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Generalized Zoning of Urbanized Areas by Analysis of LANDSAT MSS Data

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1 Introduction

Recently, the techniques of remote sensing have been remarkably developed and analysis of the imageries of invisible rays has greatly contributed to identify the phenomena on the earth surface. In this paper, by using the near infrared imageries of LANDSAT MSS data, the authors intend to identify the urbanized areas and to zone them into several categories with various landuse types, which are difficult to discriminate from each other by the observation of the aerial photographs of visible rays.

The data of near infrared (wave length: 0.7–1.1 μm, invisible) are used in this study. In the process of the permeance through the air, near infrared rays are scarcely disturbed by fine particles (*i.e.* smoke, mist, *etc.*). Also, they are absorbed at the time of passing through water surface, which has the lowest reflectivity of near infrared rays on the earth. Accordingly, the imagery of near infrared is effective to identify the water surface and marshes. Furthermore, as vigorous vegetation reflects strongly near infrared rays, the density of vegetation cover and its growing conditions may be identified by using the imagery of near infrared.

The 5th, 6th and 7th bands of the LANDSAT MSS data have the wave length of 0.6–0.7 μm (red, visible), 0.7–0.8 μm (near infrared) and 0.8–1.1 μm (near infrared), respectively. The imagery of each band from MSS data (70 mm films) was processed by the Multi Color Data System 4200–E. This system is able to classify an imagery into 12 steps by the magnitude level of reflection in each band, and to display them with different color channels on the screen of TV monitor.

The scope of MSS data of LANDSAT is about 175 km by 162 km on the ground. The processed imagery of each band is magnified to about 1:500,000 on the screen of TV monitor of the system. The authors intend to identify the urbanized areas in 6 regions by using these imageries. Next, the primate city in each region is magnified by the system. The processed imageries of a city have the scale of about 1:160,000 — 1:80,000 on the screen. Based on the analysis of the imageries, the urbanized areas are discriminated from other landuse, and they are classified into several categories of different types of landuse.

2 Imagery analysis of MSS data on regional scale

On the imagery of the 5th band of each region, plains are distinguished from hills and mountains. Photo. 1 is a processed imagery of the 5th band of the Kinki region, on which plains are displayed with black. Plains are occupied extensively by urbanized areas in this region, and they are covered by houses, buildings, factories and other urban facilities. Therefore, the plains with extensive urban use correspond to the areas which have higher reflectivity in comparison with hills and mountains.

According to the observation of the imageries of the 6th and 7th bands, plains are not distinguished from hills and mountains. The reason may be that the reflection magnitude of near infrared rays from paddy-fields and upland fields on the plains is similar to the magnitude of reflection from vegetation cover on the hills and mountains. Photo. 2 and 3 are the processed imageries of the 6th and 7th bands of the Kanto region, respectively. Though water surface is not identified from the 5th band imagery, observation of imageries of the 6th and 7th bands makes it possible. Water surface has the lowest reflectivity of near infrared, and it is displayed with black color on Photo. 2 and 3.

Highly-urbanized areas are densely covered by houses and buildings and have a small extent of parks and roadside trees. Therefore, they have relatively low reflectivity of near infrared, and they are displayed with pale blue and sky blue on Photo 2. In accordance with outgoing from highly-urbanized areas, vegetation and cultivated lands are increased, in contrast to decrease of urban landuse, and outer zones of urbanized areas have higher reflectivity of near infrared than highly-urbanized areas. But suburbs could not discriminated from rural areas. Table 1 shows a result of zoning of urbanized areas by analysis of the processed imageries of the 6th and 7th bands. Generally speaking, for the purpose of zoning urbanized areas, the use of 7th band imagery is more effective than the 6th band.

Tokyo and its environs in the Kanto region occupy extremely extensive urbanized areas with about 15 million population. Tokyo is divided into 3 subregions by the imagery of the 6th band (Photo. 2), and into 4 by the 7th band (Photo. 3). The urbanized areas of Tokyo, which are identified by the imagery of the 6th band (pale blue, sky blue, dark blue and green on Photo. 2) correspond to the actual urbanized areas, with the exception of the eastern part of the Tokyo Metropolitan Area. Also, the urbanized areas observed from the 7th band imagery (dark blue, pale blue, sky blue and green on Photo. 3) correspond to the actual highly-urbanized areas.

The urbanized areas of Osaka (about 3 million population) in the Kinki region are divided into 2 subregions by the 6th band, and into 4 by the 7th band. In the

case of Nagoya (about 2.5 million population) in the Chukyo region, they are divided into 3 subregions by both of the 6th and 7th bands.

All of Sapporo in Hokkaido, Fukuoka in Kyushu and Sendai in Tohoku are the primate cities with about 600,000 — 1,000,000 population. The urbanized areas of each city are divided into 2 subregions by the 6th band, and into 3 by the 7th band.

Table 1 Zoning of urbanized area by processed imageries (Scale 1: 500,000)

	Number of Subregions	
	6th Band	7th Band
Kanto Region Tokyo	3	4
Kinki Region Osaka	2	4
Chukyo Region Nagoya	3	3
Southern Hokkaido Sapporo	2	3
Northern Kyushu Fukuoka	2	3
Southern Tohoku Sendai	2	3

3 Analysis of magnified imageries of large Cities

Magnified imageries of MSS data of primate cities are reproduced by the Multi Color Data System. The scale of reproduced imagery of Tokyo is 1:160,000 on the screen, and the scale of the imageries of the other cities mentioned above is 1:80,000. In all cases of the 7th band imageries of Tokyo (Photo. 4), Osaka (Photo. 5) and Nagoya (Photo. 6), the urbanized areas are divided into 6 subregions with various landuse types. For example, each of 6 subregions of Tokyo is displayed with a color channel such as moss green, dark blue, pale blue, sky blue, green and red, respectively, on Photo. 4. On the imagery of the 7th band of Tokyo, the areas with the lowest reflectivity are water surface (black). Chuo-ku and Koto-ku, the central part of Tokyo, have the secondarily low reflectivity of the 7th band (moss green and dark blue). Close to Chuo-ku and Koto-ku, the areas which have relatively low reflectivity of the 7th band correspond to the inner part of Tokyo, located within borders of the Yamanote Loop Line. In general, Tokyo has a concentric pattern of 6 subregions, coping with actual regional structure of the Tokyo Metropolitan Area.

On the imagery of the 6th band, Tokyo is divided into 3 subregions with difficulty.

A result of the zoning of urbanized areas of the other cities by the imageries of the 6th and 7th bands is shown in the Table 2 and Photo. 5–9. Osaka and Nagoya have not always concentric pattern of subregions on the imageries. Sapporo is able to be divided in more detail than the cases of Fukuoka and Sendai, by the imagery of the 7th band. In Sapporo, the area with the lowest reflectivity of near infrared (black on Photo. 7) corresponds to the central part of Sapporo, with exception of water surface. Subregions of Sapporo, which are discriminated from each other, constitute a concentric structure, and this suggests that Sapporo has been developed toward the four directions.

Table 2 Zoning of urbanized area by magnified imageries (Scale 1:80,000–16,0000)

	Number of Subregions	
	6th Band	7th Band
Tokyo (Scale 1: 160,000)	3	6
Osaka (1: 80,000)	3	6
Nagoya (1: 80,000)	3	6
Sapporo (1: 80,000)	5	6
Fukuoka (1: 80,000)	4	4
Sendai (1: 80,000)	2	4

4 Conclusion

The imageries of MSS data of LANDSAT are analysed by the Multi Color Data System. The processed imagery of near infrared is effective to identify the water surface, marshes, vegetation and urbanized areas. It is also effective to divide urbanized areas into several zones with various types of landuse. This is applicable to generalize the landuse pattern of many cities.

Compositions of urbanzied areas such as buildings, roads, parks and other facilities vary regionally, and they have special characteristics of their heat capacity. Therefore, the imagery of far infrared, which reflects surface temperature on the ground, may be more effective to subdivide the urbanized areas. This was partly examined by the authors in the case of Morioka city.

References

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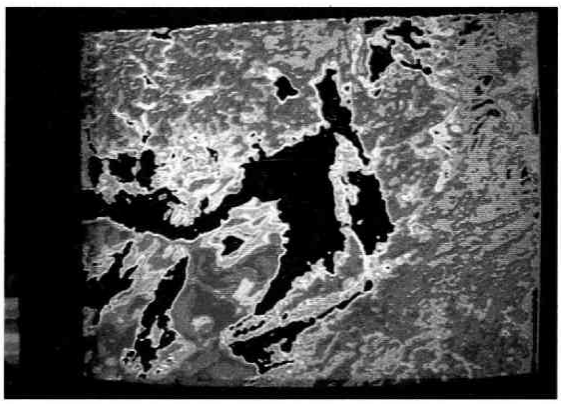

Photo 1 Kinki (5 th Band)

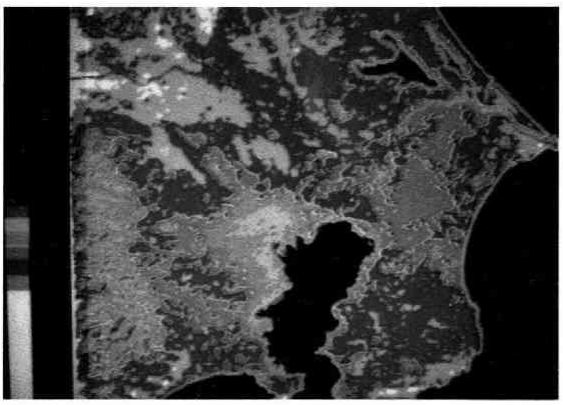

Photo 2 Kanto (6 th Band)

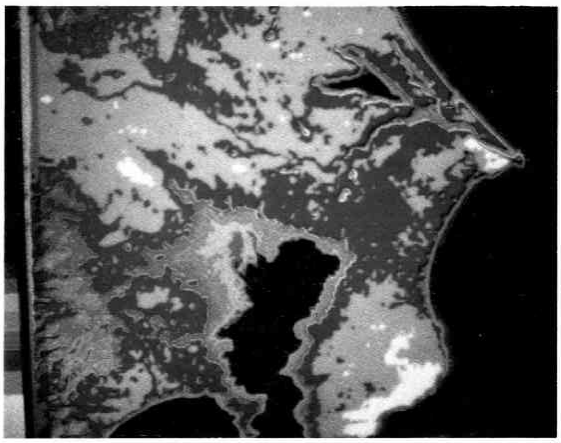

Photo 3 Kanto (7 th Band)

Photo 4 Tokyo (7 th Band)

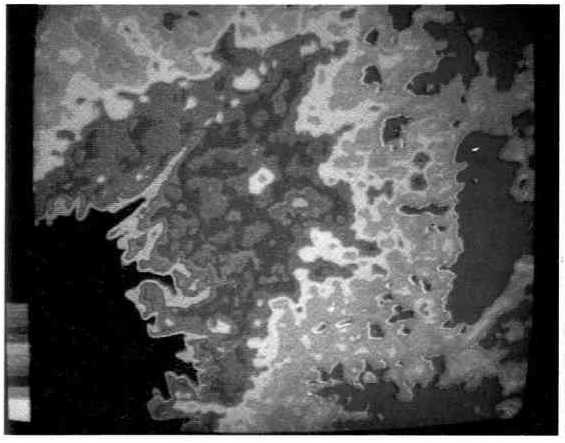

Photo 5 Osaka (7 th Band)

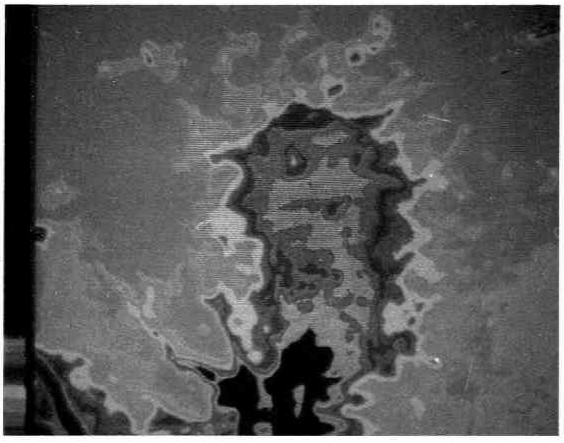

Photo 6 Nagoya (7 th Band)

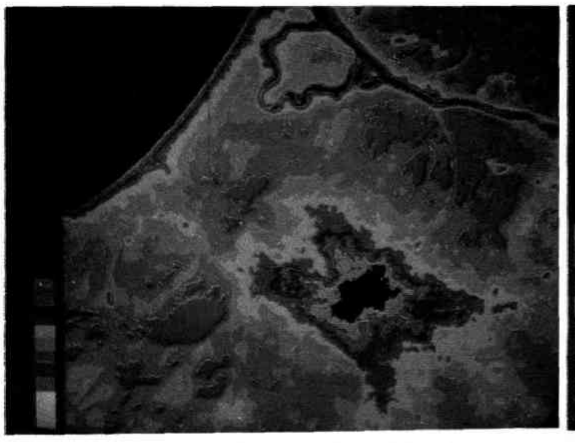

Photo 7 Sapporo (7 th Band)

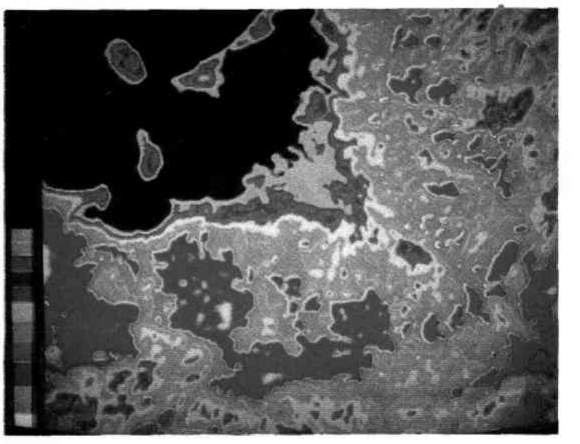

Photo 8 Fukuoka (7 th Band)

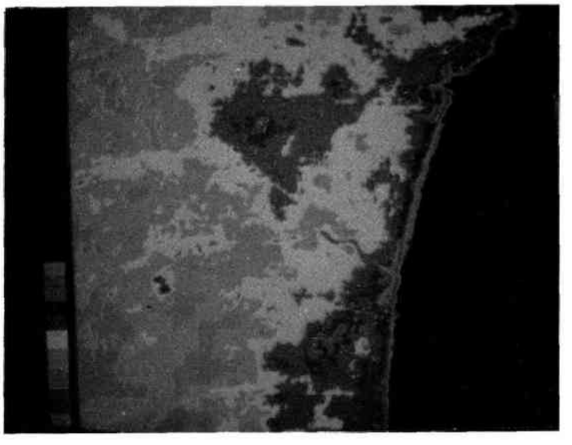

Photo 9 Sendai (7 th Band)