つくば市における社会経済の動向と土地利用変化の時空間分析

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Spatial-temporal socioeconomic dynamics and land use change of Tsukuba city

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Abstract: Spatial temporal socioeconomic dynamics and land use changes show that how the area has been developing over time. Tsukuba city is located in the northern part of Tokyo has been developed since 1960's as a science city. This study aims to investigate the spatial temporal socioeconomic dynamics and land use changes in the city using multiple regression and artificial neural network techniques. These techniques were performed to examine relationships between socioeconomic dynamics and land use changes.

Keywords: Grid Square Statistics (地域メッシュ統計), artificial neural networks（人口ニューラルネットワーク）, land use（土地利用）, socioeconomic dynamics（社会経済動向）, Tsukuba science city（筑波研究学園都市）

1. Introduction

Spatial temporal socioeconomic dynamics and land use changes show that how the area has been developing over time. Geographers, regional scientists have developed several methodologies to understand the spatial temporal phenomena (Anselin and Griffith, 1988). Socio-economic dynamics is not only known as non-linear and discontinues, but also land use changes. But we can see the findings from linear analysis.

The aims of this study are to investigate the socio-economic dynamics and land use changes, and to grasp the relationships between the land uses and socioeconomic dynamics using linear and non-linear methods. Furthermore, we will also compare the both linear and non-linear methods.

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2. Study area

Tsukuba city is located in the south of Ibaraki Prefecture (50 km northeast of central Tokyo) as an administrative unit that covers 260 square kilometers spaces (as of 2000) in the prefecture (Fig. 1). The area has flat geographical feature laid on the Tsukuba-Inashiki Plateau, 20-30m above sea level, which is covered with Kanto Loam Layer. Mt. Tsukuba (an elevation of 877 meters), one of the major mountains in Kanto region, is located in the north of the study site. Tsukuba city has been developed since 1960's as a science city. The development of science city carried a lot of facilities; national research institutes, highly educational institutes, and business opportunities.

3. Database and methodology

3.1 Databases

In this study, Grid Square Statistics (GSS) data of population with 1 kilometer resolution for the year 1990, 1995 and 2000 were processed to identify the spatial patterns of population and establishment changes in Tsukuba city for the year

1990/91, 1995/96 and 2000/01. This data was prepared by Statistical Information Institute of Consulting and Analysis (Sinfonica), Japan (http://www.sinfonica.or.jp). Each grid data was recoded and joined with the one kilometer mesh template. Spatial patterns of population were explored with different break even scales. Population change also detected cell by cell (cell = 1km^2) to identify the depopulation area and concentration area. A spatial pattern of local and migrated population was also explored.

Detail digital land use maps for the years 1984, 1989, and 1994 provided by Geographical Survey Institute were used. Land use data are reclassified into nine categories: forest and waste land, cropland, vacant land, industrial land, residential land, commercial land, road, public land, and water.

DEM and slope as topographical conditions are derived from GISMAP Terrain (scale 25,000) with 10m resolution DEM (Hokkaido-chizu co., ltd.). Topographical condition has impact on the residential and land uses.

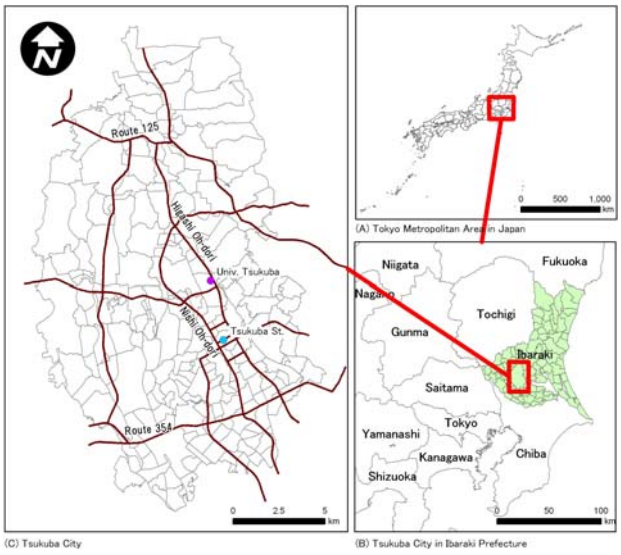

Fig.1 Study area

3.2 Methodology

At first, we explored the relations between socio-economic and land uses data. The socio-economic variable is selected as dependent where land uses are considered as independent variables. We compared the results using the multi-regression and artificial neural network (ANN).

Multi regression is selected to consider the impacts of independent variables at once as liner entity. Eligible independent variables are selected by backward elimination method at multi regression. ANN method is selected as non-linear method because ANN analyses the relations based on real data. ANN selects independents through the learning process.

3.3 Processing

Each method used population as dependent value. In 1990, the population is selected as dependent variable whereas nine land use categories in 1984, land use changes from 1984 to 1989, DEM, and slope are selected as independent variables. Land use and topographical condition are related to population distribution (Itoh and Murata, 2000; Zaiki et al., 2005). Considering the data aggregation unit of socio-economic variables, the other variables in the data were summarized by area or mean in each 1km grid. Based on land use transition rate, we used the average and standard deviation techniques to filter out the minor land use changes. ArcGIS 9.2 (ESRI, Inc) and SPSS 16.0 (SPSS Inc.) were used for spatial-temporal analysis.

4. Results and discussion

4.1 Spatial-temporal dynamics

Population has grown promisingly (1990: 162951, 1995: 175676 and 2000: 186352) in the city. Residential area developed since establishment of science city. Almost 70 % of Tsukuba city is covered by natural land use (forest and wasteland and cropland). Built-up land (residential, commercial and public land) is located at the city center area called Tsukuba center. The other residential land shows rural areas which have been before establishment of science city. Both population and built-up land construction have continues trend during study period where the population is concentrated mostly between the Nishi- and Higashi- Ohdori (Fig. 2).

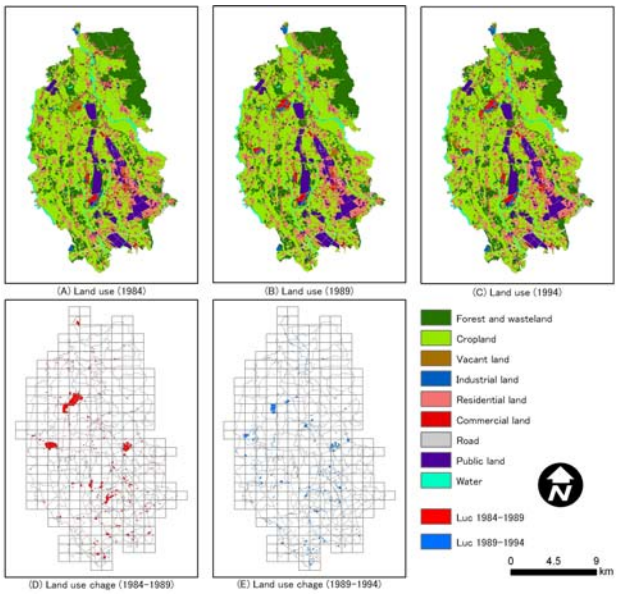

Fig.2 Land use and land use changed area

4.2 Comparisons of the methodologies

Multi-regression derived t values for each selected independent variable. Based on comparison of t value, the residential land use area has the most impacts on population during the study period. Land use changes from forest and wasteland to vacant land and from vacant land to residential land also has the impact on population. At this study, topographical conditions haven't significant impacts.

Multi-regression analysis derived negative value, although the dependent variable should be a real number (Fig. 3 and Table 1). But it's one of inevitable features of linear regression. Negative values are observed mostly between the most populated areas and the northwest side of the city.

ANN represented the trend of the population distribution except non-populated area. ANN distributed population at all of the study area, even though the place consists of steep slope which is difficult to live (Fig. 4 and Table 2). It derived the demand to filter out incompetent locations. It's one of the emerging issues. To solve this problem is to know the mechanism of the phenomena. However, these things are a kind of black box (Li and Yeh, 2002).

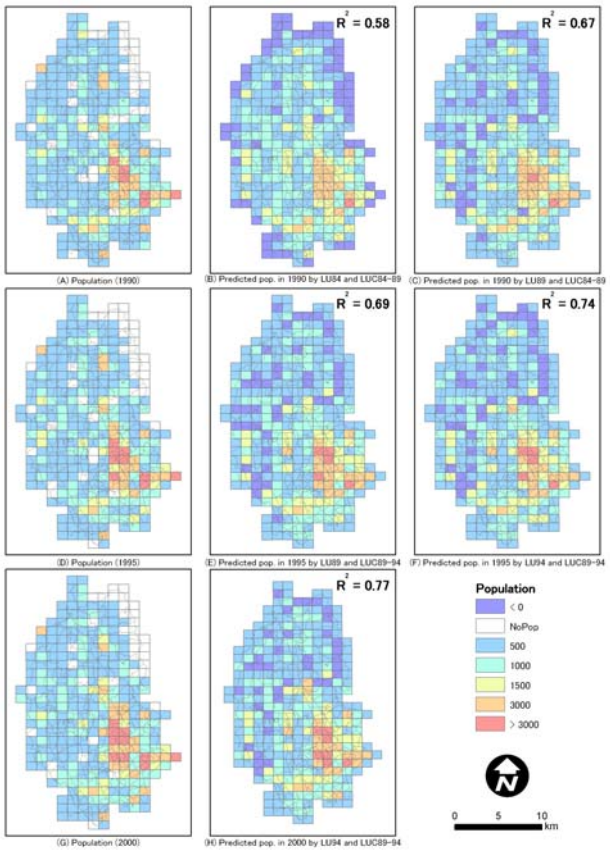

Fig.3 Population and derived population by multi-regression

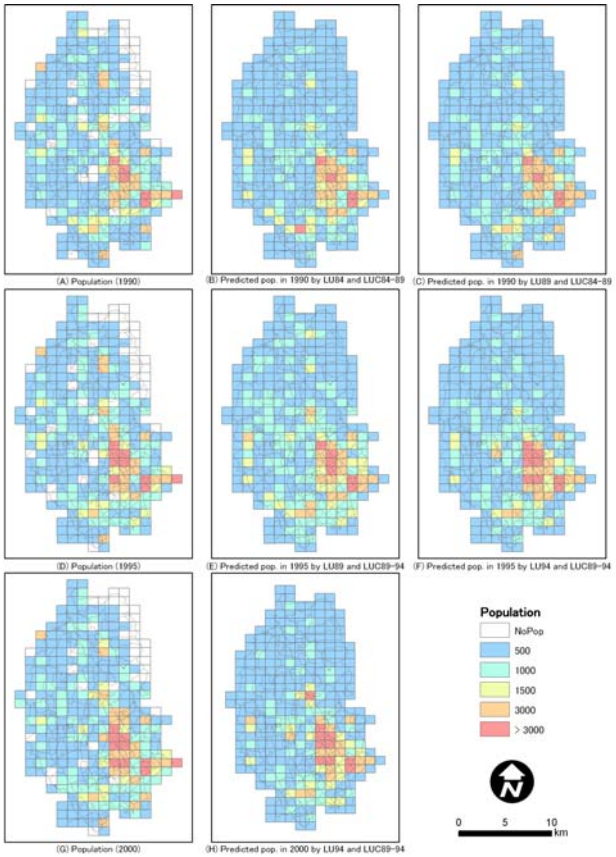

Fig.4 Population and derived population by ANN

5. Conclusions

In this study, we tried to trace the socio-economic dynamics of Tsukuba city using land uses, land use changes and topographical conditions. The relationships between socio-economic dynamics, land use and topographical conditions, residential and vacant land have impact on the population distribution.

Multi-regression and ANN have advantages and disadvantages in both methodologies. Analyzing the black box of ANN is still topic, although Itoh and Murata (2000) applied the causal index to investigate inside of the black box of ANN. Applying these methodologies, scientific tracing of these phenomena can provide a basis for future study.

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References

Anselin, L., and Griffith, D. A. (1988) Do Spatial effects really matter in regression analysis? *Paper of the regional science association*, **65**, 11-34.

Lie, X. and Yeh, G. O. (2002) Neural-network-based cellular automata for simulating multiple land use changes using GIS. *International Journal of Geographical Information Systems*, **16**, 323-343.

Itoh, F., and Murata, A. (2000) Artificial Neural Network Model Estimating Landuse- Change of Nagareyama City. *Journal of the City Planning Institute of Japan*, **35**, 1129-1134 (in Japanese).

Zaiki, M., Oguchi, T., Kagawa, Y., Takahashi, A., Koike, S., and Yamauchi, M. (2005) Relationships between distribution of Japanese residential areas and topography. *CSIS Discussion Paper*, **68**, 1-13(in Japanese).

Table 1. Statistics derived by multi-regression

	Pop90	Derived Pop90 -LU84-LUC8489	Derived Pop90 -LU89-LUC8489	Pop95	Derived Pop95 -LU89-LUC8994	Derived Pop95 -LU94-LUC8994	Pop00	Derived Pop00 -LU94-LUC8994
Data number	305	305	305	305	305	305	305	305
Minimum	0	-602.6	-444.6	0	-410	-460.1	0	-425
Maximum	5778	3221.2	3594.4	5690	4218.4	4156.4	5457	4363.4
Average	534.3	534.3	534.3	576	576	576	611	611
Std	736.3	560.5	602	799.5	688.1	689.4	841.8	746.2
Sum	162951	162951	162951	175676	175676	175676	2E+05	186352

Table 2. Statistics derived by ANN

	Derived Pop90 -LU84-LUC8489	Derived Pop90 -LU89-LUC8489	Derived Pop95 -LU89-LUC8994	Derived Pop95 -LU94-LUC8994	Derived Pop00 -LU94-LUC8994
Data number	305	305	305	305	305
Minimum	38.2	43.4	183.1	75.6	54.3
Maximum	4020.4	4488	3624.8	4378.1	4389.2
Average	484.2	524.9	665.5	572.3	592.7
Std	642.5	650.6	593.3	700.4	771.3
Sum	147694.4	160092.6	202979.4	174564.3	180774