

Study on Change in Landscape Structure over Time in Suburban Area by Using GIS

- Case Study of Kawachinagano City, Osaka -

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ABSTRACT

Now that importance of landscape planning unique to each area is emphasized, it is necessary to conduct landscape planning by taking advantage of natural environments unique to each area, because its natural environments are regarded as one of the assets the area possesses. This study targets at Kawachinagano City, Osaka, one of the residential areas that is not only rich in natural and historical elements, but also has been rapidly growing. The purposes of this study are to evaluate change in landscape structure over time by analyzing relation between landform and pattern of expanding the built-up area at three time points of 1932, 1967, and 1994 with GIS (ARC/INFO 7.0.3, ARC/View 3.0 (ESRI)), as well as to make some suggestions for planning landscape unique to the area.

Data on main ridges, sub ridges, main rivers, and other landform were read from the elevation map, and data on woodland, and parks and open spaces (having more than 3 ha area) were read from the existing land use map. The data were used to understand the natural structure of the city from topographic viewpoint. Next, the existing land use map prepared with data on the built-up area and urban axes consisting of roads and streets were overlaid on the elevation map in order to understand relation between pattern of expanding the built-up area and the natural structure.

As a result, followings become clear. In 1932, rural settlements were independently located in the area defined by wedge-shaped ridges extending from the mountainous area to the terrace lowland area. They had landscape of a surrounded image, unique to the defined area, and deep landscape consisting of the foreground of wedged-shaped ridges and the background of mountain range. In 1967, when the old residential areas were developed, and completely spread over the whole terrace lowland area, the quality of the deep landscape was lowered because the rural landscape that served as the foreground was moved back, but the landscape structure was still influenced by the natural structure. In 1994, however, the top area of ridges on the hilly area was developed for new residential area, and roads were constructed across the ridge on the hilly area. The landscape structure was largely changed by these developments, independent of the natural structure. The mountains, which served as the background of the landscaped viewed from the built-in area, were kept intact on the mountainous area. Green belts conserved on hillsides of the hilly area offered landscape unique to the area to some degree. This study suggests, therefore, that landscape planning of this city should be carried out, taken into consideration the conservation of the mountains on the mountainous area and green belts on

hillsides of wedge-shaped ridges. It is important to protect view of mountains by placing restrictions on building of new residential area on the hilly area.

Key Words : Landscape structure, Natural structure, Landform, Expansion of suburban area, GIS

I. INTRODUCTION

Suburban areas, which are located on the outskirts of big cities, nurtured landscape unique to them with their own culture and history by adjusting lives of their residents to the surrounding natural environments.¹⁾ Recently, however, built-up areas have been expanding with an economic burden put on their natural environments, which leading these areas to become similar one another and to have less regional identity.²⁾ Now that the importance of landscape planning unique to each area is emphasized, it is necessary to conduct landscape planning by taking advantage of natural environments unique to each area, because its natural environments are regarded as one of the assets the area possesses.^{3,4)} This study targets at Kawachinagano City, Osaka, one of the residential areas that is not only rich in natural and historical elements, but also has been rapidly growing. The purposes of this study are to evaluate change in landscape structure over time by analyzing relation between landform and pattern of expanding the built-up area at three time points of 1932, 1967, and 1994 with GIS, as well as to make some suggestions for planning landscape unique to the area.

II. METHODS

1. Outline of the Area to be Studied

The area to be studied was Kawachinagano City, Osaka, one of accumulations of business

activities, located about 20 km away from Osaka city in the southeast (Figure 1). Kawachinagano City has landform full of ups and downs ranging from banks of Ishikawa River at an elevation of 90 meters above the sea level to the top of Mt. Kongo at an elevation of 900 meters above. The city is topographically divided into three areas; the mountainous area consisting of Izumi mountain range and Mt. Kongo in the south part of the city; the hilly area located on the foot of these mountains; and the terrace lowland area formed by Ishikawa River (Figure 2). As for change in population (Figure 3), the city had about 20,000 residents in 1930, and then the population increased gradually to 40,000 in 1965. However, the city has faced rapid increase in population since 1965, and the population reached about 120,000 in 1995. The population has been still on the rise.

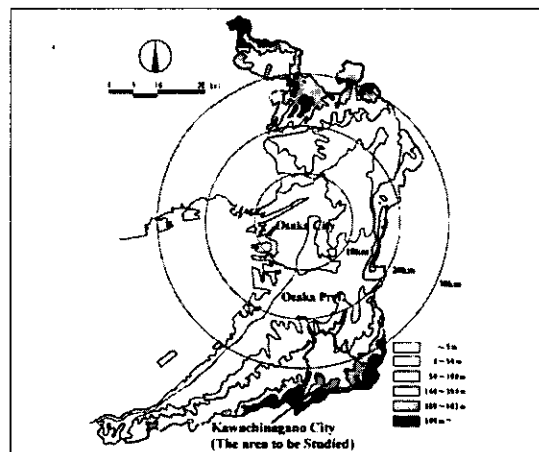


Figure 1. Location Map

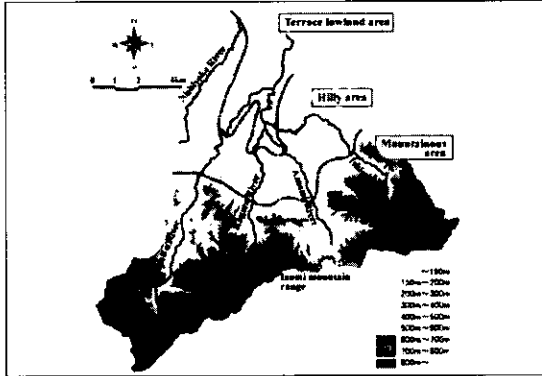


Figure 2. Elevation map of Kawachinagano City in 1930

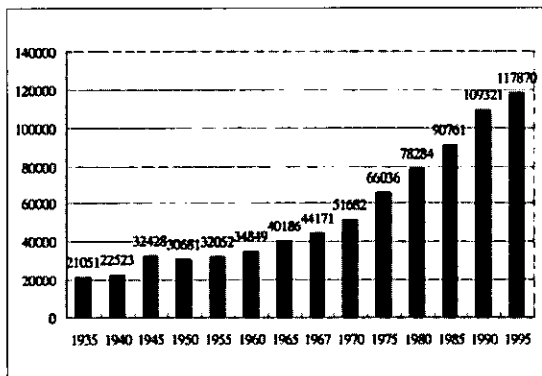


Figure 3. Change in population of Kawachinagano City

Table 1. Sources of the law data

the year of publication	map name	scale	publisher
1932	existing map	1/25,000	Geographical Survey Institute
1967	existing map	1/10,000	Kawachinagano City Government
1994	existing map	1/10,000	Kawachinagano City Government
1994	existing land use map	1/30,000	Osaka Pef. government

2. Study and Analytical

1) Methods

The data of three time points used in this study are shown in Table 1. Based on the land use data

available in 1994, the city was divided into 8 categories; woodland, farmland, roads, rivers, railways, parks and open spaces (having more than 3ha area), and others (including golf courses and graveyards) on the land use map of 1:30,000 scale prepared by Osaka Prefecture, and the land use map of the area of 1:25,000 scale was made by enlarging the scale of the prepared map. This map served as a base map. The data of 1932 and 1967 were obtained from the existing map prepared by the Geographical Survey Institute and Kawachinagano City. Revision was made on the base map when land was used differently in 1932 and 1967, compared with land use of 1994, and then the existing land use map of 1932 and 1967 of 1:25,000 scale was prepared. The elevation map of three time points was prepared by reading contour line at each 50-meter interval on the existing land use map of 1:25,000 scale of 1932, 1967, and 1994. Information on the existing land use map and elevation map of three time points were read as vector data with GIS software, ARC/INFO version 7.0.3 (ESRI), by the digitizer. Longitude coordinates were transformed to UTM axis of coordinates for land use coverage and elevation coverage. The data obtained were analyzed with ARC/View version 3.0 (ESRI).

Data obtained from 50-meter interval contour line were analyzed for geographical categorization including main ridges, sub ridges, and major rivers. Data on main ridges, sub ridges, main rivers, and other landform were read from the elevation map, and data on woodland, and parks and open spaces (having more than 3ha area) were read from the existing land use map. The data were used to understand the natural structure of the city from topographic viewpoint. Next, the existing land use map prepared with data on the built-up area and urban axes consisting of roads and streets were overlaid on the elevation map in order to understand

relation between pattern of expanding the built-up area and the natural structure. The built-up area was divided into three categories based on pattern of their development and periods when they developed; rural settlements, old residential areas, and new residential areas. These categories were used to clarify the landscape structure of three time points. Floor landscape structure map and cross landscape structure map were prepared by overlaying data on categorized landscapes zones, the urban axis, the natural structure, and categorized built-up areas in order to grasp the landscape structure of each time point. Landscape zone were divided into four categories according to landform and land use characteristics; mountainous landscape zone, hilly green landscape zone, rural landscape zone, and built-up area landscape zone.

III. RESULTS

1. Landscape Structure of 1932

In 1932, woodland totaled 82.2% of the whole city, and the built-up area accounted for 1.6%. As for the natural structure of this time point, five rivers including Ishikawa River, run through the mountainous, hilly and terrace lowland areas to the sea, and formed a trough along the river. Mountains, such as Izumi mountain range, Mt. Kongo, and Mt. Iwaki ranged in the mountainous area in the south part of the city, and served as the background landscape of the built-up area. Wedge-shaped sub ridges branched off from the main ridges, and then ranged northward. These sub ridges, covered with trees, went through the mountainous and hilly areas, and their edge contoured the terrace lowland area, which defined the space of the built-up area (Figure 4). As for relation between landform and pattern of expanding the built-in area, the naturally developed

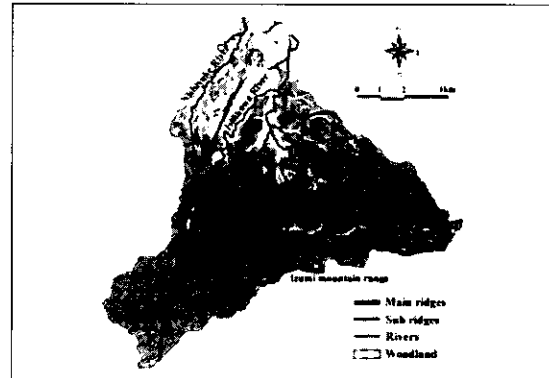


Figure 4. Natural structure map of 1932

rural settlements and the old residential areas were located 90 to 150 meter above the sea level, and they spread over the terrace lowland area, keeping each other at a certain distance. Rural settlements were also located independently along the trough extending from the hilly area to the mountainous area. The five city axes, including Koya Kaido, run along the trough formed parallel to the rivers such as Ishimi River and Amami River (Figure 5).

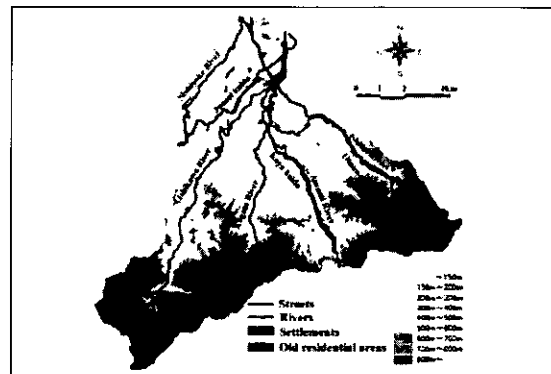


Figure 5. Relation between landform and pattern of expanding the built-up area of 1932

These results showed that the landscape structure of 1932 consisted of the main ridges, which functioned as the background of the built-up area, and the sub ridges, which branched off from the main ridges and extended southward and northward. Streets and the built-up area were

developed in the area defined by this landform, which providing the terrace lowland area with the landscape of a surrounded image. Both naturally-developed rural settlements and old residential areas offered a sense of spatial independence, and they had their unique landscape. Landscape viewed toward the south from the terrace lowland area had rural landscape spreading over the terrace lowland area at the foreground and deep mountains at the background (Figure 6 and Figure 7).

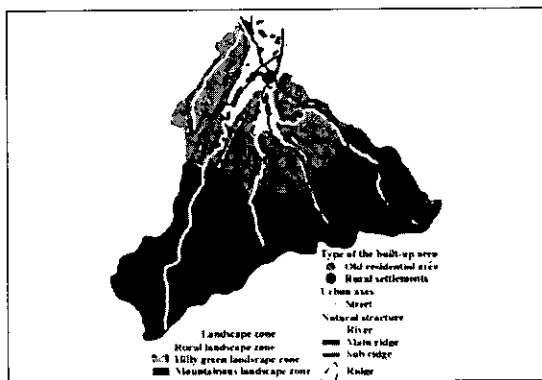


Figure 6. Floor landscape structure map of 1932

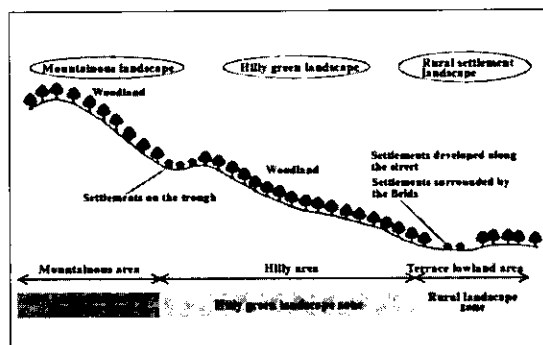


Figure 7. Cross landscape Structure map of 1932

2. Landscape Structure of 1967

In 1967, woodland totaled 79.9% of the whole city, and still occupied most part of the city, though the built-up area increased a little to 4.5%. The natural structure of this time point, like that of 1932,

consisted of the main ridges covered with trees located in the south end of the city, wedge-shaped ridges which branched off from the main ridges and extended through the mountainous and hilly areas to the terrace lowland area, and terrace lowland area spatially defined by the ridges (Figure 8).

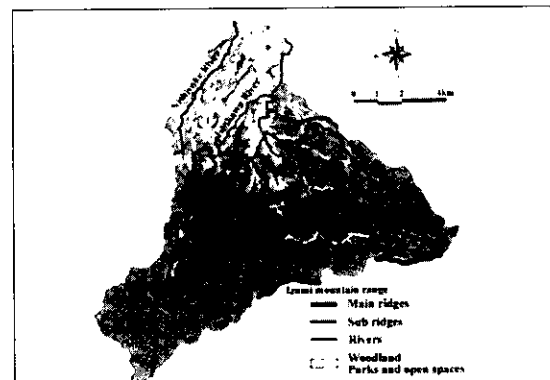


Figure 8. Natural landscape structure map of 1967

As for relation between landform and pattern of expanding the built-up area, the old streets became wider, and new roads were constructed parallel to the old streets. The streets and roads, which functioned as the city axes, increased in number, but all of them run along the trough, which showed that they were developed based on the landform. The built-up area was mostly located in the terrace lowland area, and the old residential areas and rural settlements grew around the urban axes until they were almost covered with the whole terrace lowland area. However, the space defined by sub ridges placed topographic limitation on development of the built-up area (Figure 9).

These results indicated that the built-up area tended to offer disorder to its landscape, and to lower its identity because of increased number of city axes and expansion of the old residential areas and rural settlements over the terrace lowland area. However, the development of the city axes and expansion of the built-up area still relied on the

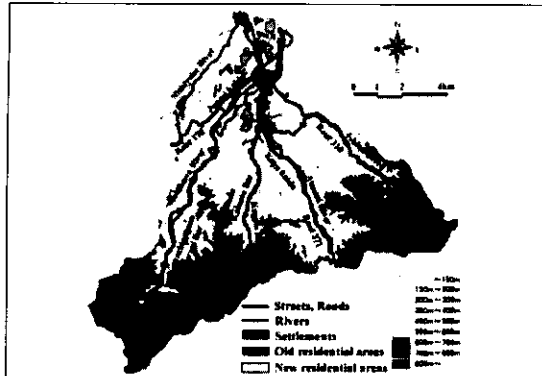


Figure 9. Relation between landform and pattern of expanding the built-up area of 1967

space defined by its landform. The landscape structure of this time point did not experience great change, but the quality of landscape viewed from the lowland area was lowered because rural landscape almost disappeared (Figure 10; Figure 11).

3. Landscape Structure of 1994

In 1994, woodland accounted for 73.7%, and still made up the most part of the whole city, though it had a rapid decrease from 1967 to 1994. The built-up area increased remarkably to 12.3%. As for the natural structure of this time point, the main ridges located in the south end and trough formed along five rivers did not experience any change. The head area of wedge-shaped ridges was developed for new

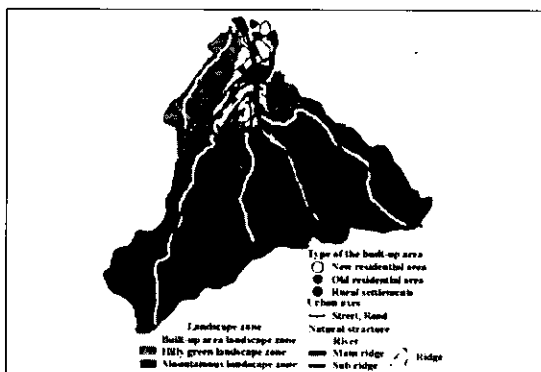


Figure 10. Floor landscape structure map of 1967

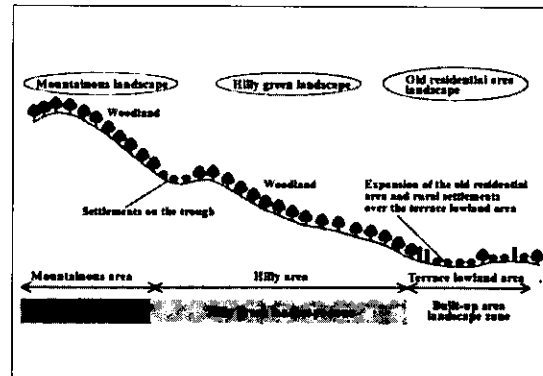


Figure 11. Cross landscape structure map of 1967

residential areas, which made the wedge-shaped ridges much shorter. Woodland remained intact on hillsides of the hilly area, and parks and open spaces rich in trees were placed over the hilly area. This terrace lowland area was surrounded by this green belt (Figure 12).

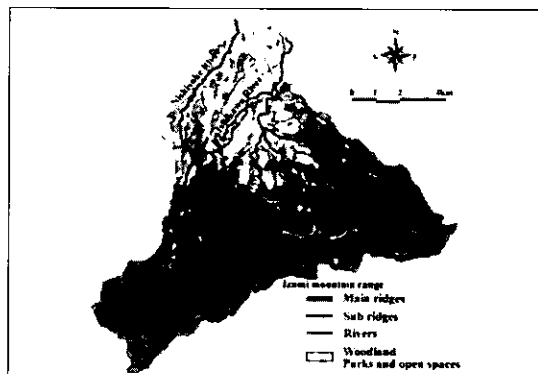


Figure 12. Natural structure map of 1994

As for relation between landform and pattern of expanding the built-up area, Rout 170 was extended along the trough formed by Ishikawa River, and bypass road for Rout 371 and Furusato-noudo, one of the roads running through farmland, were constructed across the ridge on the hilly area. These constructions destructed the topographic structure characteristic of this city. As for pattern of expanding the built-up area, the old residential areas extended in the terrace lowland area until they were incorporated into one big residential area, and new

residential areas were developed on the top area of ridges on the hilly area (Figure 13).

According to these results, it was shown that the

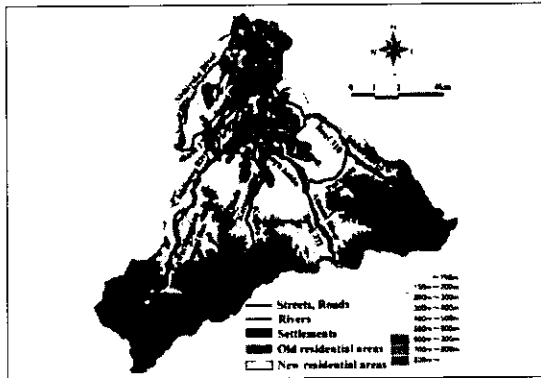


Figure 13. Relation between landform and pattern of expanding the built-up area of 1994

mountainous area still had the mountainous landscape zone, but the hilly area was divided into two areas, one that had hilly green landscape zone and the other that had built-up area landscape zone created by new residential areas. The city axes crossing the ridge were newly constructed. These land developments created another landscape structure, which was not different from the conventional one. All of the old residential areas lost their spatial independence because of their absorption into one big residential area. The mountainous area, which served as the background of the built-up area, still provided better mountainous landscape, and the terrace lowland area was surrounded by green belt, which was kept intact on hillsides of the hilly area, and offered unique landscape to this area to some degree (Figure 14; Figure 15).

IV. CONCLUSION AND RECOMMENDATIONS

These results lead to the following conclusions. In 1932, rural settlements were independently

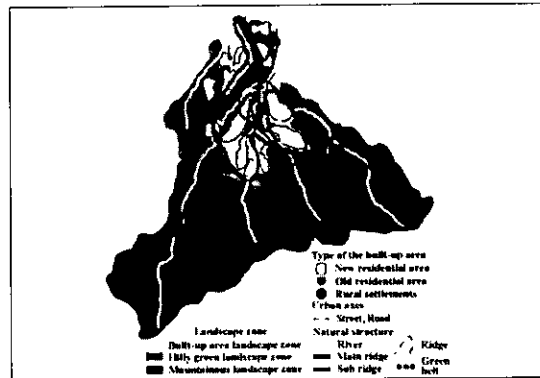


Figure 14. Floor landscape structure map of 1994

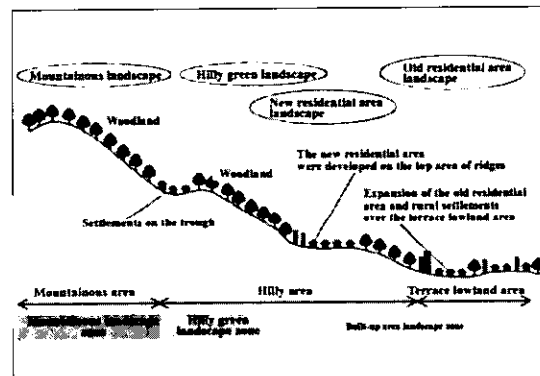


Figure 15. Cross landscape structure map of 1994

located in the area defined by wedge-shaped ridges extending from the mountainous area to the terrace lowland area. They had landscape of a surrounded image, unique to the defined area, and deep landscape consisting of the foreground of wedged-shaped ridges and the background of mountain range. In 1967, when the old residential areas were developed, and completely spread over the whole terrace lowland area, the quality of the deep landscape was lowered because the rural landscape that served as the foreground was moved back, but the landscape structure was still influenced by the natural structure. In 1994, however, the top area of ridges on the hilly area was developed for new residential area, and roads were constructed across the ridge on the hilly area. The landscape structure was largely changed by these developments,

independent of the natural structure. The mountains, which served as the background of the landscaped viewed from the built-in area, were kept intact on the mountainous area. Green belts conserved on hillsides of the hilly area offered landscape unique to the area to some degree. This study suggests, therefore, that landscape planning of this city should be carried out, taken into consideration the conservation of the mountains on the mountainous area and green belts on hillsides of wedge-shaped ridges. It is important to protect view of mountains by placing restrictions on building of new residential area on the hilly area.

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