FUNCTIONAL ANALYSIS OF URBAN GREEN COVER USING SPOT DATA AND GEOGRAPHICAL INFORMATION

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Abstract

The recent urban development in our country has resulted in a drastic decrease in green cover and the aggravation of living environment in urban areas all over the country. Currently, many measures to conserve and increase green areas have been taken. In order to promote green conservation plans and comprehensive planting plans in cities, full understanding and functional analysis of green cover in these urban ares are essential. This paper reports functional analysis of the urban greens in Kamakura City, Kanagawa Prefecture, as an example, from a macroscopic viewpoint using SPOT data and various geographical information.

1. Introduction

In big cities in Japan, a variety of measures have been taken to conserve their green environments. However, these measures work out successfully in regions subjected to legal regulation, while in areas where no legal regulation is imposed the green area has been decreasing year by year. This tendency is common all over the country, and presently, many measures for green conservation and promotion have been actively executed. In this study, an old city, Kamakura, was taken as a case study, in which SPOT data and various geographical information were used to conduct macroscopic analysis of the present situation of the green cover and functions of tress in the city.

2. Functions of Green Areas

Generally speaking, functions of green areas covered with trees in a good natural environment are summarized as shown in Fig. 1. Functions of green areas are categorized into (1) disaster prevention and land conservation, (2) better living environments, (3) ecological conservation of nature, (4) cultural function, (5) function as biological indicators, and (6) educational function.

(1) Disaster prevention/land conservation

Green areas have the function of preventing natural disasters and fire spread and alleviating pollution. From a viewpoint of natural disaster prevention, land failure prevention, soil runoff prevention, flood control and replenishment of water resources are included. In addition, green areas provide places for evacuation or prevention of fire spread at the time of a big fire or an earthquake, and alleviation of pollution which exceeds the mental torelance in daily life.

(2) Better living environment

Green areas provide conservation of natural landscape, pleasure of recreation, climatological buffering, air purification and control of urbanization, all of which closely relate to living environments, and aesthetical function such as amenity.

(3) Econological conservation of nature

Green areas has the function to assure balanced ecosystems consisting of plants and animals.

(4) Other functions include the cultural role such as cultural treasures, natural monuments and historical spots, the role as biological indicators, and the educational/emotional role provided through contact with nature.

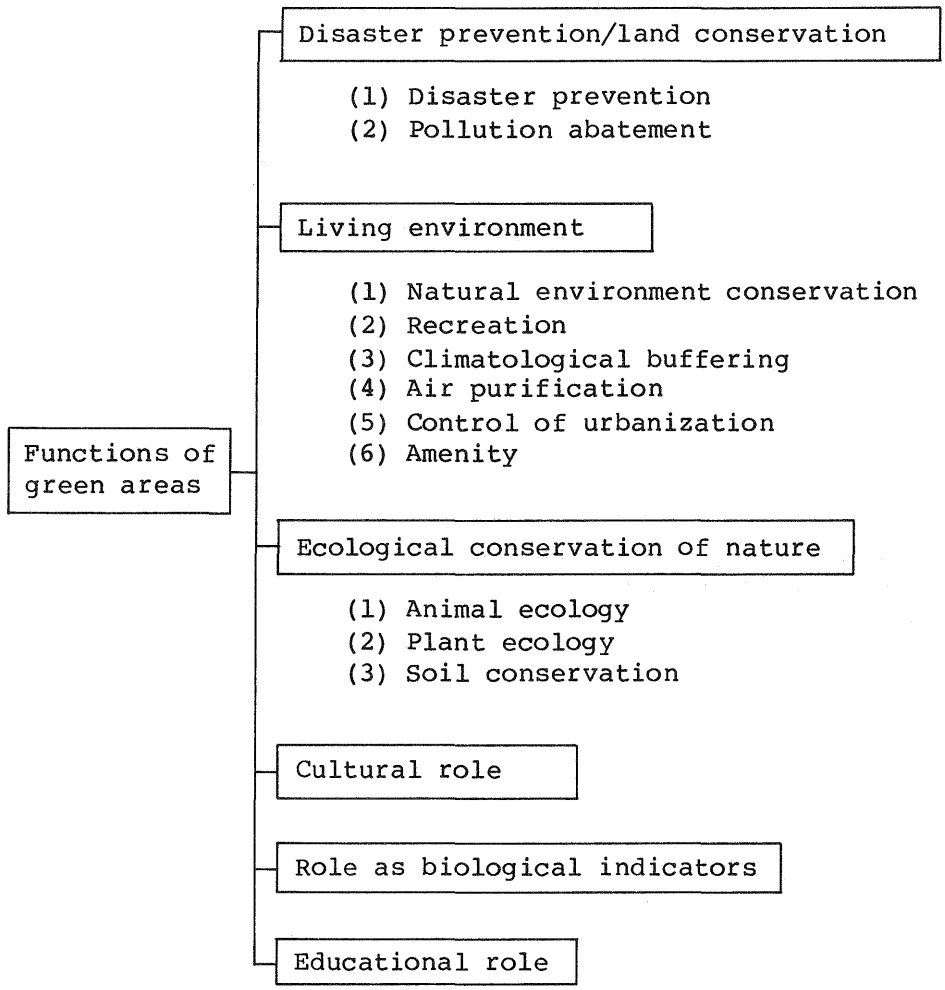

Fig. 1 Functional divisions of green areas

3. Study Area

Kamakura City is located south-east of Kanagawa Prefecture or in the east part of Shonan Area (Fig. 2), and geomorphologically in the neck of Miura Penninsula. The city covered with hilly land spreading in horseshoe shape has a low land of the Namekawa in the central part. In the 12th century, the Kamakura shogunate was established in the city as the center

of the politics and economy in the medieval ages. Even nowadays, the city has many temples and shrines built in those days, as said comparatively "Kyoto and Nara in the west, and Kamakura in the east". The city is a tourist city with abundant historical heritages and scenic beauty.

The our study covered the whole city (39.53 km^2).

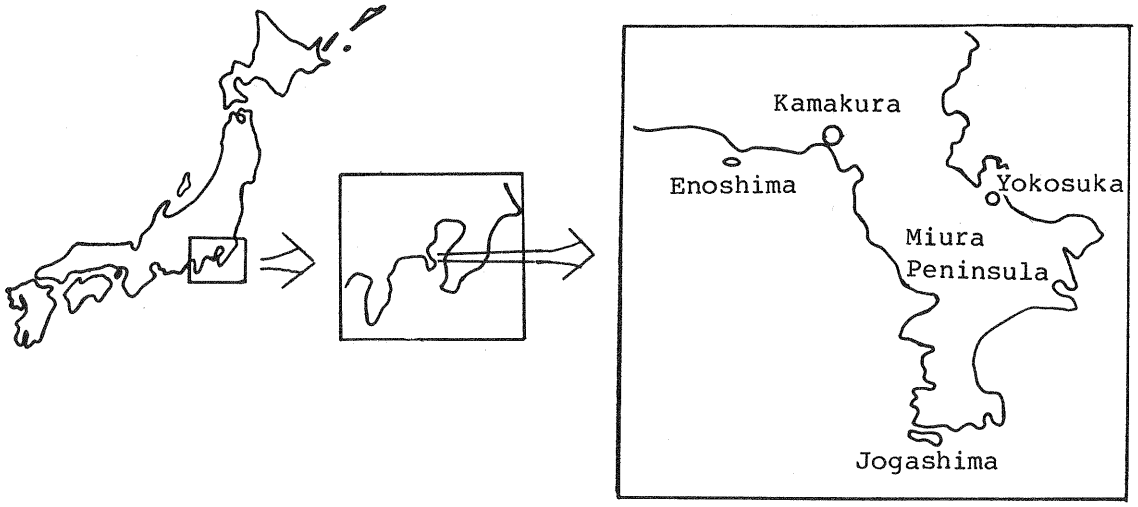

Fig. 2 Study area

4. Data to be Used

Data used for the analysis include:

- o SPOT multi-spectral data CCT Observed on 7 April 1986 K331-J279
- o 1/25,000 land use maps (surveyed in September 1978) "Totsuka", "Fujisawa", "Kamakura" and "Enoshima".
- o 1/10,000 Kamakura City Urban Planning Map (Jan. 1986)
- o Collected maps of Kamakura City Living Environments (Feb. 1983)
- o Vegetation of Kamakura (Feb. 1973)

5. Analytical Method and its Details

Fig. 3 shows a flow of the analysis.

(1) Prior to rectification and image processing and analysis of geographical information, SPOT data were subjected to rectification. The pixel distance in the re-arrangement was 20 m and the nearest neighbor method was applied. Land use maps in 1/25,000 scale, urban planning maps in 1/10,000 scale and representative ones in the collected maps of Kamakura City living environments were put in to process to color images. The pixel size of these color images was 20 m x 20 m.

(2) Execution of land cover classification

The SPOT data were used to classify land cover with the nearest neighbor method. The classification categories were forest, grasses, golf course, field, paddy field, bare land, congested urban area, urban area with abundant greens, large scale structure, and water area. These categories were integrated to prepare a green area distribution image.

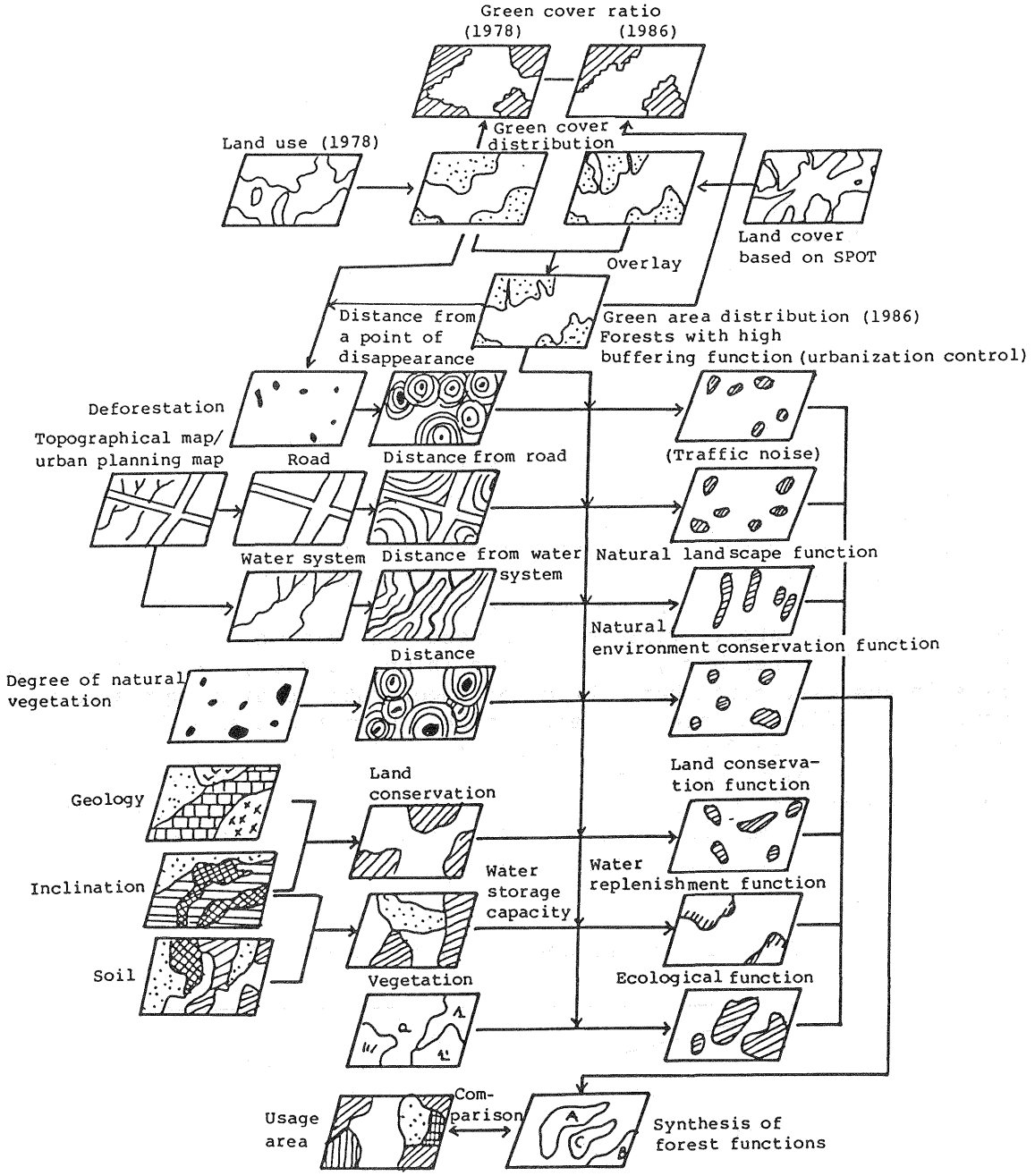

Fig. 3 Analytical method

(3) Understanding of the present situation of green areas

In order to know the present condition of green areas, these categories were integrated based on 1978 land use data (processed to images in (1)) to prepare a green area distribution image.

After this image was overlayed with the green cover distribution image made in (2) to update the information, a green cover distribution image of 1986 was prepared. Then, the green cover distribution image was used to compute the green cover rate in 100 m x 10 mm intervals. The green cover rate image and the result of the citizens' opinion survey for city planning summarized in the collected living environment maps of Kamakura City were compared to know the present situation and the green cover rate in the city.

(4) Functional Analysis of Forests

The functional analysis was made based on five categories in the light of the local characteristics of the city; 1. buffering function (buffering function against traffic noise and control/buffering function against urbanization), 2. function of conserving the natural environment, 3. function of conserving the land, 4. function of water replenishment, and 5. function of ecological conservation. In the functional analysis, each image data were overlayed in pixel unit for further processing.

6. Understanding of the Present Condition of Green Cover

Photo 1 shows the present condition of green cover as of 1986. Photo 2 gives the green cover rate computed in 100 m x 100 m intervals based on the present condition of the green cover distribution shown in Photo 1. Photos 3 and 4 indicate the result of the citizens' opinion survey for city planning (Changes in Green Area and the Present Condition of Greens, 1982.2). A comparison between the present condition of the green cover rate and the citizens' opinion survey suggests that the citizens in the Ofuna area in the north and the Koshigoe area in the south-east part where the green cover rate is very low expressed the opinion of too less green cover. On the other hand, the citizens in the Nikaido, Jomyou and Junisho areas in the east part where the green cover rate is high expressed the opinion of sufficient green cover. Table 1 summarizes annual changes in green cover from 1978 to 1986. This table indicates an approximately 3 km decrease in forests and an approximately 2 km increase in non-green area. Table 2 summarizes the areal ratio by the green cover rate as of 1986 (10% intervals). In Kamakura City, the area with 100% green cover accounts for approximately 30% of the whole city area.

Table 1 Annual changes in green area (km^2)

Green area \ Year	1978	1986
Forest	14.79	12.06
Natural green area	0.42	0.27
Green area for production	1.22	1.77
Man-made green area	1.65	1.65
Non-green area	21.45	23.78

Table 2 Ratio by green cover rate (%)

Green cover rate	Ratio	Green cover rate	Ratio
0 ∿ 10	11.19	51 ∿ 60	6.91
11 ∿ 20	13.21	61 ∿ 70	4.57
21 ∿ 30	6.85	71 ∿ 80	6.80
31 ∿ 40	7.50	81 ∿ 90	6.26
41 ∿ 50	5.27	91 ∿ 100	31.44

Photo 1. Green area distribution (1986) (© CNES 1986)

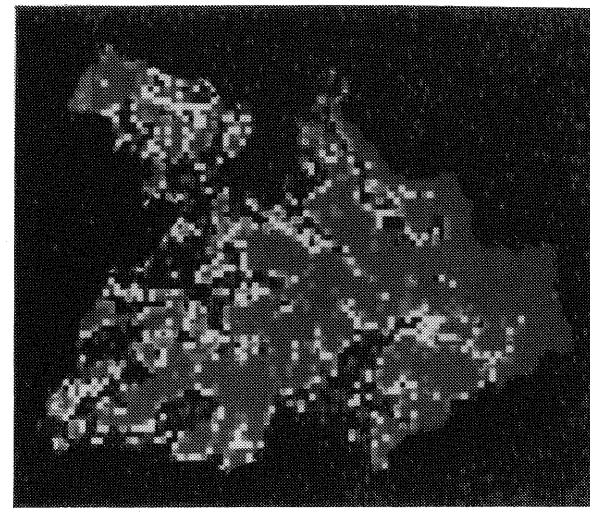

Photo 2. The present condition of green cover ratio (1986)

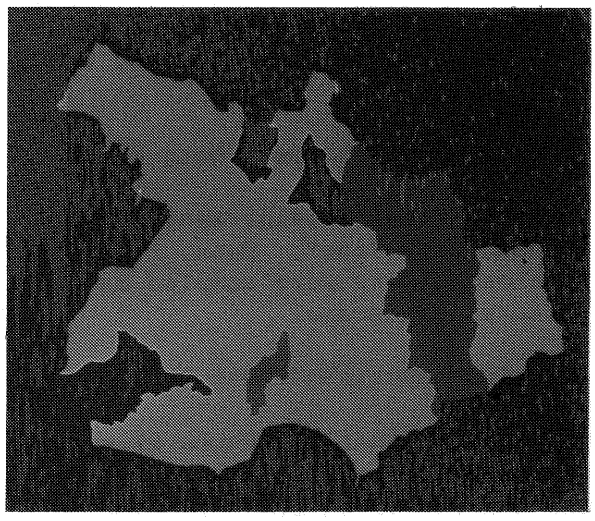

Photo 3. Change in greens

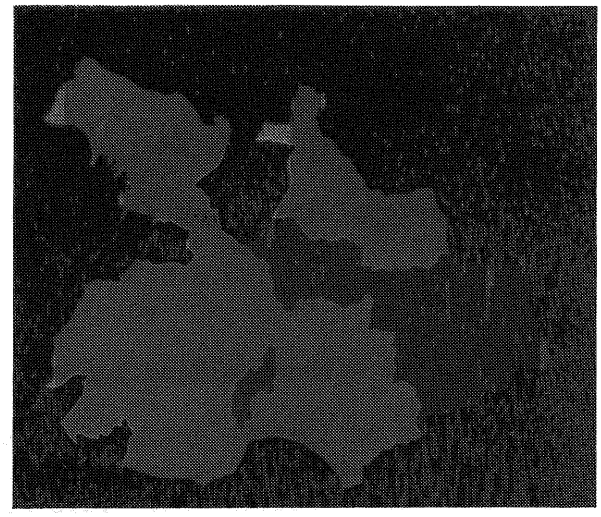

Photo 4. The present condition of greens

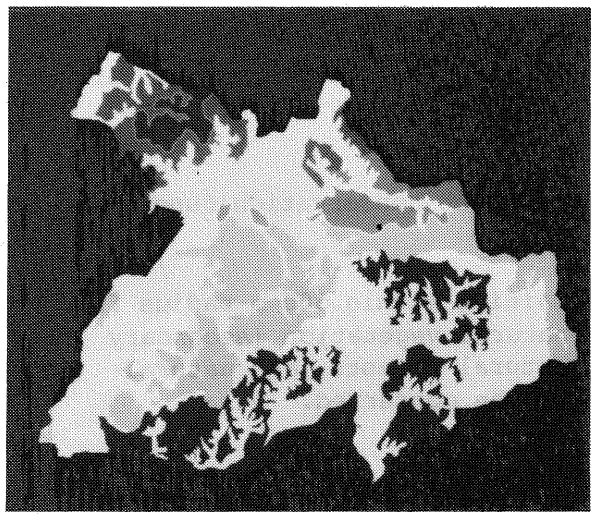

Photo 5. Surface geology

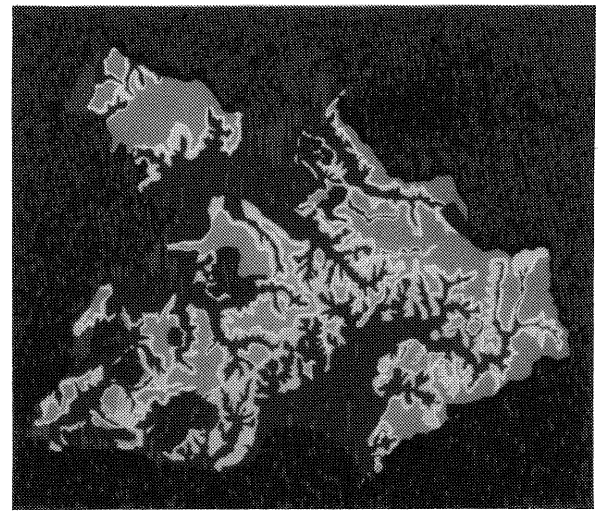

Photo 6. Inclination

7. Functional Analysis of Forests

The functional analysis of forests was made based on the green area distribution (regard as 1986 distribution) updated by the green area distribution obtained from the green area distribution using land use data (1978) and SPOT data (1986).

(1) Forests with efficient functions of urbanization control and buffering

The green area distribution in 1987 and that in 1986 was compared to know spots where forests disapeared, and forests contiguous to these spots or remaining in their neighborhood were sampled as forests with efficient functions of urbanization control and buffering. Forests remaining within 1 km radius from these spots were sampled.

(2) Forests with efficient buffering function associated with traffic noise. (Photo 7)

Forests distributing along roads function as a buffer against traffic noise. The 1/10,000 scale city planning maps were used to sample forests distributing within 500 m distance along city planning roads, as buffers. (Photo)

(3) Forests with excellent water front natural landscape (Photo 8).

Forests distributing in unity with water front provide mental functions such as "comfort" and "pleasant feeling". Then, forests distributing within 500 m distance along rivers were sampled as green areas with excellent water front natural landscape.

(4) Forests with excellent land conservation function (Photo 9)

Matrix of surface geology (Photo 5) and inclination (Photo 9) were used to classify land conservation conditions such as slope failure and slope destruction. This result and the green area distribution (1986) were overlayed in pixel unit to sample forests with excellent land conservation function.

(5) Forests with high water repleshment (Photo 10)

Matrix of soils and inclination were used to classify the degree of contribution to water repleshment. This result and the green area distribution (1986) were overlayed to sample only forests with excellent water repleshment function.

(6) Forests with excellent natural environment conservation function (Photo 11)

Natural forests distributing or remaining within 500 m radius from points with more than 8 degree of natural vegetation (secondary forests close to natural forests, natural forests, and natural grasses) were examined as subjects to be conserved.

(7) Forests providing excellent ecological fields

Forests which seemed to be very important as animal habitats were sampled as subjects.

The results of functional analysis from (1) to (7) were overlayed as pixel unit to prepare an overlayed map of forest functions. (Photo 12)

Table 3 gives a comparison between the overlapping of forest functions and usage areas. This table suggests that in Kamakura City forests with overlapped functions distribute in the first class residential areas and the second class residential areas. Table 4 compares overlapping of forest functions and places which are loved by the citizens obtained from a citizens' opinion survey for city planning in Kamakura City. This table shows that forests with 2 to 4 overlapped functions are listed as favourite places.

Table 3 Overlapping of forest functions and usage areas (expressed in area ratio)

Usage area / Overlapped functions	First class Residential area	Second class residential area	Houses	Commercial neighbourhood (200%)	Commercial neighbourhood (300%)	Commercial (400%)	Commercial (600%)	Semi-industrial	Industrial	City planning parks	Adjustment area
1. Only one function	8.4	1.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	11.4
2. Overlapping of functions	11.0	2.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	1.2	19.4
3. Overlapping of functions	6.4	2.2	0.8	0.1	0.0	0.0	0.0	0.1	0.0	0.3	17.3
4. Overlapping of functions	2.9	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	8.9
5. Overlapping of functions	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8
6. Overlapping of functions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

Table 4 Overlapping of forest functions and places loved by the citizens (expressed in area ratio)

Area / Overlapping of functions	Area (ha)	Area ratio (%)
1. Only one function	75.16	21.5
2. Overlapped functions	118.56	34.0
3. Overlapped functions	98.60	28.2
4. Overlapped functions	45.20	13.0
5. Overlapped functions	11.36	3.3
6. Overlapped functions	0.12	0.0
Total	349.00	100

Photo 7. Forest with high buffering function

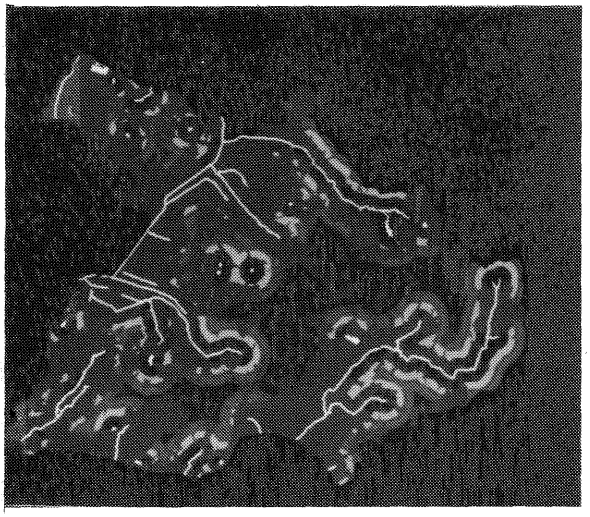

Photo 8. Forest with excellent water front landscape function

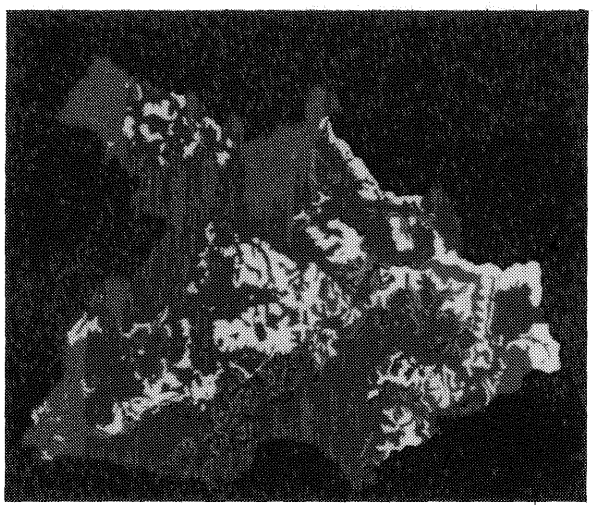

Photo 9. Forest with excellent land conservation function

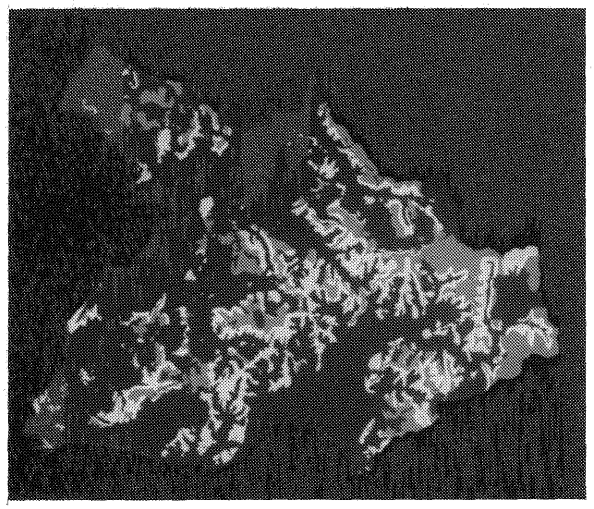

Photo 10. Forest with excellent water repleshment function

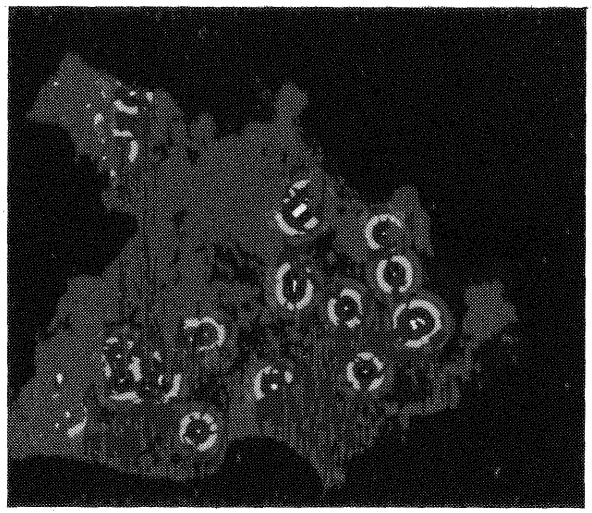

Photo 11. Forest with natural environment conservation function

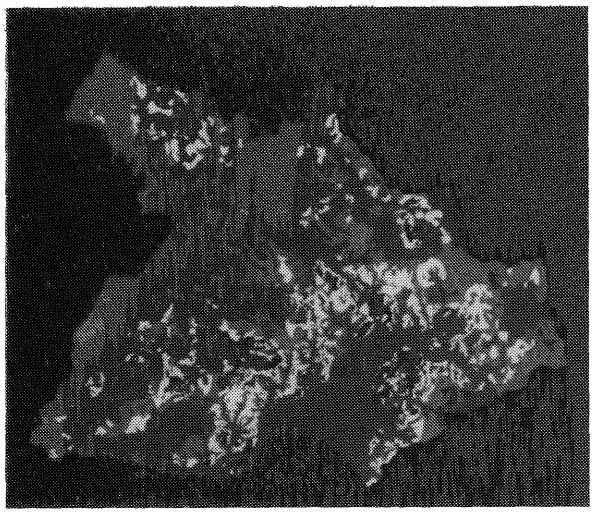

Photo 12. Overlapping of forest functions

8. Conclusion

The followings can be concluded in this study.

(1) The analysis to understand the present condition of green cover showed that the forest area decreased by approximately 3 km between 1978 and 1986, and the non-forest area increased by approximately 2 km in the same period. In 1986, the area with 100% forest cover accounts for about 30% of the whole city.

(2) The analysis of forest functions suggested that forests with overlapped forest functions distributed in the first and second class residential areas. A comparison with a citizens' opinion survey showed that places loved by the citizens are well coincident with forest with overlapping of 2 to 4 functions, and that the places were not necessarily forests with overlapping of many functions.

9. Afterword

This study was attempted to know the present condition of green areas and to analyze their functions using SPOT data and land use information on the assumption that this understanding and the functional analysis can be successfully applied to green area conservation planning and comprehensive green area planning. Some basic data used in this study were not satisfactory. Although the functional analysis can provide only qualitative, the effectiveness of our appraoch to urban green area planning was understood to some extent.

Reference

(1) Kamakura City (1983.2): Collected Maps of The Living Environment in Kamakura City (Citizens' Evaluation of the Living Environment in Kamakura City, pp 17-21)
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(4) Maruta (1983.12): Theory of City Green Area Planning