A RESEARCH ON THE URBAN DISASTER PREVENTION PLAN CONCERNIN G EARTHQUAKE RISK FORECAST BY REMOTO SENSING TN THE TOKYO BAY AREA

Ritsu KATAYAMA, Masato SHOZI, Yoshihide TOKIYA

Department of Architecture, Chiba Institute of Technology,
2-17-1, Tudanuma, Narashino 275-0016 Chiba , Japan
p08katay@pf.it-chiba.ac.jp

Session PS ThS 20- Application of Hight Resolution Data

Key Words : Hanshin large earthquake , NDVI(Vegetation Index)and UI(Uurban Index)
Tokyo Bay shore district, TM and IKONOS, GIS and Remote Sensing

ABSTRACT

A Hanshin large earthquake which had dropped Japan to fear on January 17th 5:46AM eight years ago of 1995 occurred. Kobe City caused a spreading fire in the large range from coexistence of the wooden building in the overcrowdedness urban area and the cause of a narrow road due to this large earthquake. Authors have already understood the danger of a spreading fire increases from the research aimed at Kobe City in the district where which the **NDVI(Vegetation Index)** is low, and the **UI(Urban Index)** is high from the remote sensing analysis. It paid attention to the **Tokyo Bay shore district** in the metropolitan area where the danger of the earthquake was shouted to apply the remote sensing technology to the city planning field widely, and the consideration the remote sensing analysis's whether the analysis of the city situation being enabled by the accuracy of which extent was tried through the overlapping analysis with **Geographical Information System** based on the existing research result of understanding from Kobe City. The effectiveness of an analytical technology was considered by verifying the analysis scale to not only the city level (Chiba Prefecture Urayasu City and Kawasaki City Nakahara Ward) but also districts and the town even number fields in detail and using the **TM data and the IKONOS data**. As a result, to apply the remote sensing technology to the urban disaster prevention project, it reports on the consideration whether what possibility and the problem and the proposal exist.

1. Background and purpose of research

It becomes an age when a continuous measurement and the watch of the city environment intended for the large range are necessary along with the diversification and extending the city environment. It is necessary to consider a lot of problems that the city has in doing the urban renewal enough. Properties of the city environment are adequately understood, and the thing to specify the district where it has the problem is necessary. It is effective to use the remote sensing data to be able to do a cycle short, latest data acquisition to observe the transformation of the city. [1),2) 3)] In this research, to understand the district characteristic of the city in pixel distribution situation by the remote sensing analysis and the relation to the GIS data, the following research developments were done.

2 Selection of district for investigation

In the selection of the district for the research, 1 capital and 3 prefectures (Tokyo, Saitama Prefecture, Chiba Prefecture, and Kanagawa Prefecture) in the overcrowdedness urban area which it was a lot of regions, and was the populous districts were in the Tokyo Bay area were paid to attention. Mainly the central area of Tokyo, the region where the development act was remarkably done, and the following 57 municipal districts were selected in that in consideration of the influence on the city to the flow of the change in the city environment and the population.

Table 1. List of 57 municipal districts for research

Tokyo	Saitama	Kanagawa	Chiba
23 districts	Urawa Saitama □ Ömiya Yono Kawaguchi Souka Koshigaya Hatogaya	Yokohama Totuka Izumi □ Totsuka Sakae Kouhoku Aoba □ Kohoku Midori Tsuzuki 13 municipal districts Kawasaki 7 districts	Chiba Ichikawa Funabashi Matsudo Narashino Kashiwa Urayasu
TOTAL			

3. Understanding of city environment seen from GIS

It paid attention to 7 indices of the population, the home, the health, the green tract of land, the house, the city, the public peace, fire fighting, the state of manpower, and industry to understand the city environment from GIS and the following 29 items were selected. After the collected statistical data had been united as a value per the unit area, the relations between GIS items were found by the correlation analysis and the factor analysis. And, the scatter chart of the item with a high correlation was made, and it was assumed the index to understand properties of urbanization (relation between the population density and the green tract of land) from the position of each city on the graph (Figure 1).

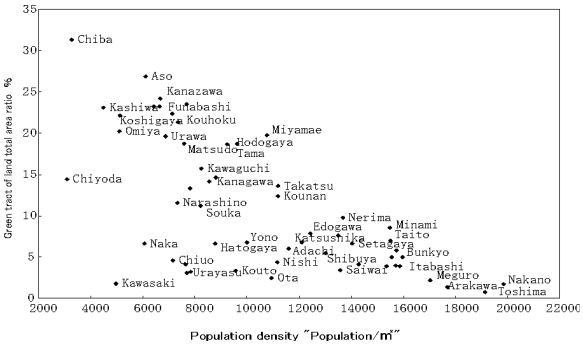
Table 2. List of city environmental survey index

Population and home	Health	Green tract of land	House and city
It is population vs. all population by 65 years old or more.	Death toll	Number of the first industrial employed	Wooden house ratio
Number of homes density	Malignant growth death toll	Cultivated acreage	Drainage diffusion
Population density	Number of doctors for every 100 alcoves in sickbed	Area of forest	Municipal district town and village road pavement rate
	Number of hospitals of 100,000 people in population	Area of city park	
	Number of general clinics		
	Number of number of doctors sickbeds		

Public peace and fire fighting	State of manpower	Industry
Breaking out number	Unemployment rate	Number of offices for each population
The number of construction vs. building breaking out number	The number of of employed vs. those who close	Diurnal external resident entrance vs. population
Traffic accident generation number	The completely unemployed	Number of those who find employment manufacturers
Crime generation number		Number of the second industrial employed
Emergency mobilization number		Number of the third industrial employed

R=-0.65

Figure 1. Scatter chart of population density and green tract of land area ratio



Thus, it was assumed the precondition which understood urbanization examining which category gave the important effect in which item the correlation was high.

4. Analysis by using Landsat TM image

It analyzed it as follows by the use of the Landsat TM image for city environmental understanding to verify even where was possible by the remote sensing analysis from the GIS item referring to the understood point.

4.1. Understanding of city properties by land coating classification

Two kinds of land coating classifications of supervised classification and unsupervised classification were done from the Landsat TM image at two time of 1985 and 2000 to which geometry was corrected by using numeric map 25,000. It classified it into 7 classes, that is, wooden, non-wooden, road□ railway, bare land, forest, rice field, and waters. In supervised classification, numeric map 25,000(map image) and the aerophotograph, the house map, and the land use investigation, etc. were used as grand truth. Figure 2 shows supervised classification result of the whole area of the district for the investigation in TM 2000.

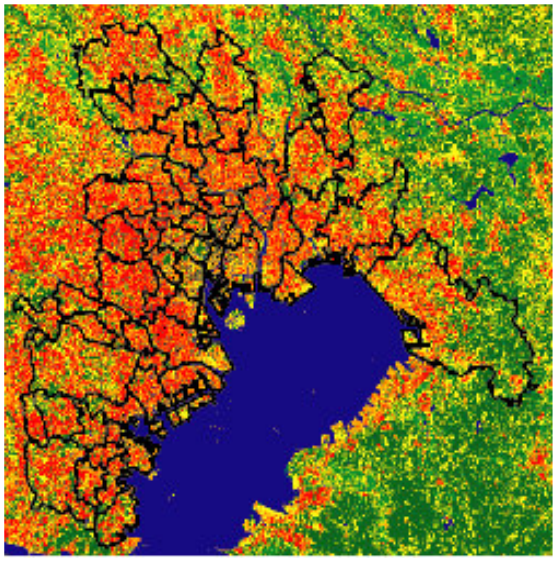
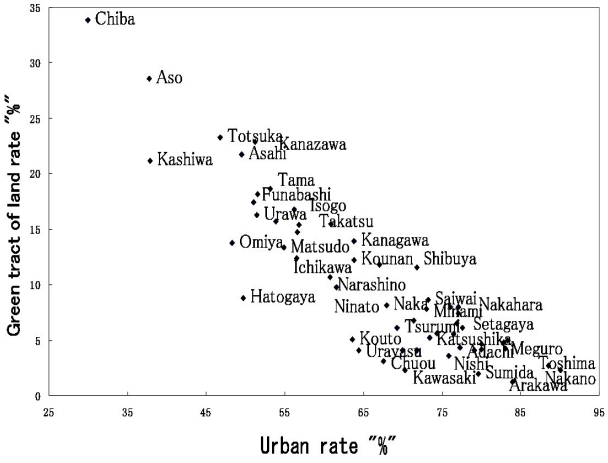


Figure 2. Land coating classification by supervised classification (Landsat TM 2000)

This of each municipal district was cut out, the area ratio of each class was calculated, and the pixel distribution situation was understood. It was thought that the point that pixel density which hit the urban area on a wooden structure, non-wooden structure, and the road was high and pixel density of the green tract of land in the bare land and the forest is low was an overcrowdedness urban area. 3 classes (the road, wooden, non-wooden) were understood as an urban area, and 3 classes (the rice field, the forest, and the bare land) were understood as a green region. The district characteristic was understood from each ratio in each municipal district (Figure 3). Because the distribution relation of the city was almost corresponding, a green region and urban situation was able to be understood from the land coating classification which used the TM image by comparing Figure 1 and Figure 3. That is, the situation of the overcrowdedness urban area where the green region rate decreased extremely was able to be understood in the place where an urban rate had increased. Moreover, the transformation tendency to the city was understood from the change in the number of pixels in 1985 by a similar analysis in the TM image. Thus, the city properties as the urban area were able to understand both the regional characteristics and the distribution situations in the outline by the land coating classification of the TM image.



R=-0.98

Figure 3. Scatter chart in composition ratio of urban area and green region (TM 2000)

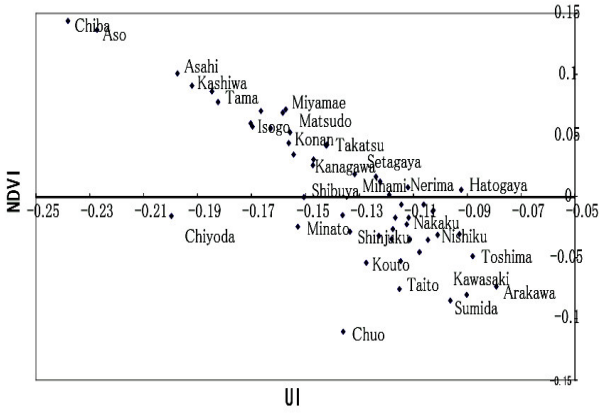
4.2. Understanding of city properties by image operation processing

In the land coating supervised classification, it is necessary to set the brightness value by using detailed regional information (grand truth). On the other hand, similar city properties to the above-mentioned were understood by using 2 indices which were able to be calculated by the operation processing in the satellite image, that is, NDVI (vegetation index) and UI (urbanization index) as another technique. Two calculated indices were made, and the mean value was taken in each municipal district and the scatter chart was made (Figure 4).

Vegetation index (NDVI) became a decrease tendency as urbanization index (UI) increased. Moreover, the distribution situation of each municipal district understood the tendency resembled closely. Therefore, urbanization in each municipal district and the state of vegetation were able to be analyzed by analyzing NDVI and UI equally to the land coating classification as well as Figure 3. It can be said a useful technique in this analysis technique's understanding the city properties in the outline, too.

R=-0.82

Figure 4. Scatter chart of NDVI□UI (TM 2000)



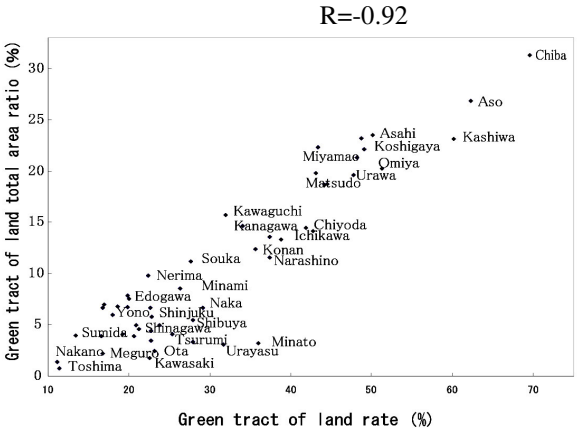
4.3. Correspondence of Landsat TM analysis and GIS

To examine the analysis which used the TM image and the correspondence with GIS, the correlation analysis of an analytical result of two techniques of the land coating classification and the image operation processing and the GIS item was done (Table 3). In Figure 5, it was understood that there was a high correlation from the relation between the GIS green tract of land area ratio of the spindle and the green region rate by supervised classification of a horizontal axis. (R=0.92) The utility of the understanding of the item of GIS was able to be confirmed from this by the remote sensing analysis.

Table 3. Correlation matrix of GIS item and Landsat analysis result

	GIS item								
	Population density	Number of homes density	Densities of those who die	Ratio of area of forest	Green tract of land total area ratio	Density of house	Wooden house ratio	Breaking out density	Supervised classification Urban rate
Population density	1.00								
Number of homes density	0.98	1.00							
Densities of those who die	0.93	0.9	1.00						
Ratio of area of forest	-0.43	-0.45	-0.47	1.00					
Green tract of land total area ratio	-0.55	-0.57	-0.56	0.73	1.00				
Density of house	0.98	0.99	0.93	-0.41	-0.55	1.00			
Wooden house ratio	-0.4	0.2	-0.22	0.25	0.57	-0.15	1.00		
Breaking out density	0.57	0.71	0.68	-0.52	-0.62	0.71	-0.57	1.00	
Supervised classification Urban rate	0.8	0.6	0.6	-0.75	-0.85	0.6	-0.5	0.62	1
Supervised classification Green tract of land rate	-0.77	-0.75	-0.79	0.75	0.9	-0.74	0.22	-0.64	-0.98
Unsupervised classification Urban rate	0.77	0.77	0.76	-0.74	-0.88	0.75	-0.24	0.69	0.98
Unsupervised classification Green tract of land rate	-0.7	-0.8	-0.72	0.85	0.93	-0.68	0.27	-0.69	-0.96
NDVI	-0.49	-0.5	-0.54	0.83	0.85	-0.48	0.46	-0.58	-0.75
UI	0.54	0.59	0.62	-0.8	-0.85	0.53	0.25	0.43	0.8

Figure 5. Correlation of land coating classification result (Landsat) and GIS item



The thing which was able to be understood from Table 3 by high accuracy was able to be understood concerning the green region rate and the urban rate which was able to be read by the Landsat TM image in this manner. Moreover, the population and the home index to which urbanization was located by specifying an urban pixel in the remote sensing analysis from this correlation matrix were able to be understood. And, the green tract of land index of GIS was able to be understood by specifying the green region pixel. Therefore, the degree of an urban overcrowdedness degree and the open space in the city is understood from the measurement of 2 indices(the green region rate and the urban rate) in each municipal district and it can be said it is possible by the Landsat TM image's being used.

5. Analysis by using IKONOS image

The city in each municipal district was able to understand the environment in the analysis of the Landsat TM image as already described. Then, the city on each town even number eyes understood the environment more in detail by using the IKONOS image of a high resolution compared with Landsat TM. Two municipal districts (the Chiba Prefecture Urayasu City and the Kanagawa Prefecture Kawasaki city Nakahara Ward) were selected from among 57 municipal districts previously selected. These two municipal districts are located along the river compared with other regions, there are a lot of overcrowdedness urban areas, and are the populous districts.

5.1. Understanding of city environment from each town even number eyes by GIS

To understand more detailed city environmental properties on the GIS analysis, 8 items (the population , the number of homes, the number of senior citizens, the death numberl, the cancer death numberl, the fire number, the emergency mobilization number, and the traffic accident number which was able to be acquired with each town even number eyes) were collected. The collected statistical data were previous similar analysis united as a value per the unit area. The extraction of the overcrowdedness urban area on GIS was tried by using these 8 items. As a result, in the Urayasu City, the district in the expressway north of Toudaijima, Nekozane, Horie, Kitasakae, and Fujimi understood the thing which was the overcrowdedness urban area from situations such as the population, the numbers of homes, and fire number. Moreover, to find the relations between items from the collected statistical data, the correlation analysis was done (Table 4). In addition, to understand the district properties, the scatter chart was made in each item. Figure 6 shows the scatter chart of the population density and the fire breaking out density. The feature of the overcrowdedness urban area that the fire breaking out density rose was able to be understood when becoming densely populated from these scatter charts.

Table 4. Correlation matrix between GIS items for units of town even number eyes

	Population density	Number of homes density	Density of senior citizen	Densities of those who die	Malignant growth death toll	Breaking out number	Emergency mobilization number density	Traffic accident generation density
Population density	1							
Number of homes density	094	1						
Density of senior citizen	071	068	1					
Densities of those who die	055	061	072	1				
Malignant growth death toll	055	068	071	098	1			
Breaking out number	04	055	044	066	065	1		
Emergency mobilization number density	064	074	064	094	093	072	1	
Traffic accident generation	056	07	062	088	085	063	09	1

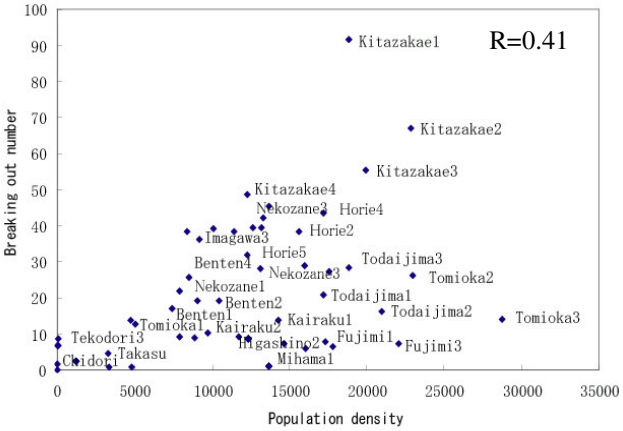


Figure 6. Scatter chart of population density □ fire breaking out density (Urayasu City □ Town even number eyes)

5.3. IKONOS

Two kinds of land coating classifications of supervised classification and unsupervised classification were done respectively by using the IKONOS image of two municipal districts (the Urayasu City and Nakahara Ward) in 2000 to understand the situation of the overcrowdedness urban area which was able to be read by the GIS analysis on the town even number eyes (Figure 7). The classification class classified it separately for 7 classes as well as the TM analysis. The town district shape was able to be perceived clearly because the IKONOS image was able to make out the road shape from Figure 7 more accurately compared with the Landsat TM image, and properties of urbanization and the overcrowdedness degree were able to be understood in detail.

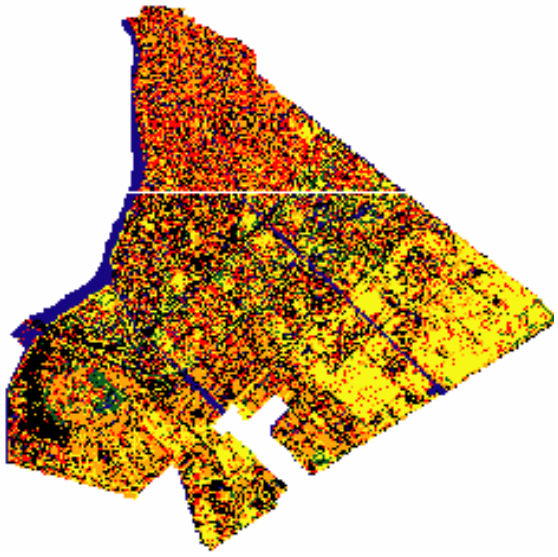


Figure 7. Land coating supervised classification chart (IKONOS 2000)

After pixel ratio of each classification class was totaled by each each town even number eyes, and pixel distribution situation was understood, pixel ratio in an urban area and a green region was calculated as well as the TM analysis. The scatter chart was made, and on each town even number eyes, pixel ratio in a green region was made a spindle and pixel urban ratio was made for a horizontal axis (Figure 8).

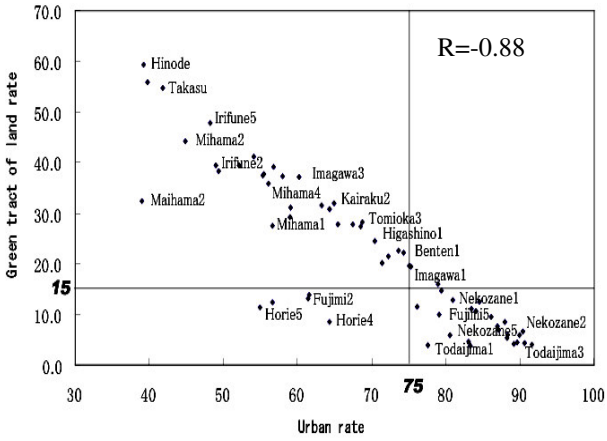


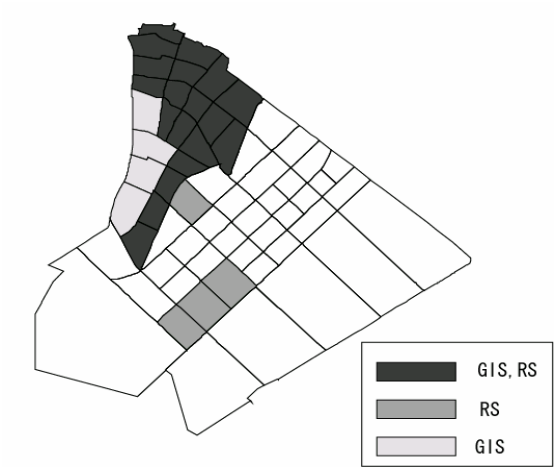
Figure 8. Scatter chart in the composition ratio of an urban area and a green region (The Urayasu City: IKONOS:2000).

The district of enumerated Toudaijima, Nekozane, Horie and Fujimi can be read by risking it from the GIS item as an overcrowdedness urban area when the district from the urban rate 75% over to the green region rate 15% below is seen from this scatter chart. Therefore, the overcrowdedness urban area on each town even number eyes was able to be specified by such an analysis in the land coating classification by the IKONOS analysis compared with the TM analysis which was understanding each municipal district, and a more detailed analysis became possible.

5.3. Correspondence of GIS (town even number eyes) and IKONOS analysis

Figure 9 shows the extraction result of the overcrowdedness urban area by the GIS analysis on the town even number eyes and the overcrowdedness urban areas by the IKONOS analysis. Judging from the thing which came in succession roughly, it was able to be understood as the overcrowdedness urban area which had been obtained by the land coating classification of the overcrowdedness urban area extracted by the GIS 8 item with the town even number eyes in Figure 9 and the IKONOS image that the understanding with each town even number eyes was possible from this figure. As for a part within the range judged to be an overcrowdedness urban area from the IKONOS analysis, the value of the eternal resident population density is low in the factory area and the warehouse street. On the other hand, it is guessed that it did not agree because the district judged to be an overcrowdedness urban area from GIS is along the river, and the waters part influenced pixel ratio.

Figure 9. Overcrowdedness urban area extraction result in IKONOS analysis and GIS



Moreover, the correlation analysis with the GIS item was done in the IKONOS analysis as well as analyzing TM (Table 5). A high correlation for the correlation coefficient to exceed 0.7 compared with the TM data was not able to be obtained in Table 5. However, because the IKONOS image is a high resolution in this, it is thought that the purpose is to have received the influence of the shadow of the structure. It will be able to be said that a high in some degree correlation is obtained if that is taken into consideration.

Table 5. Correlation matrix of GIS item and IKONOS analysis

	IKONOS analysis				GIS item							
	Urban rate	Rate of building	Open space and road	Green tract of land rate	Population density	Number of homes density	Densities of those who die	Ratio of area of forest	Green tract of land total area ratio	Density of house	Wooden house ratio	Breaking out density
Urban rate	1.00											
Rate of building	.088	1.00										
Open space and road	-.052	-.086	1.00									
Green tract of land rate	-.088	-.080	.088	1.00								
Population	.025	.094	-.095	-.092	1.00							
Number of homes density	.041	.049	-.054	-.05	.092	1.00						
Densities of those who die	.029	.043	-.041	-.052	.071	.068	1.00					
Ratio of area of forest	.052	.062	-.092	-.016	.035	.060	.072	1.00				
Green tract of land total area ratio	.032	.05	-.063	-.054	.035	.069	.071	.093	1.00			
Density of house	.057	.083	-.086	-.03	.041	.033	.041	.068	.058	1.00		
Wooden house ratio	.016	.053	-.016	-.052	.062	.070	.062	.092	.093	.072	1.00	
Breaking out density	.053	.052	-.068	-.068	.036	.070	.062	.088	.059	.063	.09	1.00

I

the land coating classification by the IKONOS analysis the pixel distribution situation. In addition, collation with the situation of an actual city was tried by using the aerophotograph to confirm pixel distribution situation of the land coating classification which used the IKONOS image (Figure 10). Districts such as Toudaijima , Nekozane , Horie , and Fujimi were the overcrowdedness urban areas in the Urayasu City according to the

IKONOS analysis as having already described. Figure 10 is an aerophotograph which compares Nekozane・Horie district and Kairaku district in the Urayasu City. As for the left Nekozane・Horie district made an overcrowdedness urban area, the town district shape can be also more complex than a right Kairaku district and the situation of the overcrowdedness urban area be understood well. On the other hand, right Kairaku district does by the readjustment of town lots by the shape of the town district in an orderly manner, and is not judged from which result of GIS and IKONOS as an overcrowdedness urban area though is an overcrowdedness ratio in a similar building.

Nekozane,Forie Kairaku

Figure 10. Aerophotograph of Nekozane・Horie district and Kairaku district in Urayasu City

6. Result and View in the future

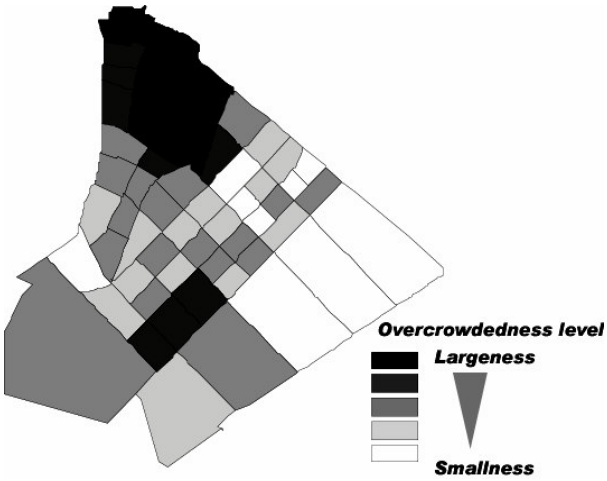
In this research, each of the utilities were examined aiming to make out the situation of the overcrowdedness urban area in the Tokyo Bay area in the pattern by using the TM image and the IKONOS image by an analytical technique which centered on the land coating classification. The population, the home, and the situation of the open space in the forest etc. as city information were able to be understood by understanding pixel density of the urban area and the green tract of land in each municipal district in the TM image analysis.

Moreover, the finding that situations of the fire breaking out number etc. were able to be guessed was obtained from the relation of GIS. Moreover, the method of understanding the situation of the overcrowdedness urban area in the outline in each municipal district was able to be obtained by measuring the distribution situation of these pixels. Moreover, because it was a high resolution, the road and the town district shape, etc. were able to be understood adequately in the IKONOS analysis. The overcrowdedness urban area was able to be understood more in detail by measuring pixel distribution situations of each town even number eyes in IKONOS compared with the TM analysis. In addition, it was able to be confirmed to understand the overcrowdedness degree adequately even if it saw from the comparison with the aerophotograph. Thus, the possibility of the understanding of a city environmental properties was able to be found by judging information which had been obtained by the analysis which used the TM image and the IKONOS image overall. However, all of the city environmental index used to analyze GIS do not agree, and there is a necessity for advancing the examination for other remote sensing (TM and IKONOS both) analysis technologies in the viewpoint of the understanding of a city environmental properties. Moreover, the use of this panchromatic film data etc. are tried to solve the problem that the shadow of the structure causes, and the thing to improve accuracy or more is an examination problem as for the IKONOS image. Moreover, it is necessary to reexamine the index which shows the city properties in consideration of the correlation between GIS items for the improvement of the accuracy of the remote sensing analysis in the future. For instance, the following expressions are examined as an index which shows the overcrowdedness degree in the building in each district (Figure 11).

$$\text{overcrowdedness level} = \sqrt{(1 - \text{building overcrowdedness level})^2 + (\text{open space rate})^2}$$

Therefore, it is likely to lead to the perception of the detection of such an overcrowdeness level of the risk of the city.

Figure 11. Rank chart by overcrowdedness level which uses IKONOS land coating classification



REFERENCES

1) Ritsu KATAYAMA et al., A Feasibility Study about Extraction Method of Densely Crowded Areas with Wooden Buildings on the KOBE Government. Part 2., : Consideration of Evaluation of Urban Fire Hazard., ISPRS, Vol□□□□,PartB7, P6 62-669, Amsterdam, 2000
2) Ritsu KATAYAMA et al., A Feasibility Study on Evaluation of DistrictEnvironmental Method Using Remote Sensing of TM and IKONOS Data for Healthy-City. : A Case Study in Urban Areas of Tokyo Bay 2000., Remote Sensing of Urban Areas, Regensburg, 2001
3) Ritsu KATAYAMA et al., A Feasibility Study on Evaluation of District Environmental Method Using Remote Sensing of TM & IKONOS Data for Healthy City., Part3., : A Case Study in Urban Areas of Tokyo Bay 2001., IGARRS.TRONTO, 2001