Improved method for identification of plant covered area in urban regions using surface reflectance spectra of IKONOS satellite image

The University of Tokyo　Regular member　○Hiroaki Furumai
The University of Tokyo　Non-member　Jinyoung Kim

１．Introduction

Plant covered area plays a significant role in rainfall interception and infiltration which results in runoff reduction and their peak delay. Accurate identification of pervious and impervious urban surface allows urban runoff simulation to assess non-point pollutant load and effectiveness of recharge of subsurface water quantitatively. Therefore, the land surface classification has been conducted by the 10m grid landuse information data (Hijioka *et al*. 2001, Furumai *et al*. 2001). Recently, remarkable advances in satellite sensor technology have made feasible the use the high resolution satellite image for urban landuse classification. NDVI (Normalized Difference Vegetation Index) has been most commonly used for identification of plant covered area such as forests in satellite image. The purpose of this study is to investigate the effectiveness of the conventional NDVI method for extraction of plant covered area in urban regions and to improve the method for urban surface with complicated textures using IKONOS satellite image.

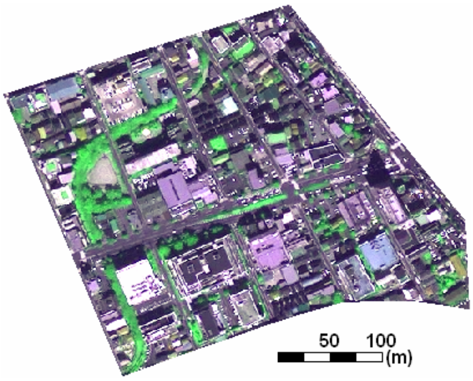

Figure 1 IKONOS image of study area

2. Method

(1) Study area and data descriptions

- Study area : Shimura district in Itabashi Ward, Tokyo, 12ha (Figure 1)
- Satellite image : IKONOS, 4 multi spectral bands, which are blue(B), green(G), red (R) and near-infrared (NIR), September/2004

(2) Vegetation indices and methodology

Spectral vegetation indices are widely used as indicators of temporal and spatial variations in vegetation structure and biophysical parameters. Most of vegetation indices make use of high reflectance at NIR and low reflectance at R. Among them, NDVI is most commonly used one. According to the surface reflectance spectra for several vegetation types (Bowker *et al*. 1985), vegetation area represents NDVI value over zero. Spectral properties at 4 bands of IKONOS satellite image for an urban region, were used to develop a new vegetation identification index and their criteria in this study.

Figure 2 Area standing for NDVI > 0

3. Results and Discussions

(1) Identification of plant covered area by NDVI method

Figure 2 shows the area which has NDVI value over zero. The area of NDVI > 0 was remarkably broader than the visually identified plant covered area in IKONOS satellite image (Figure1).

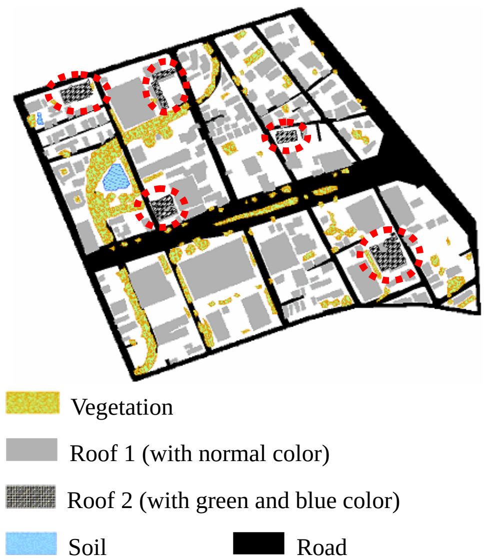

Figure 3 Five categories according to land surface type

Key Words　IKONOS satellite image, plant covered area, urban runoff, landuse classification

Contact address　〒113-8656　Research Center for Water Environment Technology,　TEL 03-5841-6239

The category of roof with green and blue color (highlighted part by dotted circle in Figure 2) represented by positive NDVI values. The application of NDVI method alone was found to be inadequate to identify the plant covered area for an urban region.

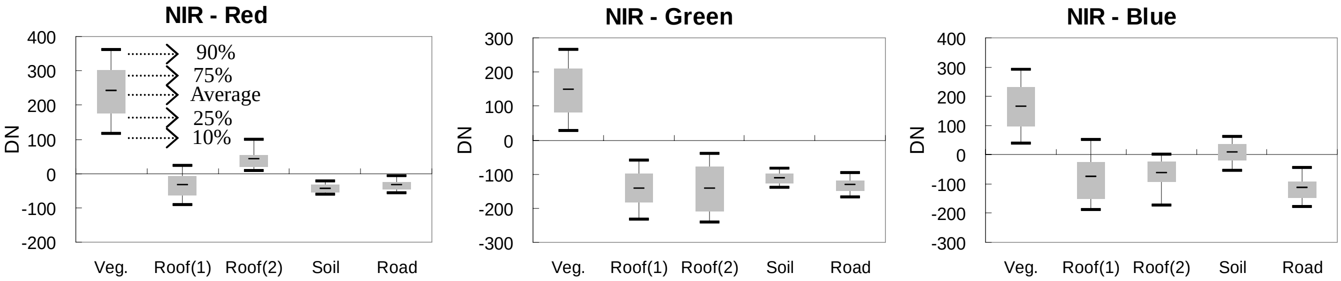

Figure 4 Spectral properties of (NIR-Red), (NIR-Green) and (NIR-Blue) for 5 surface categories

(2) Assessment of vegetation spectral properties

The study area was categorized into 5 surface types (vegetation, roof with normal color and green/blue color, soil, road) through the visual interpretation of IKONOS image and ground truth data as shown in Figure 3. In order to compare the vegetation spectral properties with the other urban surfaces, relative spectral difference among B, G, R and NIR at 5 categories were investigated. Three combinations of subtractive spectra were shown in Figure 4. Not only the (NIR-R) which represents a numerator of NDVI formula but also (NIR-G) and (NIR-B) appeared to be good indicators for distinguishing plant covered area from the other urban surfaces, compare to other combinations. Two dimensionless algebraic expressions were selected to identify the plant covered area in urban region as follows;

$$0 < (NIR\text{-}G) / (NIR\text{-}R) < 1 \quad \& \quad |(NIR\text{-}G)\text{-}(NIR\text{-}B)| / \sqrt{2} < K$$

Here, K stands for the distance from y=x line which consist of x axis of (NIR-B), and y axis of (NIR-G). The optimum K value was estimated to be 70 for this study area.

(3) Identification of plant covered area by the new indicators

Figure 5 represents plant covered area estimated with the new criteria. Comparing with the result following NDVI method, plant covered area was extracted more properly. In addition, green/blue colored roof surfaces are successfully excluded. The effectiveness of the criteria was verified through the application for three different kinds of vegetations (i.e. park, forest and marsh) in Kumamoto area, imagery of which was acquired on a different date (May, 2002).

Figure 5 Plant covered area identified with new method

4. Conclusion

The application of NDVI method to urban regions for extracting vegetation area led to overestimation of plant covered area and wrong identification of roof with green/blue color. Therefore, subtractive spectra combinations of 4 multi bands were investigated to develop an improved index and criteria for identification of plant covered area. In addition, roof garden, road with overspreading tree, planting zone in side walk and near the building sites, and plant zone in median strips are minutely extracted from urban region with complicated surface texture with the application of the improved method.

Reference

Bowker D.E., Davis R.E., Myrick D.L., Stacy K. and Jones W.T. (1985), *Spectral Reflectances of Natural Targets for use in Remote Sensing Studies*, NASA Reference Publication, 1139.

Furumai H., Hijioka Y. and Ichikawa A., 2001, *Wet Weather pollution Analysis by a Distributed Model in a Combined Sewer System Containing an Additional Stormwater Pipe for Inundation Control*, Japan Sewage Works Association, 38(467), 99-112, In Japanese.