CS-216 QUANTITATIVE EVALUATION OF URBANIZATION AND ITS INFLUENCE ON THE NATURAL ENVIRONMENT IN URBAN AREAS USING SATELLITE DATA

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1. INTRODUCTION

Rapid growth of urban areas in developing countries and its impact on the natural environment is one of the severe global environmental problems. In areas where site investigation on the ground is very difficult, development of a reliable evaluation method for the urban environment using satellite data is demanded. In this study a new evaluation method for the urban environment using earth observation satellite data is proposed and its effectiveness is verified. As a case study data from three Asian cities which have very different development conditions have been used. Namely, Colombo City in Sri Lanka, Kuala Lumpur City in Malaysia, and Nagoya city in Japan.The urban index UI calculated by Landsat TM data has been proposed and it was found that this index has a strong relation with the building cover density for 500m grids in the different urban areas. Hence UI was used to evaluate the state of urbanization. The Normalized Diffference Vegetation Index (NDVI) was found to have a strong relation with the vegetation density which represents the natural environment in the urban area. Hence NDVI was used to evaluate the condition of the natural environment in the urban area.Therefore the relation between the indices UI and NDVI represent the relation between urbanization and the natural Environment in the urban area.

2. DATA USED IN THE STUDY

Landsat TM data used of Colombo City was of December 1987 and February 1993. TM data of Kuala Lumpur City was of June 1989 and of March 1996. TM data used of Nagoya City was of Nov 1985, Nov 1991 and Nov 1995. Building cover maps of Colombo, Kuala Lumpur and Nagoya cities were scanned and the digital data was used in the study.

3. THE PROPOSED INDEX UI

The proposed index UI was defined as shown below using Landsat TM bands 7 and 4.

$$UI = \left(\frac{Band7 - Band4}{Band7 + Band4} + 1.0 \right) \times 100.0$$

Based on the relation of UI with Building Cover

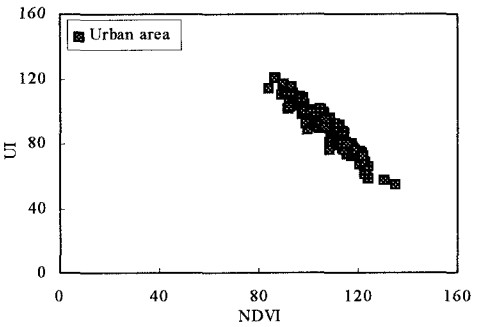

Fig.1 Colombo City

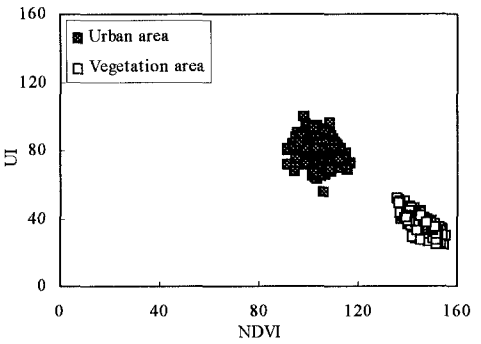

Fig.2 Kuala Lumpur City

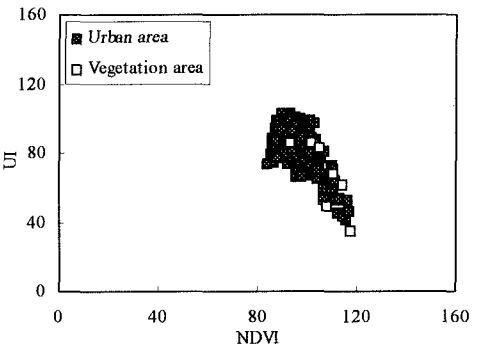

Fig.3 Nagoya City

Density for 500m grid units the UI values were modified to obtain a uniform relation between UI and the building cover density for different region and different season so that the UI values for 500m grids in the different urban areas can be directly compared.

4. ANALYSIS AND RESULTS

4.1 SPATIAL APPLICATION OF THE INDICES UI AND NDVI TO QUANTITATIVELY EVALUATE AND COMPARE URBANIZATION IN DIFFERENT URBAN AREAS

The relation between the modified UI values and NDVI values for 500m grids for the different urban areas considered in this study are shown in Figs.1 to 3. The TM data used for Colombo city was of Feb. 1993. TM data of Kuala Lumpur city was of June 1989 and TM data of Nagoya city was of Nov. 1991.The areas within the administrative boundaries of the cities have been considered. The grids have been seperated into urban and vegetation classes by a land cover classification using a neural network. If more than 70% of the TM pixels within a 500m grid belonged to one class then that grid was classified as belonging to that class. The UI-NDVI relation represents the intensity of urbanization by the number and value of the urbanized unit area. A comparison of the Figs.1 to 3 show that in Colombo there are no large vegetation areas within the city limits, while in Kuala Lumpur there are large areas of both urban and vegetation classes within the city. Nagoya city has very large urban areas and a few large vegetation areas. Therefore two types of urbanization can be recognized by these figures. In Nagoya and Colombo cities the urbanized areas have spread from the center close to the administrative boundaries of the cities while in Kuala Lumpur the urbanized areas and vegetation areas are mixed in good balance.

4.2 TEMPORAL APPLICATION OF THE INDICES UI AND NDVI TO QUANTITATIVELY EVALUATE CHANGES IN URBANIZATION AND ENVIRONMENTAL CONDITIONS

The spectral change vectors in Figs.4 to 6 show the representative large changes in urbanization and the natural environment in recent times, within the city limits of the respective urban areas. The images of the different dates mentioned in section 2 have been histogram matched and radiometrically corrected using ground truth of invariant features in the urban areas. These figures show that the changes in urbanization in Colombo and Nagoya cities are small while in Kuala Lumpur many vegetation areas have changed into urbanized areas.

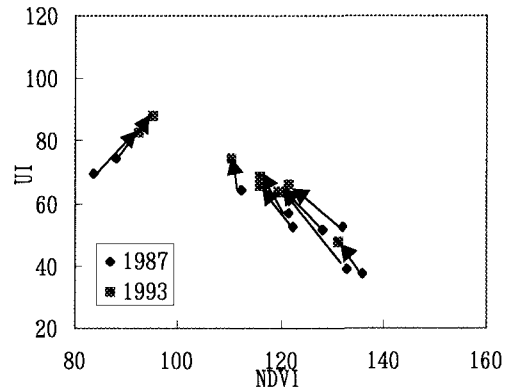

Fig 4.Representative Spectral Change Vectors for Colombo City

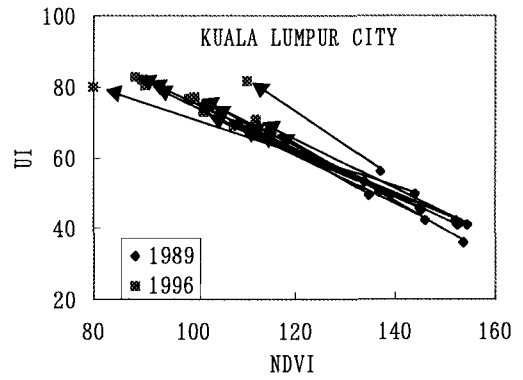

Fig 5.Representative Spectral Change Vectors for Kuala Lumpur City

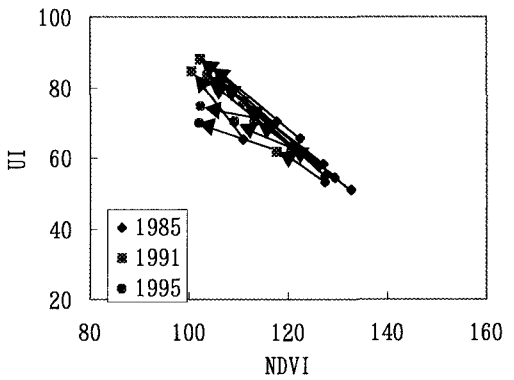

Fig 6.Representative Spectral Change Vectors for Nagoya City