Land Cover Change of Nagasaki City Associated with Natural Disasters by Using Remote Sensing Techniques

by

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ABSTRACT:

Natural disasters are inevitable and it is almost impossible to fully recover the damage caused by the disasters. However, it is possible to reduce the potential risk by developing disaster early warning strategies and to help in rehabilitation and post disaster reduction. Remote sensing technology has efficiently proven its usefulness, not only monitoring the disastrous events, but also to provide accurate and timely information well before the occurrence of disaster. This paper describes an analysis of land cover changes between 1986 and 2000, that have occurred in Nagasaki City over the past few decades. For this purpose, Nagasaki City was studied using Thematic Mapper (TM) data acquired by Landsat-5. Common and reputable unsupervised classification method, Iterative Self-Organizing Data Analysis Technique (ISODATA) is used. From the over all result of study area, it is visible that regetated area is decreasing and urban land is increasing. This trend is especially clear in detailed analysis of typically developed areas as *Tagonoura, Koebaru* and *Kaminoshima.*

1. Introduction

Land cover change plays a vital role in regional, social and economic development and global environmental changes. Japan is located in an area of severe crustal movement, and is situated in one of the world's most seismically active regions. Therefore, it is prone to all types of natural disasters such as earthquake or land sliding etc. According to the available statistics, only 25% of Japans' land area is flat and low lying with plateaus, so the Japanese people have suffered from numerous landslide disasters since ancient time (Table 1 and Fig. 1). For example, evidence of landslide failure has been unearthed from the site (Oshimo Shell Mound, Aso-Town, Ibaraki Pref.) in the middle to late of Jomon Period (3000-1000B.C.) and Nihon Shoki, written in 720, recorded numerous landslides and failures associated with the mega-earthquake (along the South Sea Trough) of November 29, 684.

Recent disasters include torrential downpours around Kumamoto and Nagasaki in 1972; disasters from typhoon No. 17 in 1976; torrential downpours in Nagasaki in 1982; disasters from typhoon No. 19 in Sept. 1991 that hit Nagasaki Pref., and many others. Human causalities from these disasters include 543 deaths in the 1972 event, 298 deaths in the 1976 event, 493 deaths in the 1982 event and 66 deaths along with 777 persons wounded in 1991 event. Among them, the

Table 1 Natural disasters in Japan (1901-2000) [1]

Disaster Type	Disaster No.	Killed	Injured	Homeless
Drought	1	0	0	0
Earthquake	52	164,700	39,974	300,312
Epidemic	3	1	0	0
Flood	37	11,516	693	618
Slide	18	841	88	0
Volcano	20	405	20	1,100
Wave/Surge	4	6,382	0	0
Wind Storm	103	33,631	5,581	1,688,015

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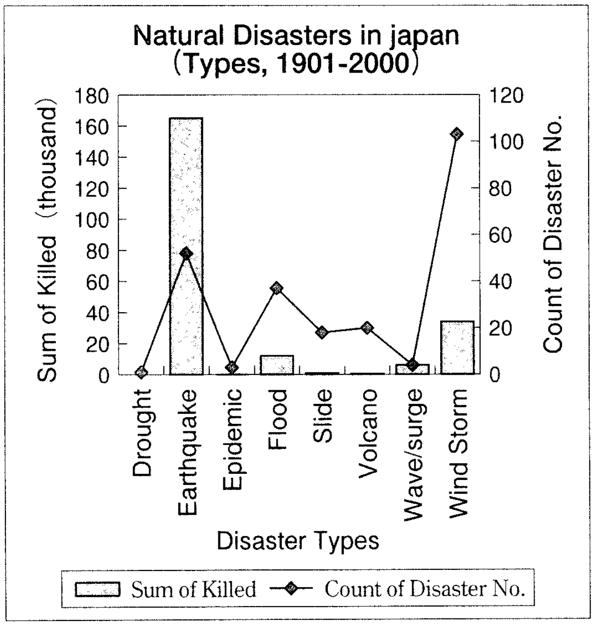

Fig. 1 Natural disasters in Japan (1901-2000) [1]

tragedy of 1992 was devastating [1].

The population density of Japan is 340.4 persons/km^2 (based on the 2000 census population of 126.92 million) [2]. However, the population density of low-lying areas and plateaus of Japan is 1,312 persons/km^2 indicating the severity of land use in Japan.

Landslides generally occur along gently to moderately sloping ground that is also important as these areas include residential and agricultural use. Because of these conditions, active efforts must be developed to protect the slopes from future land sliding and failures in Japan.

Now we can access information gathering and organizing technologies like remote sensing and geographical information systems (GIS), which have proven their usefulness in disaster management and monitoring. Using remote sensing data, such as satellite imageries and aerial photos, allow us to map the variability of terrain properties, such as vegetation, water and geology, both in spatially and temporally. Remote sensing also allows monitoring the event during the time of occurrence while the forces are in full swing. After the departure of disaster event, remote sensing can help to prevent the occurrence of such disasters again in future.

Land cover change in Nagasaki City is significant over the past few decades. The aim of this study is to obtain reasonable change information by land classification using multi-temporal Landsat TM data.

2. Study Area and Used Data

Nagasaki City was selected for analyzing land cover change. The population of Nagasaki City is 426,500 (year 2002) and land area is 241.2 km^2[3]. As other cities, this city includes land cover types of forest, grassland, urban and built-up land, agricultural land, wetland, etc. In the last few decades, due to natural disasters and urbanization, the land cover in this area has changed significantly.

For this study, aerial photographs of Nagasaki City and Thematic Mapper (TM) data acquired by Landsat-5 were analyzed by using ERDAS Imagine 8.5 software. The satellite data used are three scenes as shown in Table 2.

Table 2 The satellite data used in the study

Data Type	Number of bands	Acquisition Date
Landsat/TM	7	12 th May 1986
Landsat/TM	7	12 th May 1992
Landsat/TM	7	2 nd May 2000

3. Methodology

3.1 *Data acquisition and Image Preprocessing*

Seven banded remotely sensed data were acquired by TM on Landsat 5, having 5,965 lines and 6,920 pixels. The data used in this study were extracted as a sub-scene from the original dataset. 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.

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 commercial data provider has removed the radiometric and systematic errors of Landsat/TM data, while the unsystematic geometric distortion remains in the image.

The geometric errors were corrected by using ground control points (GCP). While correcting the data geometrically, nearest-neighbor re-sampling method was used. A correlation threshold is used to accept or discard points. The correlation range was within limits, i.e. 1 pixel size. Both the x and y errors were below 0.5 pixel.

3.2 *Classification Analysis*

Certain classification schemes that can readily incorporate land use and/or land cover data obtained by the interpretation of remotely sensed data have been developed (e.g. U.S. Geological Survey Land Use/Land Cover Classification System, NOAA Coast Watch Land Cover Classification System, Asian Land Cover Classification System) [4] [5].

The US Geological Survey Land Use/Land Cover Classification System (Level I) was chosen and referred to for the classification system of this study. By considering the four levels of the US Geological Survey Land Use/Land Cover Classification System, the classification system shown in Table 3 was created.

The three remotely sensed images of Nagasaki City were studied to analyze the land cover change in the area of study. The images were then classified with common and popular unsupervised, Iterative Self-Organizing Data Analysis Technique (ISODATA) classification algorithm.

The interpreted data were located in the aerial photographs and topographical maps. It confirms the accuracy of evaluation of remotely sensed data.

Finally we converted the pixels into area to detect the change variation.

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.

Table 3 Land cover classification system

Class	Description
1.	Urban or built-up land
2.	Agricultural land
3.	Rangeland
4.	Forest land
5.	Water
6.	Forested wetland
7.	Barren land
8.	Tundra

To perform ISODATA clustering, following parameters were specified:

- N — the maximum number of cluster to be considered. Since each cluster is the basis for a class, this number becomes the maximum number of classes to be formed (10 in this study).
- T — a convergence threshold, which is the maximum percentage of pixels whose class values are allowed to be unchanged between iterations (95% in this study).
- M — the maximum number of iterations to be performed (24 in this study).

With the information derived from remotely sensed data, land cover change and its impacts were identified for the appropriate economic development and environmental protection of the studied area.

4. Results and Discussion

4.1 *Land Cover Change in Whole Nagasaki City*

The results of ISODATA classification of Nagasaki City are presented in Figures 2- 4. The calculated areas of each land cover are shown in Table 4 and Figure 5.

From the over all result of the area, it is visible that vegetated area is decreasing and urban 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 gradually for more than 15 years. So, the agricultural area of 1986, seen in Table 4, seems to be too large. On the other hand, the forest seems to be small. We interpret that part of the forestland is classified into the agricultural land in 1986.

4.2 *Detailed View in the Typical Areas*

Three different sites, within the study area are chosen to show the typical change in land cover. The locations are shown in Fig. 6. The graphical representation of land cover change, in terms of percentage, is presented in Figs. 10, 11 and 12, where forest and agricultural land are integrated into one category. The decline in forest, inside the selected sites, is shown in Figures 7-9. In Nagasaki City, forest is declining, therefore it is important to take some precautionary measures in order to avoid this decreasing trend of forest.

Table 4 Statistical result of land cover change in Nagasaki City

Area in km^2	1986/5/12	1992/5/12	2000/5/2
Water	4.0	3.4	3.5
Forest	125.4	138.5	131.4
Rangeland	28.1	28.2	29.2
Urban Land	33.3	49.0	52.2
Agricultural Land	41.0	17.8	18.8
Barren Land	9.5	4.3	6.2

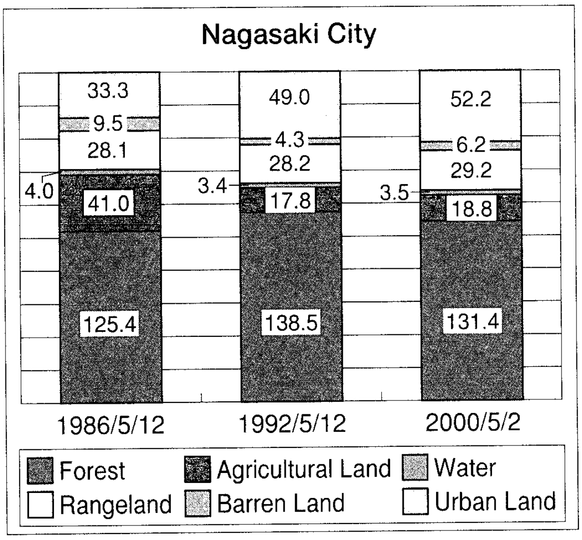

Fig. 5 Graphical representation of land cover change in Nagasaki City

Color	Class Names
	Water
	Forest
	Rangeland
	Urban & Built-up Land
	Agricultural Land
	Barren Land

※Orchards are included in Rangeland.

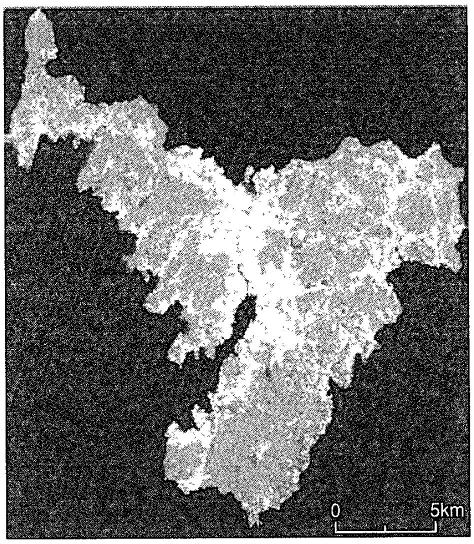

Fig. 2 Result of land classification Dated 12. 05. 1986

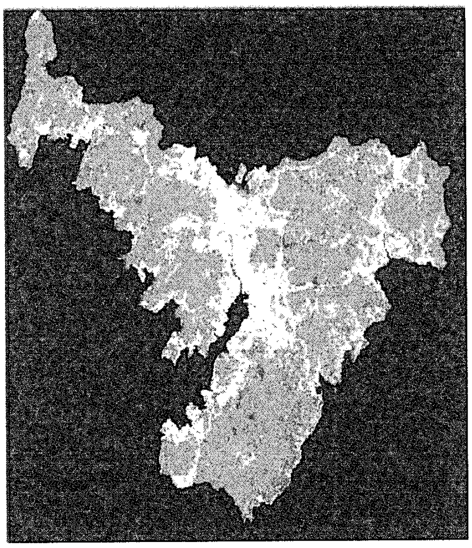

Fig. 3 Result of land classification Dated 12. 05. 1992

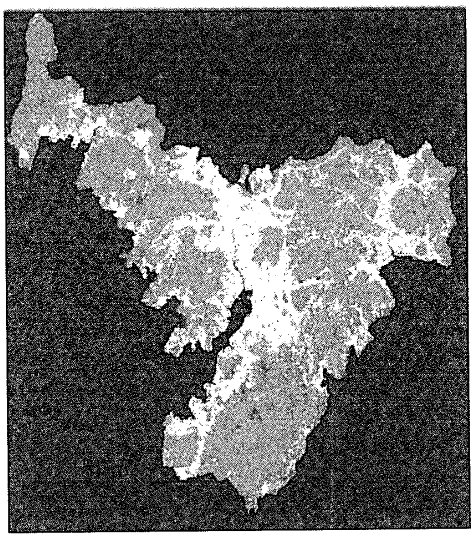

Fig. 4 Result of land classification Dated 2. 05. 2000

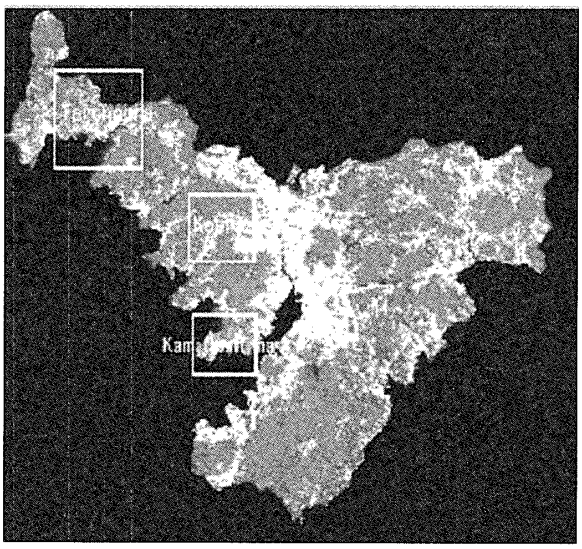

Fig. 6 Location of three selected areas

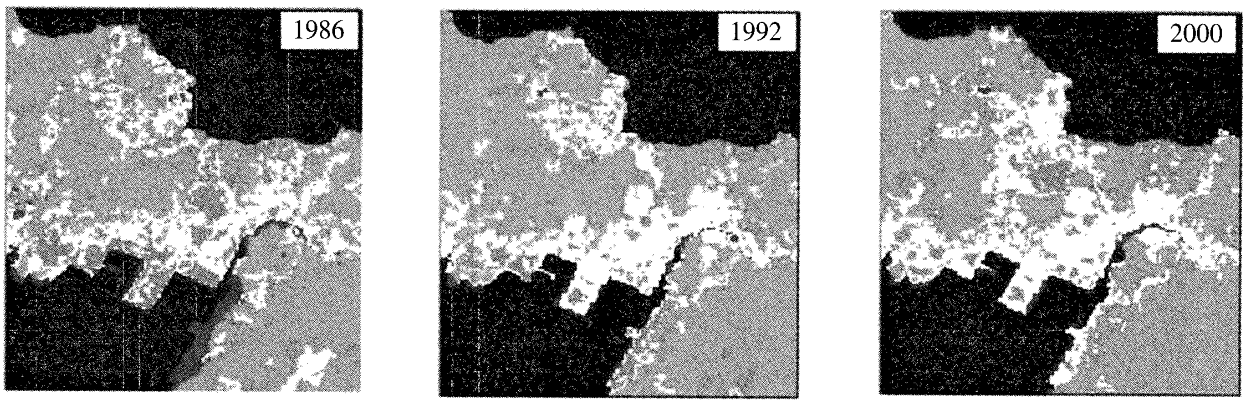

Fig. 7 Land cover classification map of Tagonoura in 1986, 1992 and 2000

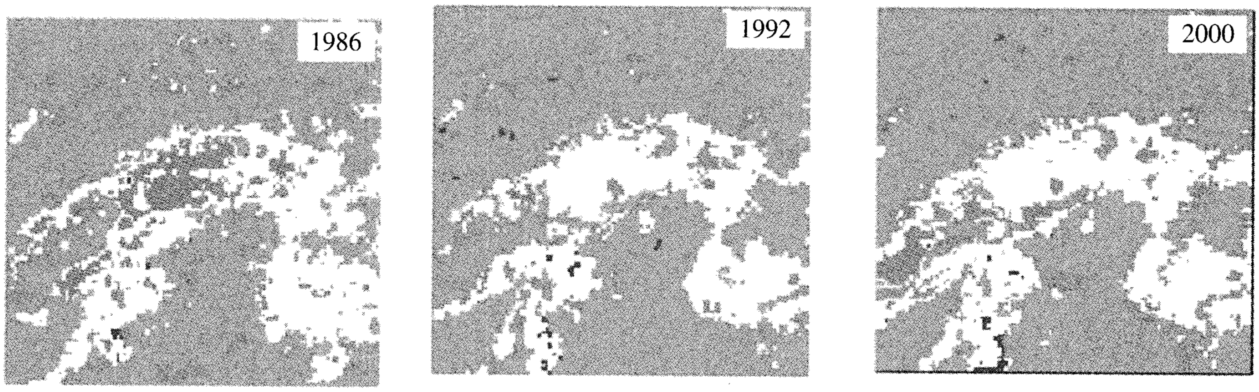

Fig. 8 Land cover classification map of Koebaru 1986, 1992 and 2000

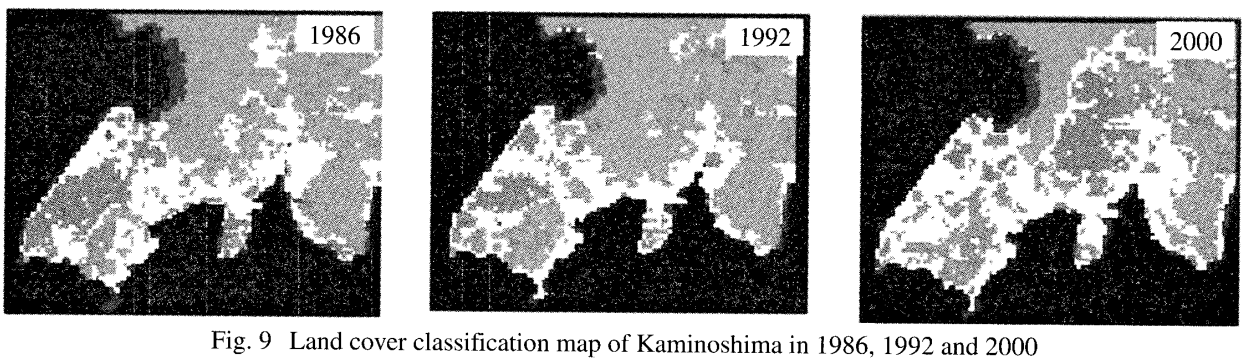

Fig. 9 Land cover classification map of Kaminoshima in 1986, 1992 and 2000

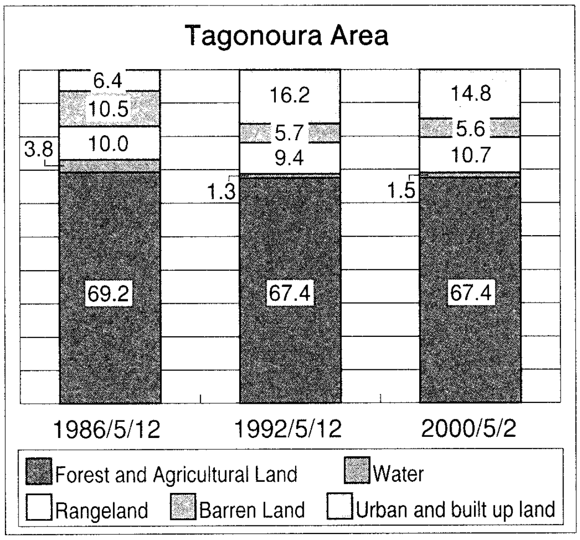

Fig. 10 Geographical representation of Tagonoura area

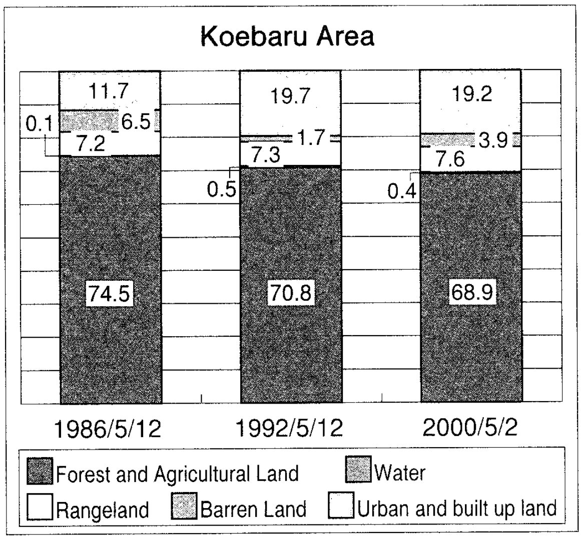

Fig. 11 Geographical representation of Koebaru area

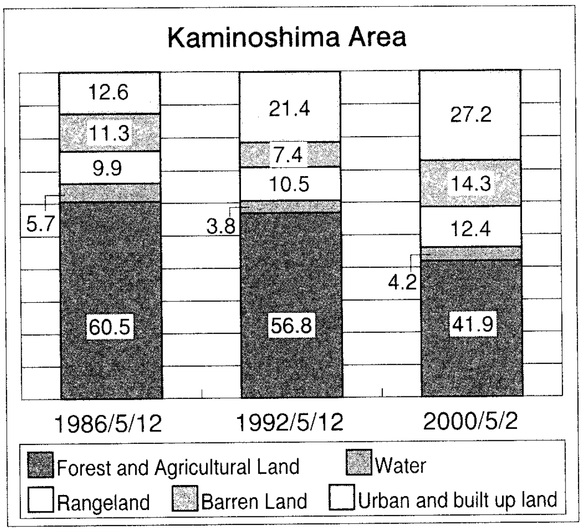

Fig. 12 Geographical representation of Kaminoshima area

5. Conclusion

Forests are the most representative of terrestrial ecosystems on earth. Not only are they indispensable resources for the sustainable development of human society, but also protect land from disasters. They reduce the sharp peak of rainfall influence. Although more than 50% of the study area has been covered by forest, forestland is currently decreasing. In this study, during the last eight years the forest area has reduced from 138.5 km^2 in 1992 to 131.4 km^2 in 2000. The dynamic changes in forest land cover are also clearly visible in three typical sites within the study area. It is therefore necessary to take some measures, based on more detailed investigations, to protect forests. If not, deforestation may impact directly on the activities of human beings and the survival of other living organisms in this area.

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