Research into the Relationship between Urban Structures and Changing Structures in Green Spaces

Bull. Univ. Osaka Pref., Ser. B, Vol. 45,
大阪府立大学紀要, 農学・生命科学, 1993

Research into the Relationship between Urban Structures and Changing Structures in Green Spaces

Satoshi YAMAMOTO, Noboru MASUDA, Yasuhiko SHIMOMURA,
Daishu ABE, and Kazutoshi ITO

Laboratory of Urban Landscape Design, College of Agriculture

(Received, 1992)

Abstract

This research was carried out in Sakai City, and it takes into account some of the important future topics in the conservation of green spaces. The research aims to clarify the relationship between the state of urbanization in a city and the changing distribution and structure of green spaces. It was found that forested land in the city tends to remain in a state of equilibrium in high-rise/high-density residential areas. In low-rise/high-density residential areas, agricultural and forested land tend to become bare land or more heavily built up. In low-rise/low-density residential areas, half of the quasi-agricultural land tends to become bare land or more heavily built up.

Purpose of Research

In recent years, the rapid disappearance of forested land, agricultural land, and other green spaces in cities and suburbs has inspired a variety of countermeasures aimed at conserving those spaces. It is thought that the issues involved in conserving urban greenery differ according to the state of urbanization. This research was carried out in Sakai City, and it takes into account some of the important future topics in the conservation of green spaces. The purpose clarify the relationship between the state of urbanization in a city and the changing distribution and structure of green spaces.

Research Method

1) *Survey area and units of analysis*

All of Sakai City was surveyed, and the elementary school districts were used as the units of analysis.

2) *Survey of urbanization and greenery*

The Sakai City Regional Services Planning Chart (first edition) was used in the survey of urbanization to determine the 1980 population density, road-to-land ratio, and building-coverage in each of the city's elementary school districts. Then the 1980 Sakai City Planning Map was divided up with a checkerboard grid to measure the relative areas of residential-, commercial-, and industrial-use land, as well as controlled urbanization

districts, in each elementary school district.

In the survey of greenery, the 1: 10,000 scale "state of greenery" maps from 1980 and 1990 were divided up with a checkerboard grid and measured to determine the area of forested land, grass land, agricultural land, arboricultural land, bare land, and water land. The degree of coverage seen in the green spaces of 1980 and 1990 was measured, and the difference between the two was calculated.

3) *Analytic method*

Using the above data regarding the state of urbanization, principal component analysis and the cluster analysis were applied. Each elementary school district was stereotyped and a clear picture of the urban structures was obtained by drawing up a distribution map. The same analytic method was applied to the data regarding green spaces so as to clarify the changing structures in those spaces between 1980 and 1990. Finally, the overlay method was used to reveal the relationship between the urban structures and the changing structures of green space in Sakai City.

Results of Analysis and Consideration

1) *Urban structures*

Table 1 shows the results of the principal component analysis. Table 2 and Figure 1 show the results of stereotyping each elementary school district.

In this survey, three principal components used in further calculations were those with a eigenvalue of 1.0 or more and an accumulated coefficient of determination of 70% or more. Three principal components met these criteria: the first principal component described high-rise/high-density residential areas; the second described commercial-use, industrial-use, and mixed commercial/industrial-use areas; the third described agricultural-use.

A cluster analysis of the principal component scores for each elementary school

Table 1. Results of principal component analysis (urban structures)

		First principal component	Second principal component	Third principal component
Population density		0.473	−0.067	0.216
Road-to-land ratio		0.443	0.208	−0.205
Building coverage		0.268	0.351	0.478
Zoning	Residential	0.403	−0.569	−0.082
	Commercial	0.272	0.553	0.198
	Industrial	−0.131	0.445	−0.639
	Controlled urbanization districts	−0.505	0.034	0.482
Eigenvalue		2.561	1.671	1.151
Accumulated coefficient of determination		36.6 %	60.4 %	76.9 %

Table 2. Stereotypes of urban structures

	Elementary school district	
	Number of districts	%
Industrial type	3	3
Commercial type	5	6
Mixed commercial/ industrial type	5	6
Concentrated type	8	9
Residential type (high-rise/high-density)	23	26
Residential type (low-rise/high-density)	20	22
Residential type (low-rise/low-density)	17	19
Agricultural type	9	10
Total	90	100

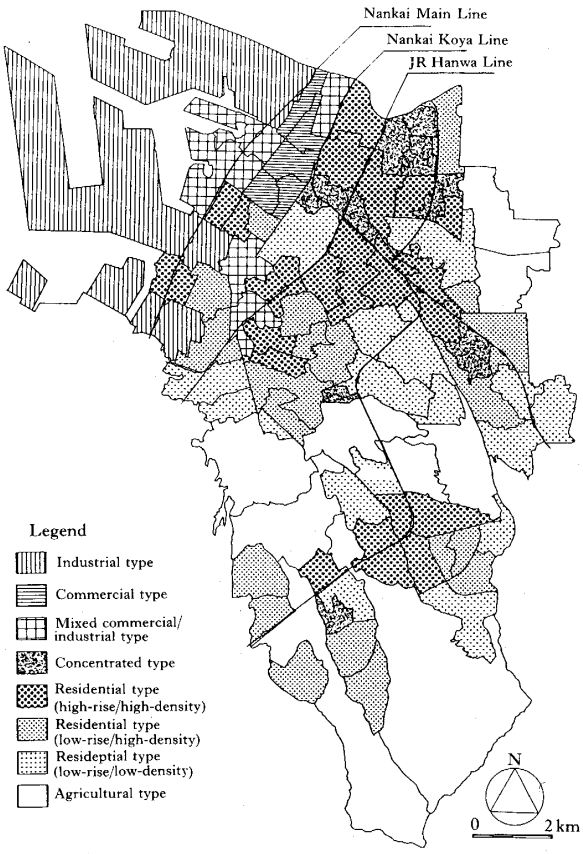


Fig. 1 Urban Structures

district was carried out. Ninety school districts were grouped into eight stereotypes on the basis of these results. The eight stereotypes were as follows: industrial, commercial,

mixed commercial/industrial, concentrated, residential (high-rise/high-density), residential (low-rise/high-density), residential (low-rise/low-density), and agricultural-type.

It was found that Sakai City is composed mostly of residential types. The high-rise/high-density residential stereotype was most common, accounting for 23 of the city's 90 school districts. These districts were concentrated in the northern part of the city along the JR Hanwa Line and the Nankai Koya Line, and around Izumigaoka Station in the Senboku New Town. The second most common stereotype was the low-rise/high-density residential type, accounting for 20 school districts. This type of school district was concentrated along the railroads that pass through Sakai City. Seventeen school districts were stereotyped as low-rise/low-density residential type. These were concentrated in the central part of the city.

2) *Structure of green spaces in 1980*

Table 3 shows the results of the principal component analysis. Table 4 and Figure 2 show the results of stereotyping each elementary school district.

In this survey, three principal components used in further calculations were those with an eigenvalue of 1.0 or more and an accumulated coefficient of determination of 70% or

Table 3. Results of principal component analysis (structures of green spaces)

	First principal component	Second principal component	Third principal component
Forested land	0.652	0.071	−0.061
Grass land	0.585	−0.072	0.177
Agricultural land	−0.053	0.607	0.449
Arboricutural land	0.405	0.463	−0.182
Bare land	0.251	−0.638	0.265
Water land	−0.040	−0.003	0.812
Eigenvalue	1.786	1.311	1.109
Accumulated coefficient of determination	29.8 %	51.7 %	70.2 %

Table 4. Stereotypes of green space structures

	Elementary school district	
	Number of districts	%
Water-coverd type	2	2
Forested type	1	1
Arboricultural type	1	1
Agricultural type	9	10
Quasi-agricultural type	15	17
Bare land type	5	6
Urban forested type	18	20
A little greenery type	10	11
Little greenery type	29	32
Total	90	100

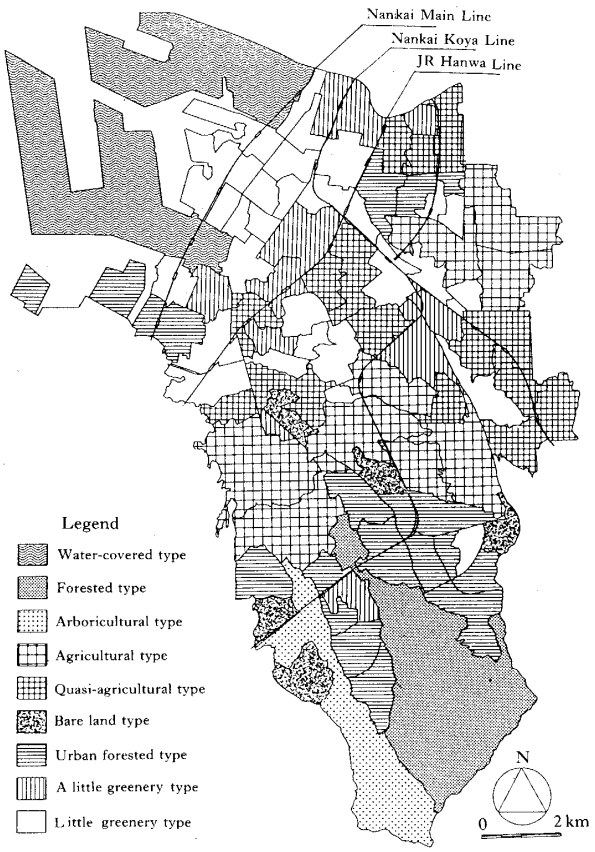


Fig. 2 Green space structures

more. Three principal components met these criteria: the first principal component described forested and grass land; the second described agricultural land and arboricultural land; the third described water-covered surfaces.

A cluster analysis of the principal component scores for each elementary school district was carried out. Ninety school districts were grouped into nine stereotypes on the basis of these results. The nine stereotypes were as follows: water-covered, forested, arboricultural land, agricultural, quasi-agricultural, bare land, urban forested, a little greenery, and little greenery-type.

It was found that the most common green space stereotype in Sakai City (1980) was the little greenery type, which accounted for 29 of the 90 school districts. This type of school district was most common in the northwestern part of the city and in the vicinity of train stations in surburbs. The second most common stereotype was urban forested type, accounting for 18 school districts. This type of school district was concentrated in the Senboku New Town and the northeastern part of the city. Fifteen school districts were stereotyped as quasi-agricultural. These were concentrated around built-up areas in the central part of the city.

3) *Changing structures of green spaces*

Table 5 shows the results of the principal component analysis. Table 6 and Figure 3 show the results of stereotyping each elementary school district.

In this survey, the principal components used in further calculations were those with an eigenvalue of 1.0 or more and an accumulated coefficient of determination of 70% or

Table 5. Results of principal component analysis (changing structures of green spaces)

	First principal component	Second principal component	Third principal component
Forested land	0.131	0.166	0.896
Grass land	0.013	0.650	−0.290
Agricultural land	0.506	0.114	−0.286
Arboricultural land	0.598	0.000	−0.060
Bare land	−0.604	0.067	−0.123
Water land	0.066	−0.730	−0.111
Eigenvalue	2.069	1.164	1.052
Accumulated coefficient of determination	34.5%	53.9%	71.4%

Table 6. Stereotypes of changing structures of green spaces

	Elementary school district	
	Number of districts	%
Unchanged	22	24
Slight changed	32	36
Urbanization type 1 (reduction of all greenery area)	12	13
Urbanization type 2 (reduction of bare land)	3	3
Urbanization type 3 (reduction of forested land)	2	2
Under-urbanized type 1 (water land changed to bare land)	3	3
Under-urbanized type 2 (agricultural land changed to bare land)	15	16
Increasing type of agricultural land	1	1
Total	90	100

more. Three principal components met these criteria: the first principal component described the change from bare land to built-up land and the change from bare land to agricultural land/arboricaltural land; the second described an increase in grass land or the change from water-covered surfaces to grass land; the third described an increase in forested land.

A cluster analysis of the principal component scores for each elementary school district was carried out. Ninety school districts were grouped into eight stereotypes on the basis of these results. The eight stereotypes were as follows: unchanged, slight changed, urbanization type 1 (reduction of all green area), urbanization type 2 (reduction of bare land), urbanization type 3 (reduction of forested land), under-urbanized type 1 (water land changed to bare land), under-urbanized type 2 (agricultural land changed to bare land), increasing type of agricultural land.

It was found that the most common type of change in Sakai City's green spaces was

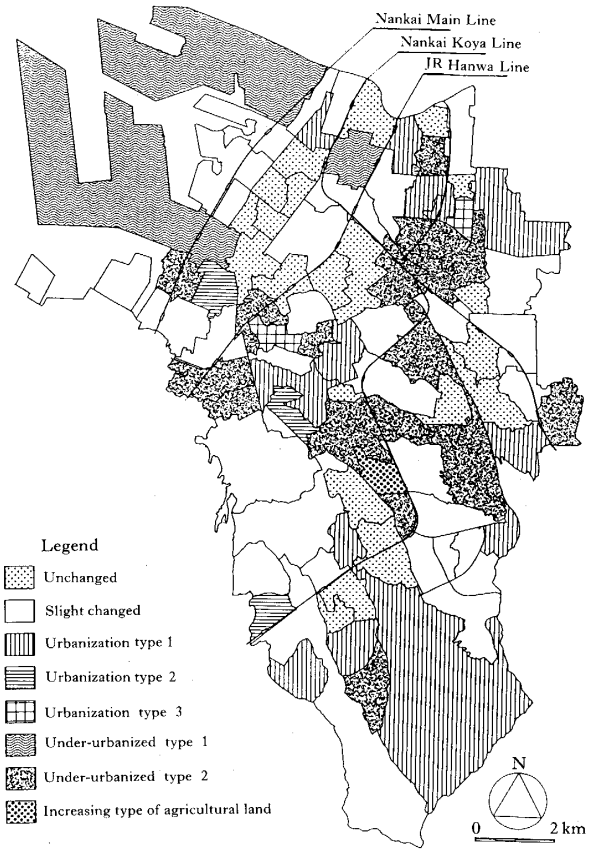


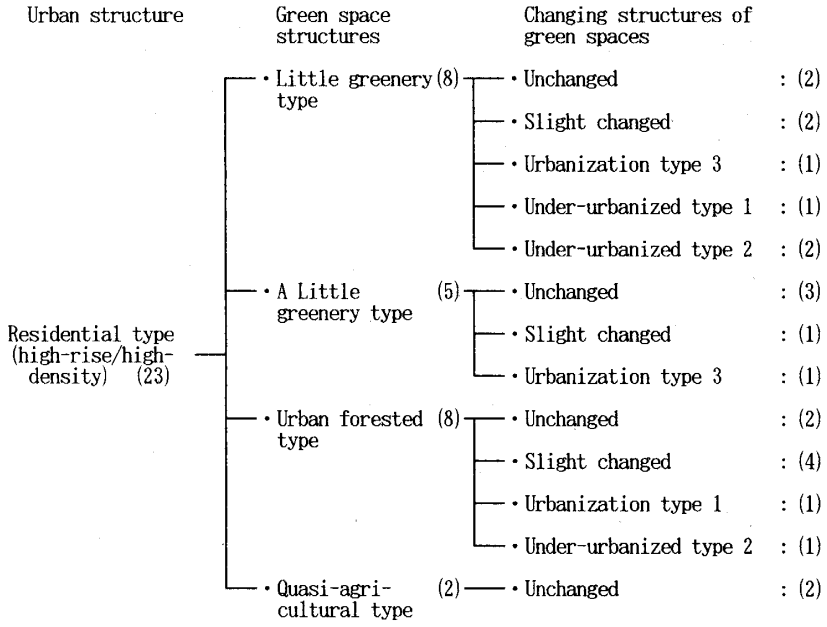
Fig. 3 Changing structures of green spaces

slight changed, which accounted for 32 of the city's 90 school districts. A further 22 school districts were stereotyped as unchanged. Thus the two types of school districts where there was slight changed or unchanged in green spaces acconuted for well over half of the school districts. Among the green spaces where changes were readily seen, urbanization type 1 and under-urbanized type 2 were the most common types of changes. The 12 school districts showing urbanization type 1 changes were dispersed throughout the city, while the 15 school districts showing under-urbanized type 2 changes were concentrated in the central part of the city.

Conclusion

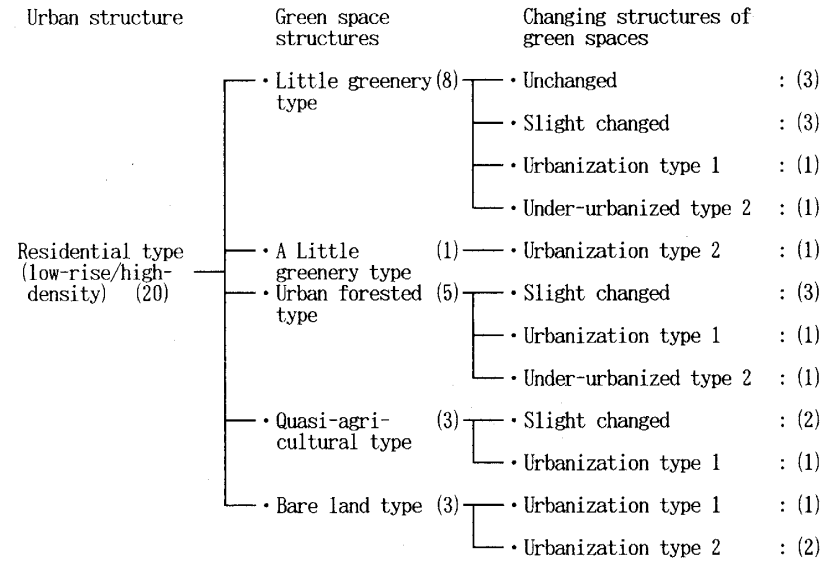
Figures 4 to 6 show the relationship between changing structures of green spaces and the three types of residential areas that make up the bulk of Sakai City, i. e. high-rise/high-density, low-rise/high-density, low-rise/low-density.

As shown in Figure 4, the most common types of green spaces in the 23 high-rise/high-density residential of 1980 were the little greenery type and urban forested type, each of which accounted for eight school districts. Among the eight school districts stereotyped as little greenery type, the changing structures in four districts were described as unchanged and slighit changed. The other four showed a trend toward urbanization or under-urbanized type. Two of the school districts stereotyped as urban forested showed unchanged, while four showed slight changed. These results make it clear that urban



(Figures in parentheses indicate number of school districts)

Fig. 4 The relationship between urban structures and changing structures of green spaces (1)



(Figures in parentheses indicate number of school districts)

Fig. 5 The relationship between urban structures and changing structures of green spaces (2)

forested land in this type of residential area tends to remain largely unchanged. However, if this type of residential area has little green cover to begin with (little greenery type), greenery tends to be reduced further until the land is barren.

As shown in Figure 5, the most common type of green space among the 20 low-rise/high-density residential school districts of 1980 was the little greenery type, which accounted for eight school districts. Next were five urban forested districts, three quasi-agricultural districts, and three districts classified as bare land. Among the districts classified as little greenery type, the most common changes seen in the decade were

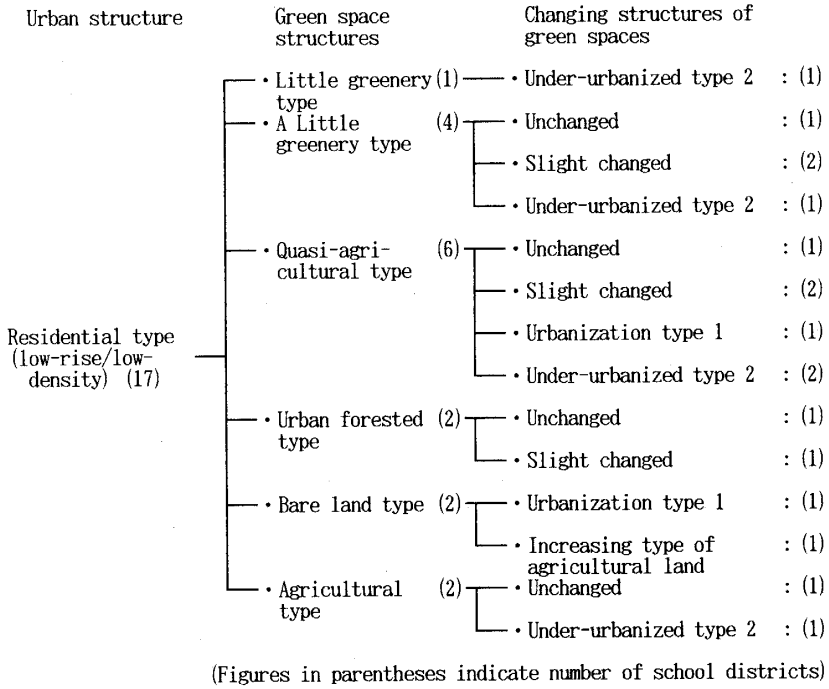


Fig. 6 The relationship between urban structures and changing structures of green spaces (3)

unchanged and slight changed, which numbered three districts each. Unchanged and slight changed was also a strong trend in districts classified as urban forested and quasi-agricultural, but here it was mixed more evenly with further urbanization. These results make it clear that there is some tendency for urban forested land and quasi-agricultural land in this type of residential area to be changed bare land, while bare land tends to be built up.

As shown in Figure 6, only one of the 17 low-rise/low-density residential school districts of 1980 was classified as having little greenery type. On the other hand, six of the 17 districts were classified as quasi-agricultural type, which suggests a relative abundance of greenery. Among the six quasi-agricultural districts of 1980, the types of changes seen in three districts were unchanged and slight changed, while the change in two other districts was under-urbanized type 2 and the remaining district showed an urbanization type 1 change. These results make it clear that this type of residential area has a lot of quasi-agricultural type, and that half the quasi-agricultural type remains unchanged and slight changed while the other half tends to be changed bare land or be built up.

Using the case of Sakai City, this research clarifies one of the most important topics in the conservation of green spaces, namely the relationship between urban structures and the changing structures of green spaces.

References

1) SAKAISHI SOUGOU KIKAKUBU., (1983). *Sakaishi Chiiki Seibi Keikaku Vol. 1 Chiiki Karute.* Sakaishi Sougou Kikakubu. (*in Japanese*)
2) SAKAISHI SHICHOU KOUSHITSU HISHO KOUHOUBU CHOUSA TOUKEIKA., (1988). *Sakaishi Toukeisho.* Sakaishi Shichou Koushitsu Hisho Kouhoubu Chousa Toukei-

ka. (*in Japanese*)

3) TABATA, S., (1979). *Toshi no Green Matrix.* Kashima Shuppankai. 269 p. (*in Japanese*)

4) YOSHIKAWA, K., (1978). *Chiikikeikaku no Tejun to Shuho.* Morikita shuppan. (*in Japanese*)