Land surface change detection in Nagasaki and Kangnung using multi-temporal Landsat data

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Abstract: Land cover change has been recognized as one of the most important factors influencing the occurrence of rainfall-triggered landslides. Satellite remote sensing provides detailed information regarding the spatial distribution and extent of land cover/use changes. This study describes the land cover changes in Nagasaki City, Japan and Kangnung City, South Korea. The former has been suffered from rainfall-triggered disasters for long term and latter was damaged by Typhoon Rusa in 2002. The results obtained from both study areas clearly show that land cover changes have occurred in the last decade as a result of both natural forces and human activities.

Keywords: Remote Sensing, Land Cover, Natural Disasters.

1. Introduction

Changes in vegetation cover are amongst the more obvious of the alterations that mankind or natural forces has caused to the global environment. For many reasons, the detections and monitoring of vegetation cover dynamics is highly desirable. Satellite remote sensing methods, which can be used to monitor very large areas in a reasonably short period of time, have notable potential for monitoring land cover changes.

Natural disasters are inevitable and it is almost impossible to fully recoup the damage caused by the disasters. The increase availability of Remote Sensing data during the last decades has created more opportunities for a more detailed and rapid analysis of natural hazards.

Japan and Korea are located in an area of several crustal movements. Both the islands are located within the monsoon zone and receive abundant rainfall. Coupled with early summer rainy spells and later typhoons. Recent disasters in above two countries include torrential downpours in Nagasaki in 1982; disasters from typhoon No. 19 in Sept. 1991 that hit Nagasaki Pref., Typhoon Saomai in 2000, Typhoon Rusa in 2002, and many others. Human causalities from these disasters include 66 deaths along with 777 persons wounded in 1991 event, 213 casualties and 33 missing in 2002. Among them, the tragedy of 1992 was devastating. Hundred of people died and many became homeless due to ruinous event of disaster and afterwards land sliding.

Typhoon Rusa stroked the Republic of Korea during in August 31, 2002 to September 1, 2002, bringing torrential rain, floods, and landslides in the east and south of the country. Packing winds of up to 120 miles per hour, Rusa was the most powerful hurricane to strike the Korean Peninsula since Typhoon Sarah in 1959. The coastal city Kangnung, about 250 km east of Seoul, suffered the worst damage. 17,046 homes were submerged or damaged and hundreds of acres of farmland were destroyed.

2. Site Description

Case study areas include Nagasaki City, Japan and Kangnung City, South Korea. Nagasaki City is located at the western extremity of the Japanese archipelago and has a land area and population of 241.2km^2 and 426,500 (year 2000). Only 10% of the land area is “flatland” and 58% of the total area is comprised of forests. Nagasaki has annual temperature and precipitation of 16.6 Celsius and 2,000mm, respectively. Kangnung City is located in the center of Youngdong area, 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 and 1,282mm.

2. Data and Methods

1) Remote Sensing Data

In this study, we have used 5 images of Landsat 5 TM and 2 images of Landsat 7 ETM+. Details on satellite, sensor, acquisition date, and locations are given in Table 1. Three images of Landsat 5 were used for analysis of Nagasaki City, while four images, two Landsat5 and two landsat 7, were analyzed to detect the land cover changes of Kangnung City. For the purpose of temporal land cover change detection; remotely sensed data were obtained in the same month, i.e. May, of 1986, 1992 and 2000, 2002 and 2003.

The selection of satellite images was based on the following ideal criteria:

1. Availability of high-quality satellite imagery with minimal cloud coverage;
2. Similarity in annual precipitation patterns;

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 used for the analysis of Kangnung City was found with cloud cover. This caused some difficulties in the interpretation of the latest data.

2) Preprocessing of the Satellite Data

With constraints such as spatial, spectral, temporal and radiometric resolution, relatively simple remote sensing devices can not record well the complexity of the earth's land and water surfaces. Consequently, error creeps into the data acquisition process and can degrade the quality of the remotely sensed data collected. Therefore, it is necessary to preprocess the remotely sensed data before the actual analysis. Radiometric and geometric errors are the most common types of errors encountered in remotely sensed imagery.

The TM satellite images were geo-referenced to the UTM map format by locating approximately 20 points in each image and reference map. The geometric registration accuracy (root mean square) was within one pixel. While correcting the data geometrically, nearest-neighbor re-sampling method was used.

3) Classification of the Satellite Data

The images were classified with common and popular unsupervised, Iterative Self-Organizing Data Analysis Technique (ISODATA) classification algorithm. The ISODATA clustering method uses spectral distance as in the sequential method, however iteratively classifies the pixels, redefines the criteria for each class, and classifies again, so that the spectral distance patterns in the data gradually emerge. ISODATA is iterative in that it repeatedly performs an entire classification and recalculates statistics. Self-Organizing refers to the way in which it locates clusters with minimum user input. The ISODATA method uses minimum spectral distance to assign a cluster for each candidate pixel.

In the classification process, initial number of classes was selected to be 12 that later on reduced to 5 and 3 classes for Nagasaki City and Kangnung City analysis respectively. All 12 classes from the unsupervised classification phase were interpreted using color composites, geological maps, aerial maps, and other sources of information.

Table 1. Satellite data applied in the study

Satellite	Sensor	Acquisition date	Location
Landsat 5	TM	1986-05-12	Nagasaki City, Japan
Landsat 5	TM	1992-05-12	Nagasaki City, Japan
Landsat 5	TM	1992-05-19	Kangnung City, South Korea
Landsat 5	TM	2000-05-02	Nagasaki City, Japan
Landsat 5	TM	2000-05-25	Kangnung City, South Korea
Landsat 7	ETM+	2002-05-23	Kangnung City, South Korea
Landsat 7	ETM+	2002-05-10	Kangnung City, South Korea

3. Results

1) Land Cover Change in Nagasaki City

From the over all result of the area, it is visible that forestland is decreasing and urban land and agricultural land is increasing. Urban land is constantly showing its tendency towards increasing from 1986 till 2000; on the other hand, Agricultural and Barren Land decreased from 1986 till 1992 and then started increasing from 1992 till 2000.

Referring to the City Statistics, managed agricultural land has decreased for more than 15 years. The decrease in the agricultural area since year 1986 till year 2000 shows the difference of 22.2km^2. On the other hand, the forestland seems to be short. We interpret that part of the forestland is classified into the agricultural land in 1986. The results of ISODATA classification of Nagasaki City are presented in Figures 1. The calculated areas of each land cover are shown in Table 2.

2) Land Cover Change in Kangnung City

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 show the area of agricultural land in the year 2003 as 65.9151km^2, but we assume 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 49km^2. After comparing cloud covering 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. 12.2km^2 is actually agricultural land.

Statistics also illustrate an increasing tendency towards Urban and built-up land from 1992 till 2002. We presume that clouds have covered almost 60% of the urban land in the satellite image of year 2003. After adding that 60% cloud covered area, the urban area comes to 105.56km^2 in year 2003 in comparison to 129.42km^2 in the year 2002.

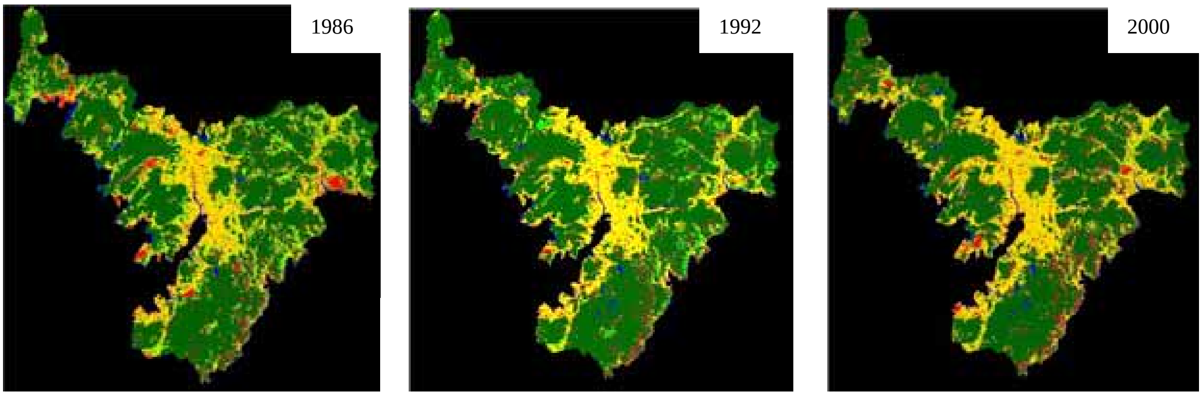

Fig. 1. Land classification results of Nagasaki City, Japan

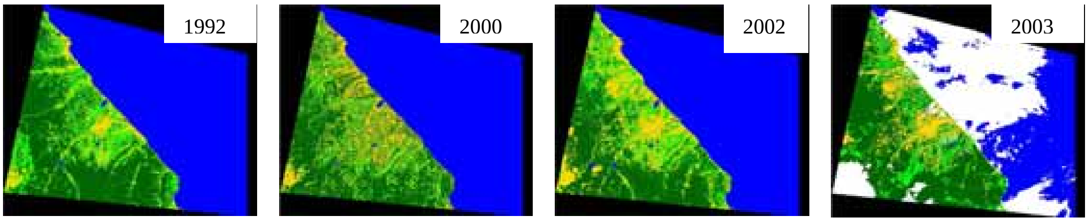

Fig. 2. Land classification results of Kangnung City, South Korea

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

Table 2. Statistical result of Land Cover Change in Nagasaki City, Japan

Area in km^2	1986/5/12	1992/5/12	2000/5/2
Water	4.0	**3.4**	**3.5**
Forest & Agricultural Land	**166.4**	**156.3**	**150.1**
Rangeland	**28.1**	**28.2**	**29.2**
Urban Land	**33.3**	**49**	**52.2**
Barren Land	**9.5**	**4.3**	**6.2**

Table 3. Statistical result of Land Cover Change in 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

4. Conclusion

The results of the study leads to the conclusions:

1. The construction of new towns in Nagasaki City has significantly changed the agricultural land of those areas into urban land.

2. In Kangnung City, largely due to Typhoon Rusa, agricultural land is badly affected and probably converted into forestland.

In-depth research on land cover change in Kangnung City is still going on.

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