Urban Growth Simulation Considering Disaster Risk in Provincial Cities

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Abstract: The purpose of this paper is to propose a method of urban growth simulation considering disaster risk. Object area is Tokushima Urban Area in Japan. Disaster risk evaluation was executed by past proposed method. Our proposed urban growth model was used to estimate future urban form. The results of disaster risk evaluation were used as a constraint of urban growth simulation. From the results of case based simulation, we discussed development control method in Tokushima Urban Area.
Keywords: Urbanization, Disaster Risk, Disaster Mitigation, Landuse Planning, Simulation

1. Introduction

Recently, there are two major issue in Japanese provincial cities, these are a disorder urbanization in suburban area and a decline in downtown. Disorder urbanization produces new urban area without sufficient infrastructure. Therefore, when the big disaster happened in these area, it will be caused a damage to these area. Land use plan considering disaster mitigation is fundamental information to formulate a safe urban planning. Future urban growth and disaster risk evaluation are important information to formulate these land use plan. The purpose of this paper is to propose a method of urban growth simulation considering disaster risk.

2. Tokushima Urban Area

Tokushima Urban Area is object area of the study. The area has two urban planning area, these are Tokushima East Urban Planning Area (UPA) and Aizumi UPA. Tokushima East UPA is divided into urbanization promotion area and urbanization control area by urban planning act. But Aizumi UPA including only Aizumi town does not have these area, so the town does not have urban development regulation. Figure 1 shows Tokushima Urban Area and two UPA, and table 1 shows a population and a number of household in 1995 to 2005. Table 1 shows the population growth of in suburb area of Tokushima city, Matsushige, Kitajima, Aizumi and Ishii town, are observed.

3. Disaster Risk Evaluation

Three disaster risks, the vibration, the liquefaction and the flood, were evaluated by two simple method (Cabinet office of Japan, 2005, Ministry of Land, Infrastructure, Transport and Tourism, 2007). In these method, disaster risk is evaluated according to microrelief. In addition to this method, the hazard area of the mudslide and the slope collapse were used. The source of these data is the hazard map made by Tokushima prefecture. Evaluation score was set highly depends on the scale of damage.

4. Urban Growth Model

Cellular Automata urban growth model which we proposed (Watanabe and Kondo, 2000) was used to estimate future urban form. Urban growth is affected by the accessibility of urban facilities, the urbanization control and promotion area, the surrounding urbanization ratio and the elevation, in the model. The size of cell is 120 by 120 meters, and these data was arranged by the same cell size. Urbanization potential is calculated by using these data. Random number was used as a spontaneous factor. Calibration of the model was executed by using actual urban area in 1997 to 2006.

5. Case-based Simulation

Urban growth simulation was executed using the results of disaster risk evaluation. Four cases were assumed in the simulation. The case 1 is the type of the continuing status quo. In the case 2, the urbanization promotion area in Tokushima city is kept, and other area is assigned the urbanization control area. This is the case considering the compact city. The case 3 is the case which abolished the urbanization control and promotion area. And, in the case 4, development control is executed in the area with high disaster risk.

According to the evaluation method which we consulted, the microrelief data is required. In this study, we used the land form data in place of the microrelief data. Table 2 shows the evaluation score by land form. This score is reflected in the level of disaster risk.

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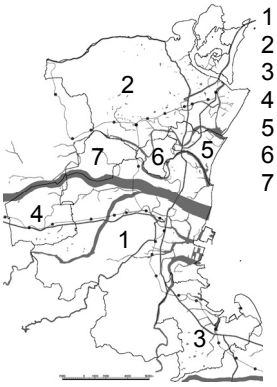

Figure 1. Tokushima Urban Area

Table 1. Population and Number of Household

No	Name	Area [km^2]	Population		Number of Household	
			1995	2005	1995	2005
1	Tokushima	191.39	268,706	267,833	98,483	109,698
2	Naruto	135.46	64,923	63,200	20,472	22,343
3	Komatsujima	45.11	43,349	42,115	13,841	15,045
4	Ishii	28.83	25,436	26,068	7,388	8,576
5	Matsushige	13.10	13,562	14,926	4,264	5,362
6	Kitajima	8.77	19,514	20,703	6,414	7,597
7	Aizumi	16.27	28,408	32,286	8,784	11,061
	Total	438.93	463,898	467,131	159,646	179,682

Table 2. Evaluation Score by Land Form

Evaluation Score	Disaster Risk		
	Vibration	Liquefaction	Flood
1	Paleozoic layer, Mesozoic layer, Paleogene layer	Mountain slope,Cliff, Plateau and terrace, Submontane dumping area, Cut and filling slope, Flat terrain	Mountain slope, Cliff, Cut and filling slope
2	Neocene layer, Hill soil, Alluvial fan, Gravel plateau	Depression contour and low valley, Alluvial fan, Sand hill	Plateau and terrace, Flat terrain
3	Natural levee, Artificial alteration, Loam plateau, Volcano and others	Natural levee, Sand hill, Valley flats, Delta area, Back marsh	Submontane dumping area, Depression contour and low valley, Alluvial fan, Natural levee, Sand bank and sand hill
4	Valley floor, Sand bank and sand hill	Abandoned channels, Banking area, Reclaimed land	Valley flats, Delta area, Back marsh, Reclaimed land
5	Reclaimed land, Back marsh and delta area		Flood channel, Low-flow channel, Marsh, Tidal flat

Table 3. Evaluation Score and Development Control

Evaluation score	Development control
4 and 5 (Vibration risk) 4 (Liquefaction risk) 4(Flood risk)	Urbanization control area
1 and 2 (Vibration risk, Liquefaction risk and Flood risk)	Urbanization promotion area
5 (Flood risk)	Development prohibition area

Table 4. Ratio of Overlapped Area with a Risk Evaluation Result and a Future Urban Area

Evaluation Score		Case 1	Case 2	Case 3	Case 4
Vibration Risk	1	0.0	0.0	0.0	0.0
	2	5.8	5.0	4.7	5.6
	3	25.7	26.2	25.6	42.7
	4	2.6	2.6	3.0	5.0
	5	66.0	66.2	66.7	46.7
Liquefaction Risk	1	5.0	4.1	4.0	2.7
	2	29.0	29.7	29.4	50.8
	3	66.0	65.9	66.7	46.5
	4	0.0	0.3	0.0	0.0
Flood Risk	1	0.8	1.2	0.6	0.4
	2	4.3	2.9	3.3	2.2
	3	29.0	29.7	29.4	50.8
	4	66.0	66.2	66.7	46.5
	5	0.0	0.0	0.0	0.0

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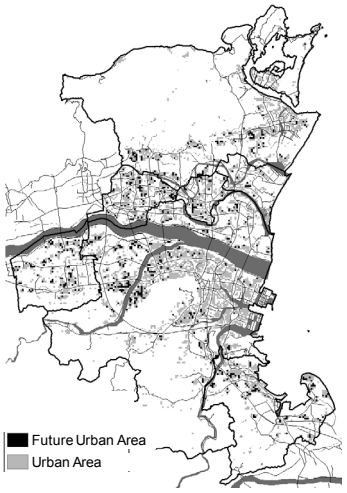

Figure 2. Future Urban Area of Case 4

Table 3 shows the relationship of evaluation score and development control area. In the case 4, new development in the hazard area of the mudslide and the slope collapse are prohibited. Neighborhood of these area is designated to urbanization control area. The area of evaluation score 3 is permitted a small quantity of development. Table 4 shows the ratio of overlapped area with a risk evaluation result and a future urban area for each case.

6. Conclusion

Figure 2 shows a future urban area of case 4. In these area, new development is controlled in the high disaster risk area, and new development is promoted in the area with low disaster risk. This is important information to formulate new urban plan considering disaster mitigation.

Acknowledgment

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