STUDY ON RELATION BETWEEN URBAN STRUCTURE AND LAND VALUE FACTORS IN THE TOKYO METROPOLIS USING GEOGRAPHIC INFORMATION SYSTEM (GIS)

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KEY WORDS: GIS, Urban, Land Use, Vegetation, Landsat

ABSTRACT:

The city environmental element was extracted using Geographical Information System (GIS). The influence of the city environmental element was correlated with the formation of land values and analyzed using multiple linear regression analysis. Tokyo is the center of major activities and developments of Japan. The impacts of the changes took place in Tokyo was large even outside its periphery and that has resulted in the land value increase in the nearby prefectures also. The natural conditions of land specifications, such as convenience, comfortable nature, economical efficiency inhabitation or a production activity may determine the land value. The purpose of this research verifies whether a city consists of some various elements which the geographical feature and the green environment, are being reflected in a land value, in order to evaluate the expansion of Tokyo Metropolis during the bubble economic term from the center of Tokyo to its suburbs. Multiple linear regression analysis is used to analyze the impact of green environment factor on the formation of land value of a residential region. It is very difficult to explain the influence of the vegetation impact on the land value of area through a meso-scale of 70 km range from the center of Tokyo. However, this influence is more clarified through an area of a local scale of 4.4 km range from the closest station in the railway, as considered one of the elements that the vegetation could influence the formation of land value in the residential region.

1. INTRODUCTION

1.1 Background

The urbanization around the center of Tokyo was expanded due to the increasing population of Tokyo region (Tokyo, Chiba prefecture, Saitama prefecture, Kanagawa prefecture). The housing establishment and city traffic have developed the suburbs which were before an agricultural land and mountainous area. The rapid expansion of Tokyo from the end of 1980s till the beginning of 1990s due to the impact of the economic bubble have increased the land and stock values, thus increased the problem of urban environment, and it is difficult to evaluate the effect of the expansion of Tokyo metropolis on the city environment.

A land price in a city is a comprehensive value which is controlled by many environmental and other related functions, local economical structure and their close interrelation. Moreover, it is an important factor to which the land value has specified the spatial pattern of various elements which constitute time and spatial change of an internal structure of city (Wakita, 1976).

Geographic Information System (GIS) and remote sensing technologies provide potential opportunities for quantifying and monitoring urban environments. For instance, medium resolution remote sensing data (e.g. Landsat Thematic Mapper) have been widely utilized in mapping urban land use and land cover through classification algorithms (Harris & Ventura, 1995 and Treitz *et al.*, 1992).

1.2 Purpose

The natural conditions of land specifications, such as convenience, comfortable nature, economical efficiency inhabitation or a production activity may determine the land value. The purpose of this research verifies whether a city consists of some various elements which the geographical feature and the green environment, are being reflected in a land value, in order to evaluate the expansion of Tokyo metropolis during the bubble economic term from the center of Tokyo to its suburbs.

2. DATA AND STUDY AREA

2.1 Data

(a) 10m Grid Land use of Metropolitan Area (in 1984 and 1994)
(b) Land classification map of 1:500000 scale (Chiba prefecture, Saitama prefecture, Tokyo prefecture, Kanagawa prefecture)
(c) Official announcement of land price in 1985 and 1997.
(d) 2 scenes of Landsat TM data acquired during daytime August 3rd, 1985 and July 19th, 1997（Path：107 / Row：35）

2.2 Study Area

Tokyo is the center of major activities and developments of Japan. The impacts of the changes took place in Tokyo was large even outside its periphery and that has resulted in the land value increase in the nearby prefectures also. These prefectures include parts of Tokyo metropolis, Chiba prefecture, Saitama Prefecture, and Kanagawa Prefecture.

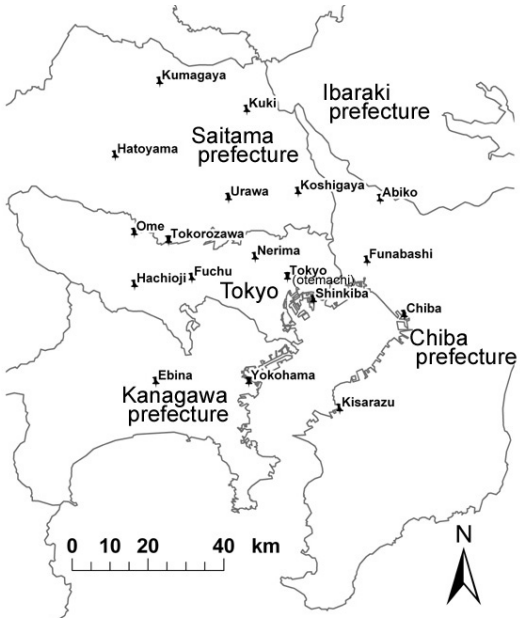

Figure 1. Tokyo region

Analyzed city	Latitude	Longtitude	Altitude(m)
Kumagaya	36? 6.8′	139? 3.0′	30
Kuki	36? 5.0′	139? 8.4′	12
Hatoyama	35? 8.2′	139? 5.4′	44
Urawa	35? 2.4′	139? 5.4′	8
Koshigaya	35? 3.4′	139? 7.6′	5
Tokorozawa	35? 6.2′	139? 5.0′	119
Ome	35? 7.2′	139? 9.0′	155
Nerima	35? 4.0′	139? 0.2′	38
Hachioji	35? 9.8′	139? 9.2′	123
Fuchu	35? 0.9′	139? 9.2′	58
Tokyo(Otemachi)	35? 1.2′	139? 5.9′	7
Shinkiba	35? 8.0′	139? 0.5′	6
Abiko	35? 2.5′	140? 2.0′	20
Funabashi	35? 3.7′	139? 9.8′	24
Chiba	35? 6.0′	140? 6.4′	4
Kisarazu	35? 2.5′	139? 5.3′	5
Ebina	35? 6.0′	139? 3.2′	18
Yokohama	35? 6.2′	139? 9.4′	39

Table 1. Analyzed city

3. THE ANALYSIS METHOD

3.1 Land use/cover change in Tokyo metropolis

The extent of Tokyo metropolis is about 100 km and there are many cities existed also on the fringe of Tokyo. It is necessary to understand the land use change in Tokyo metropolitan area, in order to examine the influence of this change on the environment. 1984 and 1994 were selected since during this period the economic bubble has took place and there was serious change in the land use of Tokyo metropolitan area.

3.2 Extracted city environmental elements using GIS

(a) Relation between land value and spatial distance from Tokyo station

Wakita (1976) described that the negative correlation between a spatial distance and the land value is an index of the accessibility to the center of Tokyo metropolitan.

(b) Relation between land value and landform

Topography is a major natural factor that affects the valuation of residential lands because land surface properties are closely related to hazard vulnerability and amenities for human living. Supposed disaster damages especially those due to floods are evaluated as negative profits, resulting in the decline of the land value. The influence of topography on residential land value has been evaluated by deriving land value functions of which major explanatory variables are topographic and geographic attributes of each residential land. As a result, the land value of lowland was evaluated at about 85 % of that of upland (Mizutani, 2000).
The land price data were classified into four classes based on geographical features (lowland, upland, hilly land, reclaimed land). Using the land classification map of 1:50000 scale with the aid of GIS, a new factor of city environment was extracted

3.3 Relation between land value and green environment

Two Landsat TM data were used for the present study. Of these one was acquired before bubble economy period (August 3rd, 1985), and the other was after the bubble economy (July 19th, 1997). The vegetation indices were extracted based on the following equation (1).

$$NDVI = \frac{NIR(TM\ band\ 4) - RED(TM\ band\ 3)}{NIR(TM\ band\ 4) + RED(TM\ band\ 3)} \quad (1)$$

The area where the value of NDVI was larger than 0.1 was assumed to be a vegetated region, therefore, the value (0.1) of NDVI was used generally as a threshold of the vegetation region and non-vegetation region (e.g. Kondoh, 2004). The ratio of green covering around the analytical point (within a radius of 4.4 km from the analytical point) was calculated. The average area of an administrative district in Tokyo metropolitan area becomes about 60 km^2, and corresponds to the area of the concentric circle of 4.4km in the radius that centers on the analyzed city.

3.4 Multiple linear regression analysis

The influence of the city environmental element was correlated with the formation of land values and it was analyzed using multiple linear regression analysis.
Regression equation that evaluates the effect of city environment onto the land value is indicated in equation (2):

$$P(z) = f(Z1 + Z2 + Z3 +, \cdots, + Zn) \quad (2)$$

Where, Z1 is the spatial distance from Tokyo station， Z2 is the spatial distance up to near station, Z3 is the building structure (reinforced concrete, steel framework, timbered), Z4 is the with or without of town gas, Z5 is the with or without Sewerage, Z6 is the with or without Water supply, Z7 is the land area, Z8 is the building coverage ratio, Z9 is the building capacity ratio,

Z10 is the land form (hilly land, upland, lowland, reclaimed land) and Z11 is the green covering ratio.

Multiple linear regression analysis was used to analyze the factor of the green environmental impact on the formation of land value in 70 km range from the center of Tokyo (meso-scale) and in 4.4 km range from the city of Tokyo metropolis (local-scale).

Official announcement of land price data of the local scale was classified into four areas:

(a) Nerima, Tokyo (Otemachi) and Shinkiba in Tokyo city area located within a radius of 20 km from Tokyo station.

(b) Funabashi, Urawa, Koshigaya, Fuchu and Yokohama around Tokyo city area located within concentric circles of 20～30 km from Tokyo station.

(c) Abiko, Chiba, Kisarazu and Tokorozawa in suburban 1 area located within concentric circles of 30～40 km from Tokyo station.

(d) Kumagaya, Hatoyama, Kuki, Hachioji, Ome and Ebina in suburban 2 area located within concentric circles of 40～70 km from Tokyo station.

4. RESULTS

4.1 Land use/cover change in Tokyo metropolis

The outskirts of Tokyo (Otemachi) which is the city center of Tokyo have a small change of land use. However, it is clear that change of land use is large in the area around Koshigaya and Urawa of Saitama Prefecture from northwest to northeast within a 40 km of the city center of Tokyo.

Land uses of mountain area and paddy field have decreased since the residential area and community facilities have increased from 1984 to 1994. Urbanization has progressed in the suburbs and it has grasped spatially that the city is expanded in a suburb from the center of Tokyo. However, the land use area of park and green space increased not only in the center of Tokyo but also in the suburbs.

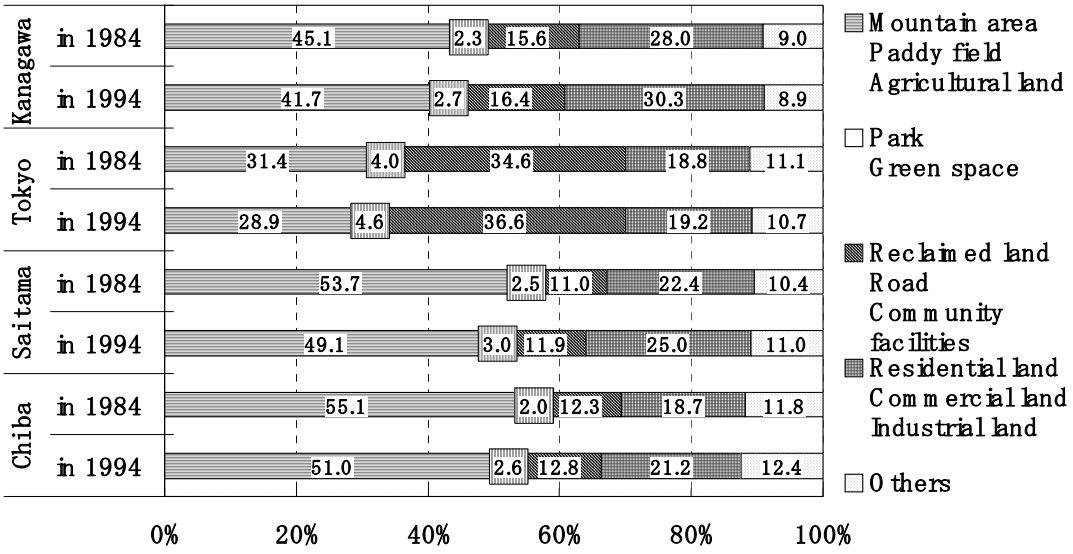

Table 2. The percentage of changes of land use from 1984 to 1994

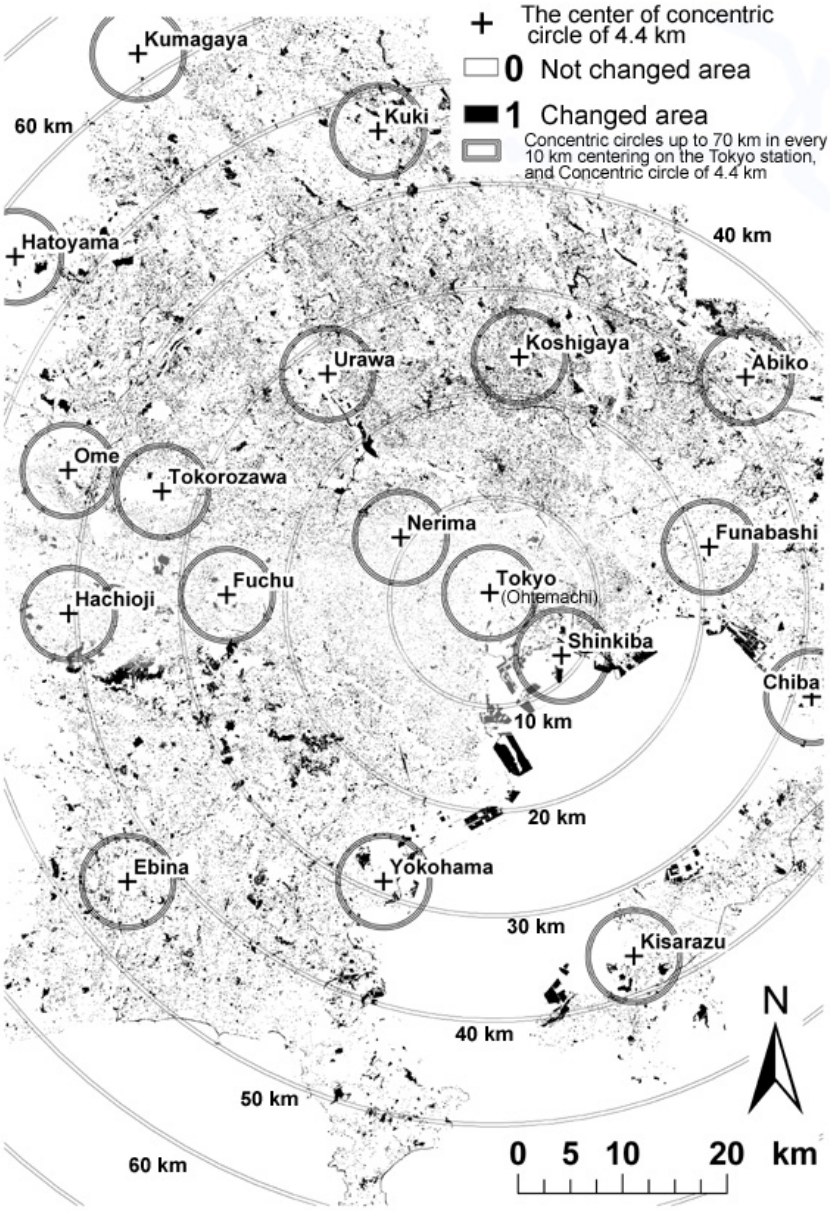

Fig 2. Land use change of Tokyo metropolitan during the period 1984-1994.

4.2 Multiple linear regression analysis

Multiple linear regression analisis (Land value in 1984 and in 1997)		
Year	in 1985	in 1997
Explaining variable 1	Spatial distance from Tokyo station	Building capacity ratio
Explaining variable 2	Sewarage	Spatial distance from Tokyo station
Explaining variable 3	Spatial distance up to near station	Sewarage
Explaining variable 4	Land form (hillyland>upland>lowland>reclaimed land)	Spatial distance up to near station
Explaining variable 5	Town gas	Building structure (reinforced concrete>steel framework>timbered)
Explaining variable 6	Building coverage ratio	Land form (hillyland>upland>lowland>reclaimed land)
Explaining variable 7	Building structure (reinforced concrete>steel framework>timbered)	Building coverage ratio
Explaining variable 8	Building capacity ratio	Town gas
Explaining variable 9	Green covering ratio	Green covering ratio
Multiple correlation coefficient	0.81	0.92
Contribution ratio (%)	64.5	85.0

Table 3. Determining factors of land values by regression analysis of the meso-scale

Multiple linear regression analisis (Land value in 1984 and in 1997)		
Year	in 1985 (Tokyo city)	in 1997 (Tokyo city)
Explaining variable 1	Spatial distance from Tokyo station	Building capacity ratio
Explaining variable 2	Green covering ratio	Spatial distance up to near station
Explaining variable 3	Building capacity ratio	Building structure
Explaining variable 4	Building coverage ratio	Green covering ratio
Explaining variable 5	Spatial distance up to near station	Land form
Explaining variable 6	Land area	Land area
Explaining variable 7	–	–
Explaining variable 8	–	–
Explaining variable 9	–	–
Multiple correlation coefficient	0.647	0.894
Contribution ratio (%)	28.3	79.5
Multiple linear regression analisis (Land value in 1984 and in 1997)		
Year	in 1985 (suburban 1)	in 1997 (suburban 1)
Explaining variable 1	Sewarage	Sewarage
Explaining variable 2	Spatial distance up to near station	Building capacity ratio
Explaining variable 3	Land form	Spatial distance up to near station
Explaining variable 4	Building structure	Green covering ratio
Explaining variable 5	Building capacity ratio	Spatial distance from Tokyo station
Explaining variable 6	Green covering ratio	Building structure
Explaining variable 7	–	Building coverage ratio
Explaining variable 8	–	Land form
Explaining variable 9		
Explaining variable 10	–	–
Multiple correlation coefficient	0.861	0.865
Contribution ratio (%)	71.4	73.6

Multiple linear regression analisis (Land value in 1984 and in 1997)		
Year	in 1985 (around Tokyo city)	in 1997 (around Tokyo city)
Explaining variable 1	Sewarage	Building capacity ratio
Explaining variable 2	Spatial distance up to near station	Spatial distance up to near station
Explaining variable 3	Green covering ratio	Green covering ratio
Explaining variable 4	Town gas	Sewarage
Explaining variable 5	–	Land form
Explaining variable 6	–	Building structure
Explaining variable 7	–	Building coverage ratio
Explaining variable 8	–	Town gas
Explaining variable 9	–	Spatial distance from Tokyo station
Multiple correlation coefficient	0.708	0.883
Contribution ratio (%)	48.6	77.4
Multiple linear regression analisis (Land value in 1984 and in 1997)		
Year	in 1985 (suburban 2)	in 1997 (suburban 2)
Explaining variable 1	Green covering ratio	Building capacity ratio
Explaining variable 2	Sewarage	Green covering ratio
Explaining variable 3	Spatial distance up to near station	Sewarage
Explaining variable 4	Land area	Building structure
Explaining variable 5	Building coverage ratio	Spatial distance up to near station
Explaining variable 6	Building structure	Spatial distance from Tokyo station
Explaining variable 7	Spatial distance from Tokyo station	Town gas
Explaining variable 8	Town gas	Land area
Explaining variable 9	–	Building coverage ratio
Explaining variable 10		Land form
Multiple correlation coefficient	0.842	0.868
Contribution ratio (%)	67.3	74.2

Table 4. Determining factors of land values by regression analysis of the local-scale

5. CONCLUSIONS

Multiple linear regression analysis was used to analyze the effect of the green environmental impact on the formation of land value. It was not be able to explain the influence of the vegetation impact on the land value of the area through the meso-scale in 70km range from the center of Tokyo, but this influence was clarified through the area of local scale in 4.4km range from the city of Tokyo metropolis as considered one of the elements that the vegetation could influence the formation of land value.

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