DISTRIBUTIONAL ANALYSIS
OF GREEN TRACTS AND VEGETATION-COVERED AREAS

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ABSTRACT:

The green tract of land is one of the significant factors for urban planning and urban management to improve and conserve the urban environment. Planning the green tracts is often carried out as a part of land use strategy based on relation to neighborhood, their scale, functions, and locational condition. On the other hand, a vegetation-covered area is a considerable focus of investigation for urban environment. For making the vegetation cover map, it is required to estimate vegetation cover ratio widely. Many previous studies have discussed methods to calculate vegetation cover ratio applying satellite remotely sensed data. In general, the green tracts contain both vegetation-covered areas and vegetation-uncovered areas because there are various kinds of parks/green zones assigned to the green tracts. In addition, the vegetation-covered areas usually include the places allocated to other land use categories excluding the green tract. In case of producing a plan for open spaces, it is necessary to confirm the current status of not only the green tracts of land use but also the vegetation-covered areas. The objective of this study is to develop the comparison method for the difference of distribution between the green tracts and the vegetation-covered areas using a land use map and satellite remotely sensed data. The decision tree method including the two viewpoints from parcel level and local area level was examined as the comparison method. It was shown that the developed method might provide some suggestions for producing a plan for open space.

1. INTRODUCTION

The green tract of land is one of the significant factors for urban planning and urban management to improve and conserve the urban environment. It plays an important role in the evaluation of urban environment; fire spread prevention, refuge place in disaster, field of relaxation, etc. Planning the green tracts is often carried out as a part of land use strategy based on relation to neighborhood, their scale, functions, and locational condition. On the other hand, a vegetation-covered area is a considerable focus of investigation for urban environment. It is expected to use a vegetation covered map for the urban climatic simulation, the evaluation of fire spread prevention, the estimation of the sensible temperature, and so on. For making the vegetation cover map, it is required to estimate vegetation cover ratio widely. Many previous studies have discussed methods to calculate vegetation cover ratio applying satellite remotely sensed data.

In general, the green tracts contain both vegetation-covered areas and vegetation-uncovered areas because there are various kinds of parks/green zones assigned to the green tracts. In addition, the vegetation-covered areas usually include the places allocated to other land use categories excluding the green tract. In case of producing a plan for open spaces, it is necessary to confirm the current status of not only the green tracts of land use but also the vegetation-covered areas. Through the comparison of the distribution between the green tracts and the vegetation-covered areas, the regions, where the green tract covered with vegetation should be improved, might be suggested. The objective of this study is to develop the comparison method for the difference of distribution between the green tracts and the vegetation-covered areas using a land use map and satellite remotely sensed data. We estimated vegetation-covered areas applying normalized vegetation index（NDVI）derived from QuickBird data and land use data. The decision tree method including the two viewpoints from parcel level and local area level was examined as the comparison method. It was shown that the developed method might provide some suggestions for producing a plan for open space.

2. METHODS AND MATERIALS

2.1 Study Area

Figure 1 shows a study area in this research. The area is located in the Kansai district, the western part of Japan. It covers 10 km horizontally by 10 km vertically. There have been a variety of urbanization types since the end of World War II in this area. Therefore, many kinds of land use exist: industrial areas, residential areas, residential areas（new town type）, commercial areas, etc. There is a large difference of greenery status between their locations.

2.2 Data

We used two kinds of spatial information for applying the calculation of a green tract map and a vegetation-covered map as follows.

2.2.1 Satellite Data: Multispectral data of QuickBird, observed on 21 February 2002 with a spatial resolution of 2.4 m/pixel, were adopted. The off nadir angle in the

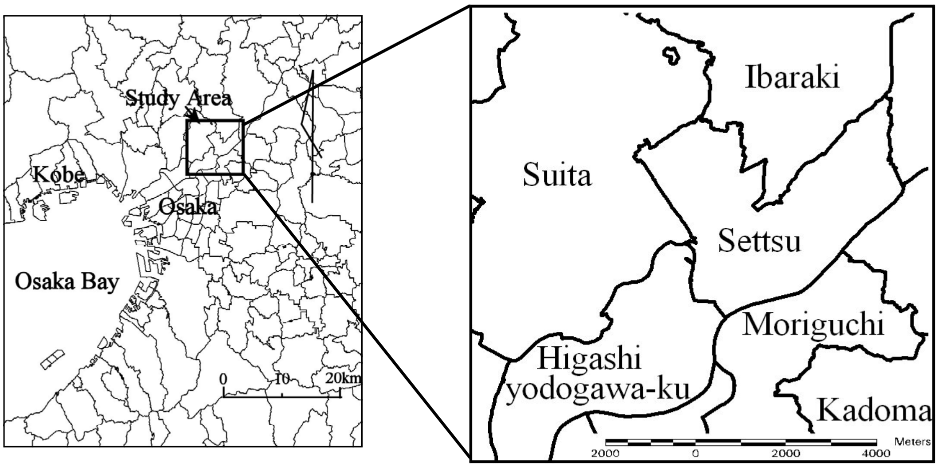

Figure 1. Study area in this research. The area is located in the Kansai district of Japan. It covers 10 km horizontally by 10 km vertically. Five cities and one ward are mainly included in this area.

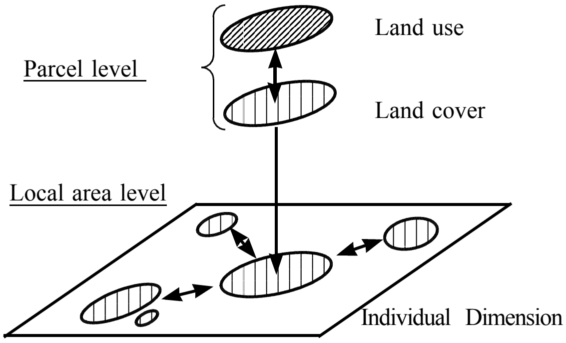

Figure 2. Concept of the decision tree method developed in this study.

observation of the data was 5 degrees. Atmospheric correction based on MODTRAN was carried out so that NDVI was derived from the reflectance data. Before the calculation of vegetation cover ratio, reflectance data were resampled with a spatial resolution of 10 m/pixel.

2.2.2 Land Use Map: We applied Detailed Digital Information（10 m grid land use）of Kinki area to the analysis as land use data. The categories of these land use data contain industrial area, residential area, commercial area, road, public space, forest/grassland, agricultural land, and park/green zone.

2.3 Methods

2.3.1 Concept of the decision tree method: Figure 2 shows the concept of the decision tree method developed in this study. The method is composed of two viewpoints: parcel level and local area level. In general, it is required to investigate the conditions of vegetation cover considering land use because the greenery planning depends on their land-use categories. At the parcel level, theses comparisons are carried out as parcel scale evaluations. In addition, the viewpoint of local scale is necessary for the vegetation-covered areas. It is notice that the lineation of the vegetation-covered areas with some cores of greenery plays an important role in the conservation of ecosystem. Therefore, this method contains the relative evaluation of individual dimension of the current vegetation-covered area（CVA）in a local area. It is clarified the relative role of the CVA in the conservation of greenery in the local area at the local area level.

2.3.2 Calculation of Vegetation-covered Area: We applied the practical estimation method based on the assumption that the radiance of a mixel was represented by linear combination of the radiance of its components（Hirano, et al. 2002）. This estimation method is described with Equation（1） as

$$\alpha = \frac{a\ NDVI + b}{c\ NDVI + d} \qquad (1)$$

where
$$a = V_s + NIR_s$$
$$b = V_s - NIR_s$$
$$c = V_s - V_v + NIR_s - NIR_v$$
$$d = V_s - V_v - NIR_s + NIR_v$$

α is vegetation cover ratio in percent, V reflectance in the visible band, NIR reflectance in the near-infrared band, v and s mean vegetation-covered area and vegetation-uncovered area, respectively. Through conforming the land-cover categories to the land-use categories, we decided the reflectance values of V_s, NIR_s, V_v, and NIR_v of each land-cover category using the land use data.

Then, the areas, where the vegetation cover ratio were more than 50 %, were defined as vegetation-covered areas（VA）. On the other hand, regardless of vegetation cover ratio, the areas, where land-use categories were agricultural land, were defined as VA.

2.3.3 Calculation of the Local Vegetation Cover Ratio: For investigating local status of greenery, we calculated a local vegetation cover ratio（LVR）with window process, each 500 m by 500 m in size. The VA were applied to this calculation. We compared the LVR with the standard value, 15%, established as the one of the objectives for greening by the local government, Osaka prefecture.

2.3.4 Calculation of Dimension per Vegetation-covered Area: Practically, to examine the LVR is not sufficient for evaluating the local greenery. The role of a

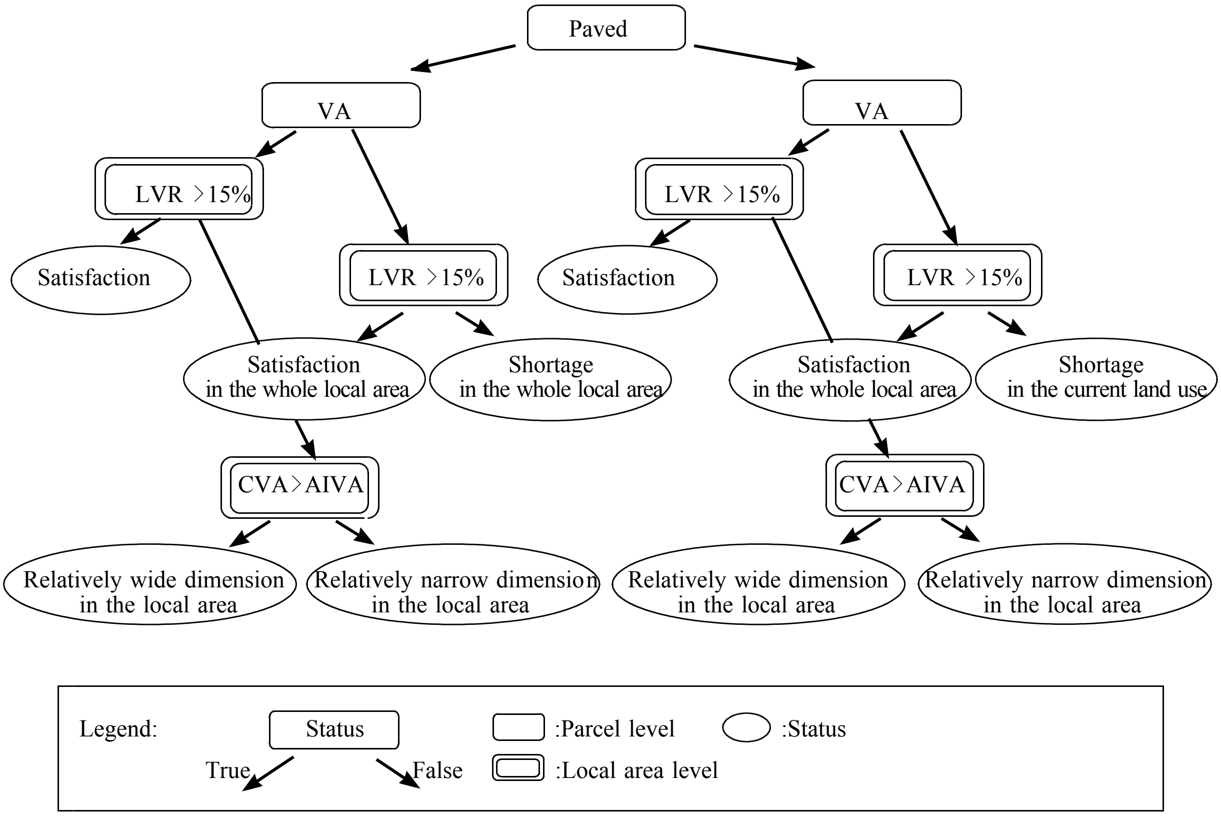

Figure 3. Decision tree methods developed in this study. This method includes 4 stages and 9 branch points.

vegetation-covered area depends on its individual dimension since a vegetation-covered area, which is attended with large dimension, has a possibility to become a core of greenery in a local area. Thus we calculated individual dimensions of VA, called IVA. IVA is the number of pixels of a VA, which form a region in isolation from each other. As the standard of local comparison, the average of IVAs, AIVA, in a local area is calculated as follows.

$$AIVA = \sum_{i=1}^{N} \frac{IVA_i}{N} \qquad (2)$$

where N is the number of the formed regions of a vegetation-covered area in the local area.

2.3.5 Decision Tree Method: Figure 3 shows the decision tree method we developed in this study. This method includes 4 stages and 9 branch points. On the first and second stages, investigation from both sides of land use and land cover is carried out by pixel as parcel level processes. We divided land use categories into two classes: a paved area and an unpaved area. While the paved area contains industrial area, residential area, commercial area, road, and public space, the unpaved area includes forest/grassland, agricultural land, and park/green zone.

As the local area level process, the analysis of VA in a local area is situated on third and forth stages. Comparison between LVR and a standard value of 15 % is performed so that it is necessary for greenery planning to clarify the vegetation cover ratio in a local area. Then, through the calculation of a difference between the dimension of CVA and the AIVA, the relative feature of a vegetation-covered area in a local area is indicated.

The result of the decision method contains 6 kinds of status; "Satisfaction" means the satisfaction of standard vegetation cover ratio. This status includes a recommendation to conserve the CVA because it composes the local greenery in conjunction with other VA. "Satisfaction in the whole local area" shows that VA in the whole local area satisfy the requirement although there is not a CVA at the center of the local area. It implies an advisement to conserve the VA totally in the local area. Two of them mentioned above belong to the group serving the need for the greening of prefecture policy. On the other hand, "Shortage in the whole local area" reveals the lack of VA in the local area. This status suggests recommendation of greening since there is the lack of the dimension of VA in the local area. "Shortage in the current land use" shows there are no CVA and the shortage of VA in the local area even though the current land-use category is allocated unpaved area. It is concerned with the usage of the current land use. "Relatively wide dimension in the local area" and "Relatively narrow dimension in the local area" show the relative feature of the CVA in the local area where there is the shortage of greenery. The one reveals that the CVA has a potential for becoming the core of green belt because it has larger dimensions than AIVA. The other indicates that since the dimension of CVA is smaller than

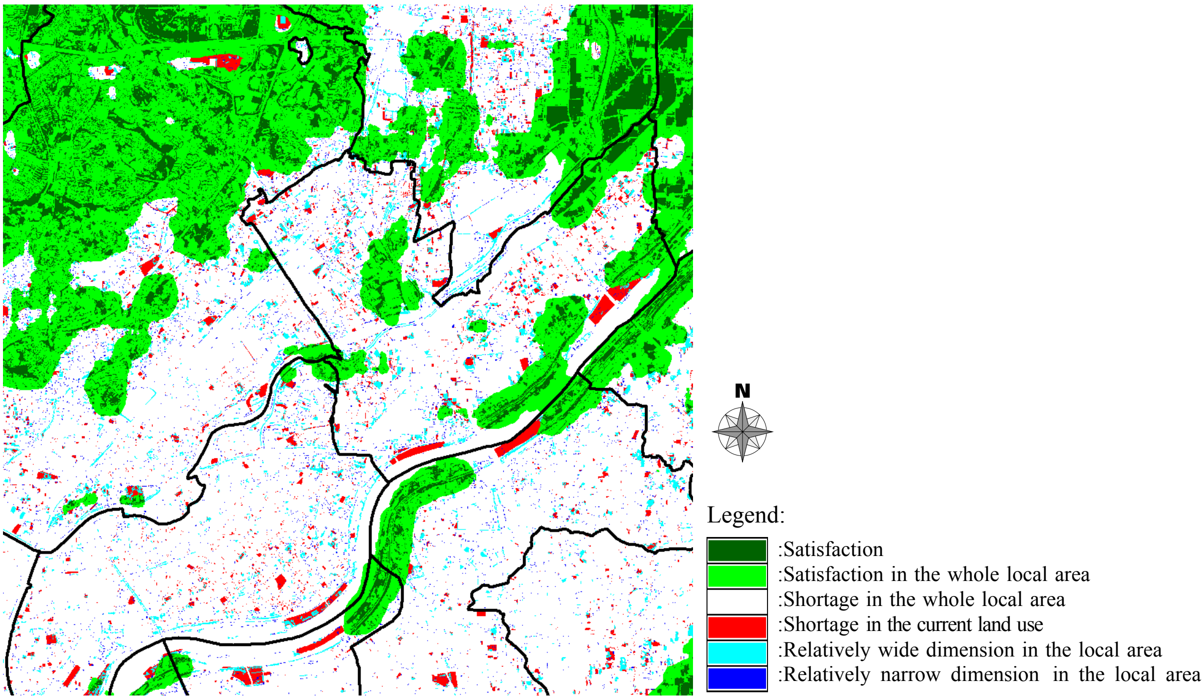

Figure 4. Result of the decision tree method developed in this study. The result contains 6 categories concerned with status of vegetation cover.

AIVA, it is necessary to consider it to be conserved and to become a factor composing the linear of VA.

3. RESULTS AND DISCUSSION

3.1 Results of Application of the Decision Tree Method

Figure 4 shows the result of application of the decision tree method. It seems that there are large areas of "Satisfaction" and "Satisfaction in the whole local area" in the northwest and northeast part of this site. While the northwest part contains large residential areas （new town type）, the northeast part has a lot of agricultural lands. Most of center areas have a tendency to belong to "Shortage in the whole local area" colored with white. However, there are many parts of "Relatively wide dimension in the local area" colored with cyan around the white areas. These cyan areas seem to be situated along linear structures: confluent, road, and railroad. It is suggested that because these linear structures include greenery; trees lining a street, green lands along riverbeds etc., they may play important role in greening in the local area.

3.2 Application of the Results

Through interpreting the result of the decision tree method, some suggestions about greening planning are derived. This section examines briefly the interpretation of the result.

3.2.1 "Shortage in the current land use" + "Shortage in the whole local area": Both "Shortage in the current land use" colored with white and "Shortage in the whole local area" colored with red on Figure 4 mean the shortage of VA. At the place where the white area and the red area are adjacent to each other, however, there area possibility to increase VA in a unpaved land use area. This increasing may become feasible since it is not necessary to change the current status of land use.

3.2.2 "Shortage in the current land use" + "Relatively wide dimension in the local area": "Relatively wide dimension in the local area" colored with cyan reveals the start point of greening to make the lineation of the VA. In case that the cyan area and the red area are adjacent to each other, it may assume a higher priority for achieving the standard of vegetation cover ratio.

4. CONCLUSIONS

In this study, the decision tree method concerning relationship between land use and land cover was developed. The paved/unpaved information as a land use data and the vegetation-covered/uncovered areas as a land cover data were applied to this method. It was implied that the results of this method might provide 6 suggestions for greenery planning.

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