# Land Cover Change Detection: A Spatio-Temporal Study of Kangnung, South Korea

O Asif Ahmed SHAIKH Student Member Graduate School of Science and Technology, Nagasaki University
Kaoru TACHIIRI Member Department of Civil Engineering, Nagasaki University
Keinosuke GOTOH Member Graduate School of Science and Technology, Nagasaki University

## 1. Introduction

Land cover type is the most important surface parameter, from both scientific and management viewpoints. From the scientific perspective, land cover influences the mass and energy exchanges between the surface and the atmosphere (energy, carbon dioxide and other greenhouse gases) and thus influences local/global weather and climate. Land cover is also a primary determinant of land use and of land management activities. Satellites offer the unique new capability of obtaining land cover information over large areas and at specific time periods. Due to the strong influence of vegetation on the satellite measurements, land cover and its changes can be tracked in a systematic manner. Since satellites offer flexibility in spatial resolution, the coverage and level of detail can be adjusted so that the information is obtained in an optimum manner.

In South Korea, typhoons cause the profound impact on the way of living and regional socio-economy. Determination of risk areas and land cover analysis of affected areas are needed not only for flood warning but also for rehabilitation works. In the year 2002, a typhoon called RUSA hit the Republic of Korea, bringing torrential rain, floods, and landslides in the east and south of the country. It, along with the typhoon Maemi in 2003, is reportedly the most powerful typhoon to hit the country since 1959. The coastal city of Kangnung, about 250 km east of Seoul, suffered the worst damage. 17,046 homes were submerged or damaged, more than 200 people were reported dead, 33 ones missing and 27,474 ones left homeless. Typhoon RUSA also badly affected the agricultural and forestland in and around Kangnung City and therefore changes the land covers of the area.

## 2. Objective of the Study

The main objective of this study is to analyze the land cover changes in and around Kangnung City, South Korea from 1992 till 2003.

## 3. Data Analysis and Study Area

The present study is focused on the coastal city of Kangnung, about 250 km east of Seoul, South Korea. Kangnung City is located in the center of Youngdong Province, on the east coast of the Korean Peninsula, including a range of mountains on its western border. The city has an area of 76 km$^2$ and a population of 173,100 (year 2002). More than 81% of the area comprises of forests. Average temperature and precipitation of Kangnung are 12.5°C and 1,282mm[1].

In this study, we acquired one image of Landsat 5 TM and two images of Landsat 7 ETM+ data from May 19, 1992 to May 10, 2003 (a time series of observations), which covered Kangnung City. The selection of satellite images was based on availability of high-quality satellite imagery with minimal cloud coverage. However, some exceptions to the above criteria were made in order to get a satisfactory temporal coverage. One Landsat ETM+ image acquired on 2003.5.10 was found with cloud cover. This caused some difficulties in the interpretation of the latest data.

## 4. Methodology

All images processing was performed using ERDAS Imagine 8.5 on a Windows 2000 PC desktop. The May 19, 1992 image was orthorectified to the May 25, 2000 image. Orthorectification was accomplished using 20 ground control points, producing a 0.43 pixel root mean square error (RMSE).

Classification of satellite image can be considered as the process of pattern recognition or identification of the pattern associated with each pixel position in an image in terms of the characteristics of the objects or materials those are present at the corresponding point on the Earth's surface [2]. In order to classify the satellite images, we adopted unsupervised spectral clustering method. In classification process, we used unsupervised Isodata clustering algorithm [3] on the subset image of original satellite image. We used all available bands for the classification purpose. The resultant classified images reflect the vegetation cover and the state of environments within the study area.

In an effort to monitor major fluctuations in vegetation and map the density of green vegetation over the study area we calculated the Normalized Difference Vegetation Index (NDVI). NDVI is calculated from the visible and near-infrared light reflected by vegetation [4]. Healthy vegetation absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light [5].


Fig. 1 The study area, Kangnung, South Korea
(http://www.learningenrichment.org/wc_sou_map.html)

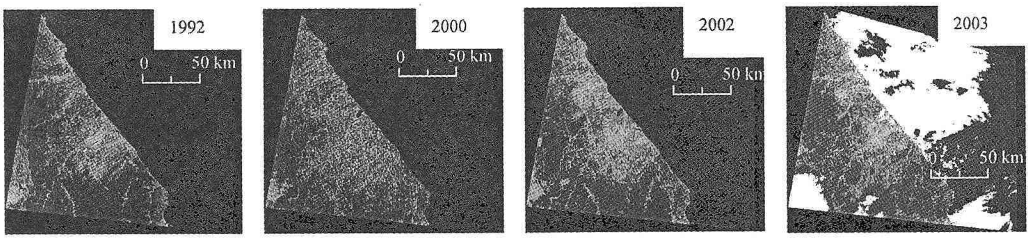
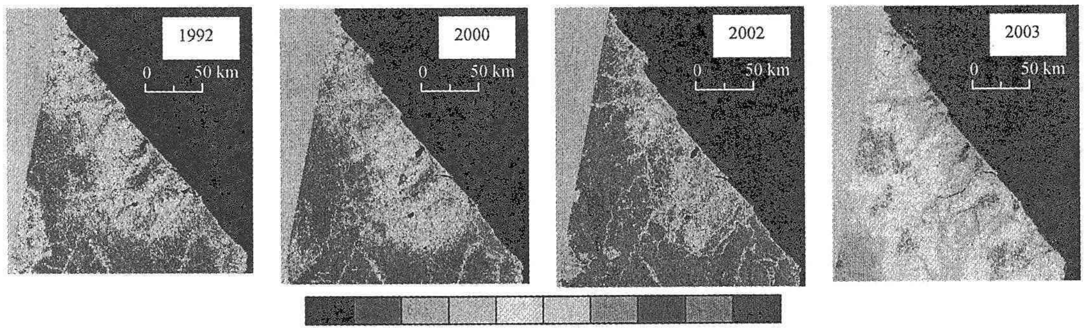



Fig. 2 Results of land classification
Kangnung City, South Korea

| Class Name | Color | Class Name | Color | Class Name | Color |
|---|---|---|---|---|---|
| Water | | Rangeland | | Agricultural Land | |
| Forest | | Urban & built-up Land | | Barren Land | |




Minus values 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Color Code

Fig. 3 NDVI results of Kangnung, South Korea

Table 1. Statistical result of Land Cover Change in/around Kangnung City, South Korea

| Area in $km^2$ | 1992/5/19 | 2000/5/25 | 2002/5/23 | 2003/5/10 |
|---|---|---|---|---|
| Agricultural land | 107.3 | 122.4 | 99.4 | 65.9 |
| Forestland | 299.2 | 261.4 | 250.5 | 288.3 |
| Urban and built-up land | 72.7 | 115.0 | 129.4 | 76.2 |

## 5. Results and Discussion

The results obtained after analyzing satellite images show a decreasing tendency towards agricultural land in and around Kangnung City. It has been noticed that the agricultural land is sharply decreased after the catastrophic event of typhoon Rusa in the year 2002. The agricultural land in the vicinity of Kangnung City was 99.4 $km^2$ in year 2002 that reduced drastically after the disastrous event of typhoon Rusa. Although the result shows the area of agricultural land in the year 2003 as 65.9$km^2$, we interpret that it is not the actual figure. Cloud cover is noticeably seen in the satellite image of year 2003. Although a great part of the cloud cover is over sea surface but a portion of it is covering the land surface area, measuring almost 49$km^2$. After comparing cloud covered areas in the image of year 2003 with that of year 2002, which is cloud free, we assume that 25% of cloud cover over land surface area i.e. 12.2$km^2$ is actually agricultural land, making total agricultural land as 78.1$km^2$ in the year 2003. It shows the decrease of 21.3$km^2$ in agricultural land from year 2002 to year 2003.

**References**

[1] Korean Local Authorities Foundation for International Relations. http://www.klafir.or.kr

[2] Mather, P. M., 1999, *Computer Processing of Remotely Sensed Images-An Introduction*, John Willy & Sons, Toronto. PP. 70-75, 75-89, 139-146.

[3] Duda, R. O. & Hart, P. E. 1973. *Pattern Classification and Scene Analysis*. New York, NY: Wiley and Sons

[4] Choen Kim and Kwang-Hoon Chi, 1998, Flood damage mapping in North Korea using multi-sensor data, *The 19th Asian Conference on Remote Sensing, Manila, 16-20 November 1998.*

[5] Hans Tommervik, Kjell Arild Hogda, Inger Solheim, 2003, Monitoring vegetation changes in Pasvik (Norway) and Pechenga in Kola Peninsula (Russia) using multi-temporal Landsat MSS/TM data, *J. Remote Sensing of Environment*, 85:370-388.