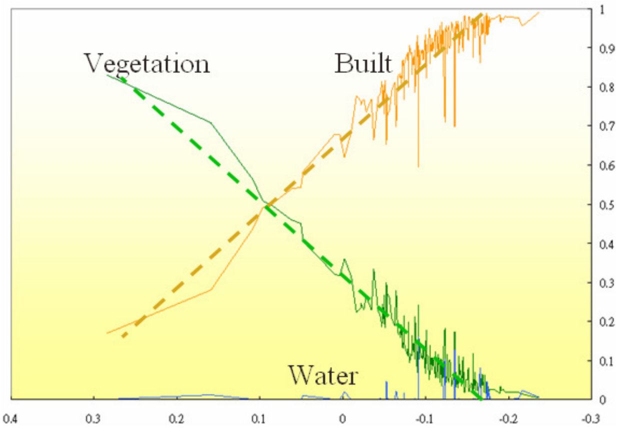

Figure 4. Relationships between base-cell average NDVI and coverage ratios of individual landcover types – Tokyo.

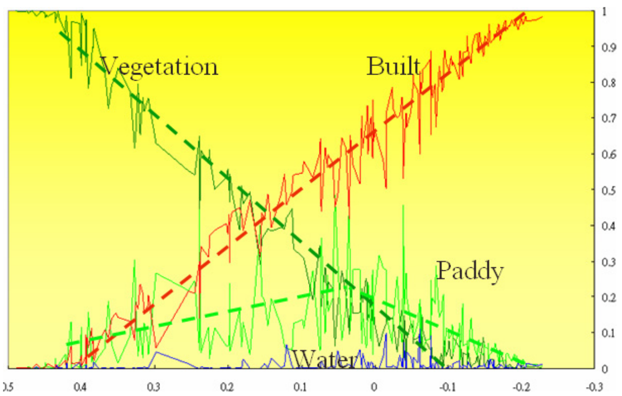

Figure 5. Relationships between base-cell average NDVI and coverage ratios of individual landcover types – Kyoto.

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