Impact of Vegetation in Reducing Heat Island Phenomenon of Fukuoka City By Applying Remote Sensing Technique

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Abstract: Recently, the heat island phenomenon in which the temperature of a city part rises from the circumference ground has developed into a big problem. In this study, we aimed at examining the impact of increasing vegetation in urban areas to reduce the heat island phenomenon by taking the Fukuoka City of Japan as a case. In order to discuss the relation between vegetation environment and the heat island phenomenon, we have calculated Normalized Difference Vegetation Index (NDVI) and mapped the spatial vegetation distribution. These are then compared with the heat island phenomenon investigations in Fukuoka City. The results of the study revealed that the areas showing comparatively lesser heat island phenomenon are those having increased vegetation.

Keywords: Remote sensing, Vegetation index, Heat island phenomenon

1. Introduction

Recently, heat island phenomenon resulting from high land surface temperature in the urban areas are occurring in many cities and developed into a major problem in Japan. As a method to reduce the heat island phenomenon, green vegetation is very effective, which also fixes the carbon dioxide of the greenhouse gases by photosynthesis. In addition to this, green vegetation also provides to urban residents a place for recreation and an opportunity to come in close contact with nature.

However, this green-covered area usually decreases as urban development progresses. Therefore, it is indispensable to consider green conservation into urban plan and very important to develop the useful method to monitor their changes in different parts of the city. In this respect, satellite remote sensing is very effective to monitor the growth and changes of green vegetation.

In the backdrop of the situation described above, this study examined the changes of vegetable activity and heat island phenomenon using satellite images from LANDSAT 5 / TM and QuickBird for Fukuoka City,

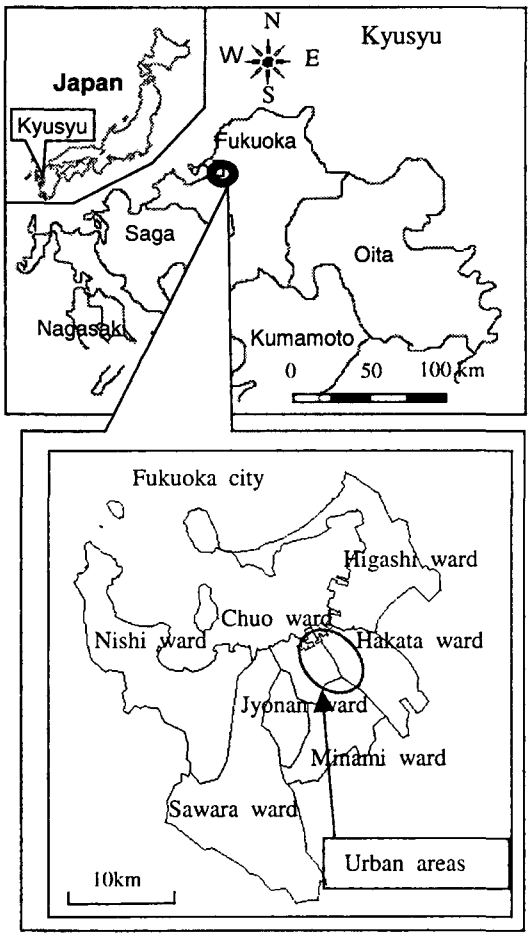


Fig.1. Location of the study areas.

Kyusyu, Japan (see **Fig.1** for the location of the study area). Finally, the results of the satellite image data are compared with that of the field investigation data published by the Fukuoka City Authority [2].

2. Field Investigation on Heat Island Phenomenon in Fukuoka City

A heat island phenomenon investigations was conducted by Fukuoka City Authority in 67 points of the city for three months, July~October, 2003 and observation of temperature was carried out [2]. The observation point was selected by having an interval of three kilometer and located in public facilities such as elementary school, which are evenly distributed in the city.

Observation results showed difference in temperature between urban and suburb areas, and identified the areas in the city which are generating heat island phenomenon. Within the city particularly in Tenjin and Hakata station areas, the average temperature is high as compared to that of the other areas of the city. One radius kilometer circling the Hakata elementary school, the temperature is alarmingly recorded to be higher.

The observation results of this field study showing high temperature generating regions in percentage are described through **Fig.2**.

3. Methodology

In this study, satellite images obtained from LANDSAT 5 / TM and QuickBird are used. In order to analyze changes of the vegetable activity of Fukuoka City, NDVI (Normalized Difference Vegetation Index) is calculated. NDVI is calculated from LANDSAT 5 / TM and QuickBird images. Firstly, images from LANDSAT 5 / TM, having spatial resolution of 30m, are used to calculate the vegetation index within the period of 1990-2000, to see the changes in the vegetation activity in the whole Fukuoka City. Then, QuickBird images, having spatial resolution of 2.44m and 0.61m, are used to see the changes more closely in the regions of Hakata ward and Chuo ward of Fukuoka City, which are generating comparatively higher heat island phenomenon as revealed from the Fukuoka City Authority field investigation.

In calculating NDVI, LANDSAT data was changed into radiation luminosity and reflectance, and QuickBird data changed into reflectance. The formula for calculating NDVI is shown below:

$$NDVI = \frac{BAND4 - BAND3}{BAND4 + BAND3} \qquad (1)$$

BAND3 : Red wavelength of reflectance

BAND4 : Near-infrared wavelength of reflectance

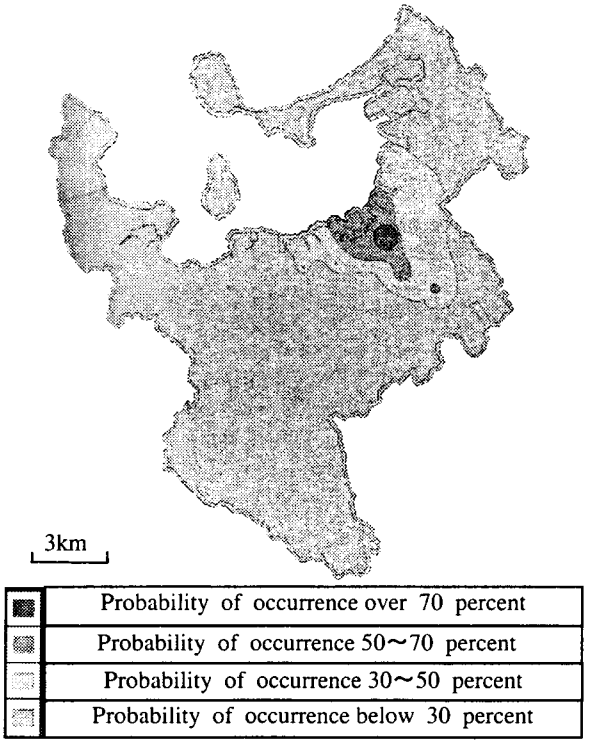


Fig.2. Probability of heat island phenomenon occurrence in percentage.

4. Results and Discussion

1) LANDSAT 5 / TM Image Analysis

The data used in this analysis is six scenes from 1990 to 2000 of LANDSAT 5/TM daytime data of summer. **Figs.3** and **4** show the image analysis result and NDVI image of Fukuoka City. The white portion shown in the NDVI image in **Fig.4** is a place with higher urban land use. The vegetation coverage rate of Fukuoka City for each area is shown in **Fig.5.** Where each district was extracted from the image having the NDVI value 0.25 or more to be considered as a vegetation region from NDVI analysis and calculated the vegetation coverage rate.

From **Fig.5** we can see that, on an average in each area of the Fukuoka City vegetation coverage rate from 1990 to 2000 is going up. Moreover, Sawara ward and Nishi ward are showing higher vegetation coverage rate compared to other areas. In Hakata ward and Chuo ward vegetation coverage rate is less than twenty percent, indicating low vegetation in these areas. This is also the

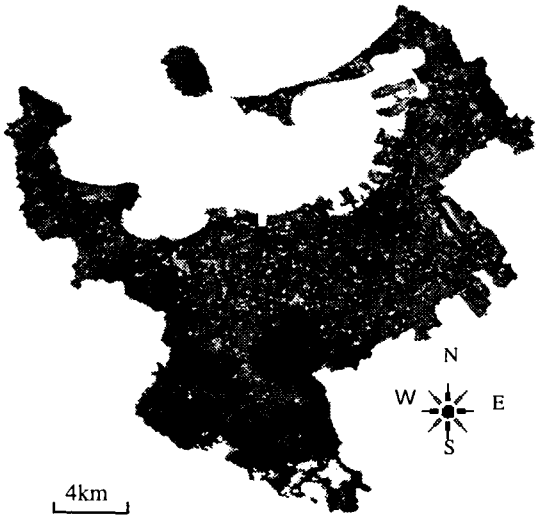


Fig.3. The false color image.

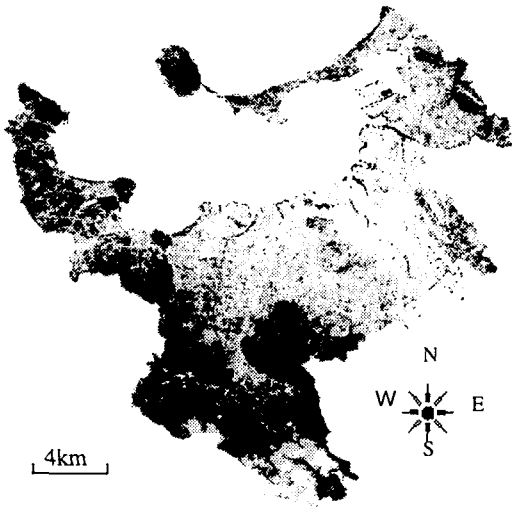


Fig.4. The NDVI image.

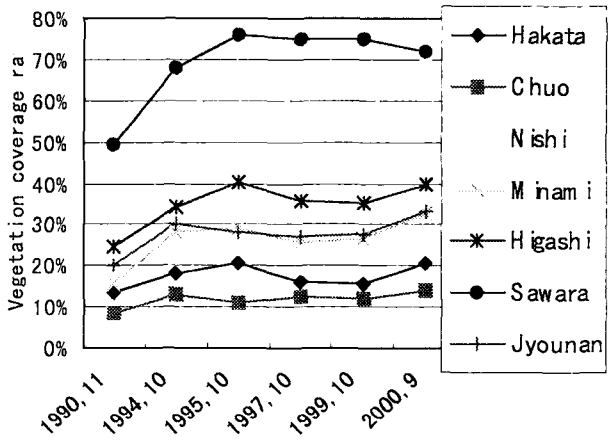


Fig.5. The vegetation coverage rate of each district.

area where the high temperature region frequency appears as shown in **Fig.2**. Thus, although heat island phenomenon is considered to be related to various factors, such as the weather etc., but low vegetation activity in the concerned region might be one of the important factors behind its occurrence.

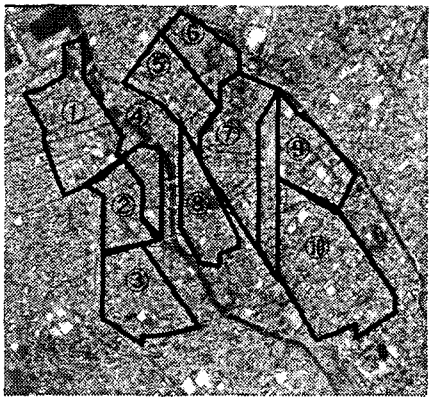
2) QuickBird Image Analysis

In this analysis, we have selected the area shown in **Fig.2** having probability of heat island phenomenon occurrence over 30 percent and short-listed them in **Fig.6. Figs.7** and **8** show the image analysis result and NDVI image of Sumiyoshi. The area of having this probability over seventy percent is in Kawabata and fifty percent in Sumiyoshi, Hakata St. Front and Tenjin, as shown in **Fig.6**. The Kawabata area also showed lower value of NDVI, as low as 5 percent (see **Fig.9**). The highest value for NDVI is observed in Gokusyo area where there are many temples and vegetation coverage rate is higher due to planting and preservation of various kinds of trees. Whereas, in Chuo-ward less vegetation activity is observed compared to Hakata ward as this area is crowded with buildings leaving little open spaces for planting trees or vegetation. Overall in both the Hakata and Chuo wards vegetation coverage rate is observed to be as low as 5 percent

In the areas where probability of heat island phenomenon occurrence was more than 50 percent the vegetation coverage rate were also found to be lower through the NDVI value. The lack of vegetation and plantation might be the cause for which heat island phenomenon is increasing in these regions as heats are absorbed by the concrete structures for long. Thus immediate increase in plantation and vegetation in these areas are highly recommended. In addition to this, roof plantation and tree planting in riverbanks or roadsides might be introduced. This will in turn act as one of the methods to reduce heat island phenomenon.

5. Conclusion

In this study, relationship of heat island phenomenon and the vegetation coverage rate is discussed by using satellite remote sensing technique. But in addition to this



①Tenjin ②Watanabe ③Shirogane
④Haryoshi ⑤Kawabata ⑥Gokusyo
⑦Hakata St. Front ⑧Sumiyoshi
⑨Hakata St. East
⑩Hakata St. Minami

Fig.6. Location of the study areas

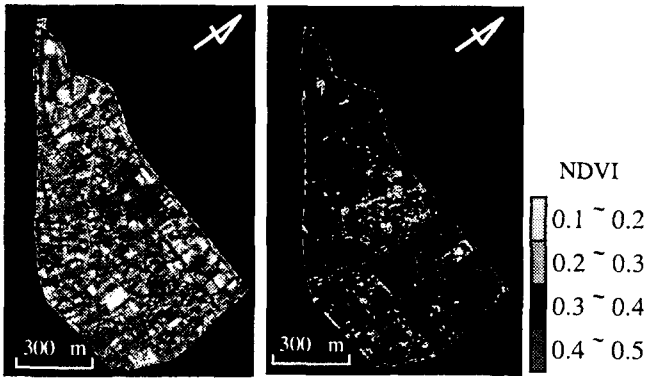
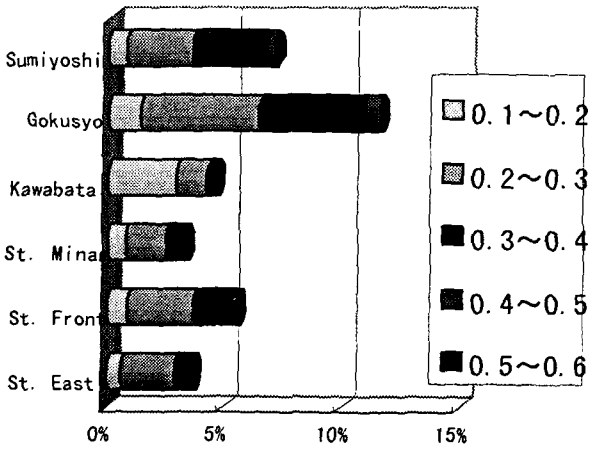
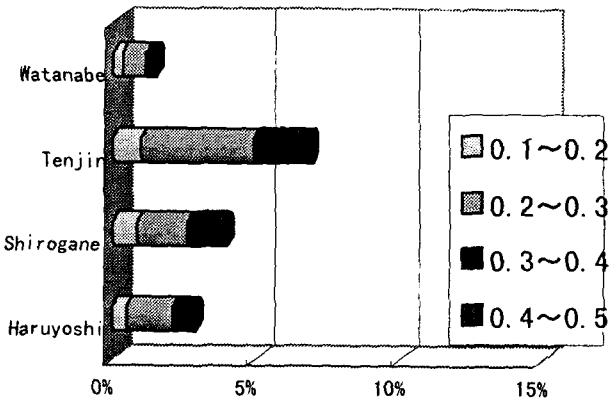


Fig.7, 8 The false color image (left) and The NDVI image (right) in Sumiyoshi.



(a) Hakata ward



(b) Chuo ward

Fig.9 The vegetation coverage rate of each town.

there are various factors that are related to this phenomenon e.g., land use, population distribution, weather condition, wind direction, humidity etc. These factors should also be incorporated in analyzing the cause for heat island phenomenon. Also the selection of proper place for vegetation and plantation such as roof, wall etc. are also important decision to reduce this phenomenon. We aim to extend our present study on these areas.

References

[1] Fukuoka City Urban Maintenance Bureau, 1999. A Ground Plan of Fukuoka City, Department of Park Planning Section.

[2] Kyusyu Environment Managers' Association, 2003. The heat island phenomenon research report.

[3] **URL:** USGS Landsat Project/Technical Information Lansat5:http://ltpwww.gsfc.nasa.gov/IAS/handbook/handbook_toc.html