Monitoring Land Development for Urban Growth Management

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Abstract

The primary purposes of this study are to identify the characteristic of land development in urban area through GIS and remote sensing techniques and to provide useful implications for urban spatial policy. To perform these tasks, Daegu metropolitan city and its vicinities were selected as study area, and remote sensing data and attribute data were collected, organized and analyzed. This study focuses on the following three steps. First, it identifies the characteristics of land development in urban areas by utilizing multi-temporal satellite image data (Landsat TM; 1980, 1985, 1990, 1995, 2000 and 2005). Second, it tries to find an answer on a critical question concerning land use conversion, i.e., which land use leads expansion of urban area? Third, it derives implications for urban spatial policies based on the previous findings. The characteristics of the urban extents tells us that the main land use converted into urban use from non-urban uses is green areas, and public sector leads the land use conversions of suburban lands. Based on these findings, this study concludes that the more systematic and technically advanced management tools should be utilized for more effective urban management.

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1. BACKGROUND

In the field of urban planning, paradigm has been shifted from quantitative growth to qualitative aspects of human life, such as environment and sprawl problems. Consequently, managing large cities, especially the edge of city where development activities are very active, becomes a heart of urban management.

Urban growth management concerns about the location, size, time, and cost of development. Therefore, land market monitoring is heart of urban growth management. Unfortunately, land market monitoring for effective urban growth management is not implemented in Korea yet. Instead, there are various restrictions and permit system to control land development, such as environment appraisal, traffic impact analysis.. But these requirements cannot be effective tool to control urban growth since it can only be applied to individual projects.

In most advanced countries, land market monitoring is widely adopted and applied to expansion pattern of urban area, land use conversion, biological and environmental studies by utilizing remote sensing data. However, there are scanty studies to apply land market monitoring system to real land market management or urban growth control. Even worse, there is little study to identify the effectiveness of various land use restrictions as urban growth management tools.

This objective cannot be achieved unless proper systematic and applicable mechanism is in operation. For these reasons, this study tries to identify the characteristic of land development in urban area through GIS and remote sensing techniques and to provide useful implications for urban spatial policy. To perform these tasks, Daegu metropolitan city and its vicinities were selected as study area, and remote sensing data and attribute data were collected, organized and analyzed.

2. DATA AND APPROACH

2.1. Data

Data used in this study can be classified into two kinds. One is spatial data which consist of vector and raster data. Another is attribute data. Vector data are digital terrain maps, land use maps, maps created by the LMIS (Land Management Information System) of Korea. These are the basis of administration maps. Data descriptions are summarized in Table I.

Table I. Data Summary

Data	Time	Use	Source
Satellite image	*'80, '85, '89, '95, 2000, 2005*	*- land classification* *- temporal developed land*	*Landsat MSS, Landsat5 TM*
Digital terrain map	*2000*	*- administrative district* *- GCP(geometric collection)* *- slope and altitude analysis* *- undevelopable area*	*National Geographic Information Institute*
Land use map	*2000*	*- undevelopable area*	*Ministry of Environment*
LMIS map	*2005*	*- land use zone* *- order restricted zone*	*Ministry of Land, Transport and Maritime Affairs*

2.2. Approach

Given the growing interest in corruption, attempts to quantify its extent have become fundamental. Although inflation and unemployment have been measured with relatively standardized "rates," corruption has not been. It is intrinsically secretive, illegal, or highly variable across different economic activities, which makes it impossible to obtain precise information on its extent within a country. Statistics on the criminal prosecution of corruption activities are, more or less, indicators of the legal tolerance of corrupt practices, than of their prevalence in a given jurisdiction. For this reason, available corruption measures rely on the "perceptions" of economic agents dealing routinely with government officials and not on concrete measures of payoffs. Currently, there are several survey-based measures of "corruption perceptions" that are available and which have been widely used in empirical researches.

The concept of land development monitoring varies with region, method, time, range, etc. In general, land development monitoring supervises land development phenomena and provides them to policy makers.

This study deals the land development monitoring with respect to urban growth management as follows. First, the spatial boundary of this study is Daegu metropolitan area. It includes Daegu metropolitan city and its vicinities. Second, this study covers three environmental aspects of land development – socio-economic, natural and everyday life environment. In particular, this study concentrates on the location and size of land development as well as developable land stocks. Third, the time span of this study is twenty five years -- from 1980 to 2005.

Lands can be classified into three categories – developed (urbanized) lands, undeveloped lands, and non-developable lands. Developed lands can easily be extracted from satellite images. Undevelopable lands can also be identified by using digital terrain map, land use map and LMIS. Rest of lands is undeveloped land.

The analysis of this study follows several steps. In order to identify the urbanized area (developed lands), geographic correction and land cover analysis of satellite images were performed. GCP (Ground Control Point) for geographic correction references permanent points in the digital terrain map. For more accurate geographic correction, SPOT images (15m by 15m resolution), rather than Landsat5 TM (30m by 30m) were used. The convergence of origin (GCP) and destination image was performed by geometric model (Polynomial model, by setting Polynomial order = 2). After the 'image to image' correction, the final image transformation was performed by applying the nearest neighbor method.

We reclassified urbanized area, agricultural area, forest, vacant land, waters by considering the land cover analysis classification of Department of Environment. We classified land cover using supervised classification model and utilized ERDAS IMAGINE signature editor. The type signatures defined is parametric (statistical).

To evaluate collecting signatures, we computed the statistical distance between signatures (separability). According to signature separability and contingency matrix, Signatures were significant. Maximum likelihood method applied to parametric rule.

Undevelopable lands in this study include waters (streams and rivers, water reservoirs, and dams) and physical limitation of development (lands with slope higher than 30 degree and .altitude higher than 200m). For slope and altitude analysis, DEM (digital elevation model) was utilized in Arcgis9.2.

All these data, along with administration maps, were built into GIS for analysis. The analysis process is summarized in Figure I.

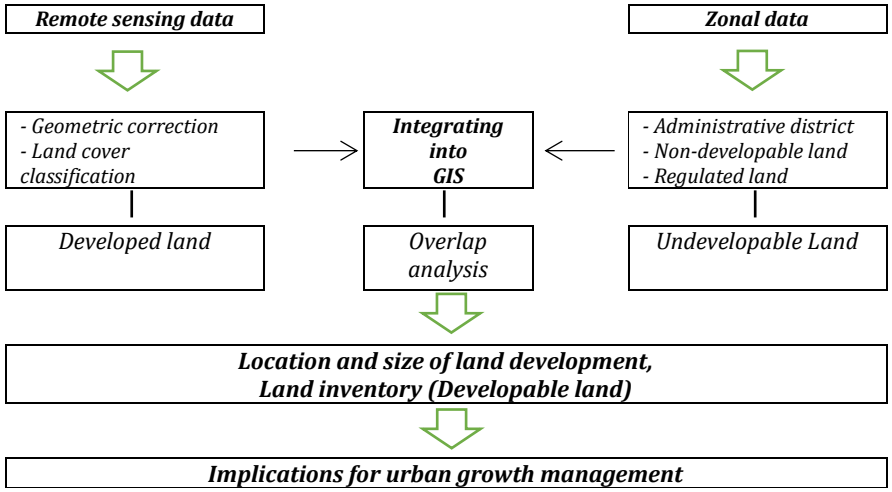

Figure I. The Process of Analysis

3. MONITORING LAND DEVELOPMENT

3.1. Study Area

Figure II shows study area. Daegu city, as a regional center of south-eastern part of Korea, contains seven 'Gu's (District, the primary self-governing body in the greater city area), 2 cities, and seven Guns (the primary self-governing unit in rural area) with total population 3,112,179 (Daegu city=2,464,547 and vicinities=647,632) in 2005. The area provides 916,632 jobs for residents (Daegu=714,703 and vicinities=201,929) in 2005. There are eight kinds of land use restrictions.

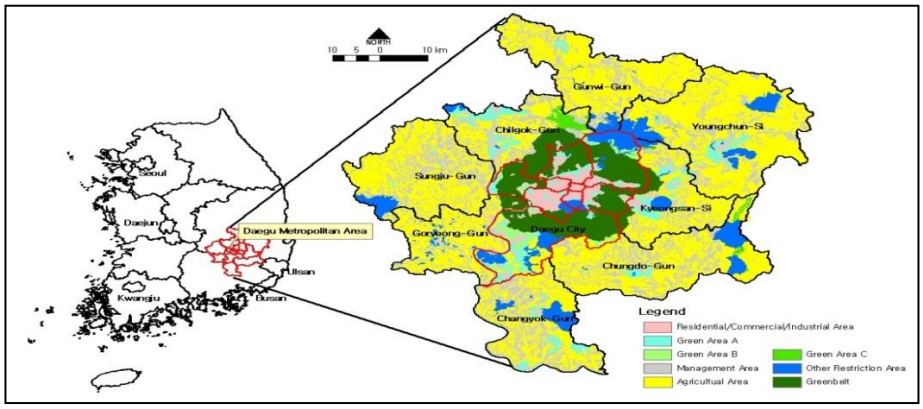

Figure II. Study Area: Daegu Metropolitan Area

3.2. Land Development by District

Table II presents non-developable lands, developed lands, and undeveloped lands by administration boundary and by year. The total study area is 5.478.8km^2 (Daegu metropolitan city = 868.8 km^2 and hinterlands = 4,610.0 km^2).

As Figure III and Figure IV illustrate, Daegu city expands rapidly since 1990. Similar pattern can be observed in hinterlands, even though the share of developed lands is low. The growth rate of urbanized area is much higher in hinterlands than in core city. Among eight districts, districts in suburban areas (such as Daegu, Dalseo, Buk, Dong, and Suseong) where large scale residential development occurred reveal higher level of land development. Other districts, as traditional city core areas, do not have room for additional development with rare vacant lands.

New development in hinterlands had been led by Gyeongsan city, Changyong-Gun, Chilgok-Gun, Youngchun city, partly because of intraregional development pressure and partly because development spillover from the central city. These trends are visually illustrated in Figure V and Figure VI.

Table II. The Trend of Land Development by District (1980-2005)

District	NDL*	1980		1985		1990		1995		2000		2005	
		DL**	UDL***	DL	UDL	DL	UDL	DL	UDL	DL	UDL	DL	UDL
Jung-Gu	0.16	6.01	0.85	5.97	0.86	6.27	0.55	6.35	0.48	6.60	0.23	6.66	0.16
Dong-Gu	105.28	7.92	68.31	10.41	65.66	14.00	62.07	17.73	58.34	19.93	56.13	25.50	50.57
Seo-Gu	0.99	7.57	8.75	10.44	5.86	12.41	3.89	12.92	3.38	13.83	2.47	14.13	2.17
Nam-Gu	5.23	7.11	5.24	7.75	4.77	8.74	3.78	9.14	3.37	9.61	2.91	9.77	2.75
Buk-Gu	16.38	10.64	65.94	11.93	64.46	15.63	60.75	20.81	55.57	25.08	51.31	28.12	48.27
Suseong-Gu	24.69	7.35	43.99	9.14	42.47	14.22	37.40	17.74	33.87	20.27	31.34	22.55	29.06
Dalseo-Gu	13.50	4.36	44.09	7.72	40.85	13.88	34.69	22.93	25.63	30.21	18.36	33.51	15.06
Dalseong-Gun	199.35	0.71	214.02	1.59	213.39	5.46	209.52	14.10	200.89	17.91	197.08	26.34	188.65

Daegucity	***365.58***	***51.66***	***451.20***	***64.95***	***438.32***	***90.61***	***412.65***	***121.72***	***381.54***	***143.44***	***359.82***	***166.58***	***336.68***
Youngchun-Si	*453.13*	*1.17*	*462.89*	*1.76*	*462.14*	*3.72*	*460.19*	*7.74*	*456.16*	*9.20*	*454.70*	*13.67*	*450.23*
Gyeongsan-Si	*187.89*	*1.83*	*218.22*	*2.93*	*217.87*	*6.67*	*214.13*	*14.06*	*206.73*	*18.66*	*202.13*	*28.47*	*192.32*
Gunwi-Gun	*362.96*	*0.13*	*249.72*	*0.31*	*250.18*	*0.68*	*249.80*	*2.91*	*247.57*	*3.13*	*247.36*	*3.68*	*246.81*
Chungdo-Gun	*480.21*	*0.37*	*215.24*	*0.53*	*215.18*	*1.38*	*214.33*	*3.71*	*212.00*	*3.97*	*211.74*	*6.00*	*209.71*
Goryeong-Gun	*121.82*	*0.25*	*257.80*	*0.37*	*257.66*	*1.03*	*257.00*	*5.36*	*252.67*	*6.08*	*251.95*	*8.91*	*249.12*
Sungju-Gun	*319.51*	*0.22*	*294.18*	*0.35*	*293.86*	*0.90*	*293.31*	*4.70*	*289.51*	*5.45*	*288.76*	*7.42*	*286.79*
Chilgok-Gun	*221.97*	*0.95*	*228.08*	*1.75*	*227.01*	*3.46*	*225.30*	*8.77*	*220.00*	*11.13*	*217.63*	*15.12*	*213.64*
Changyong-Gun	*180.89*	*0.40*	*348.90*	*0.63*	*349.11*	*2.10*	*347.64*	*13.51*	*336.23*	*14.60*	*335.14*	*17.93*	*331.81*
Hinterlands	***2,328.36***	***5.33***	***2,275.03***	***8.64***	***2,273.00***	***19.94***	***2,261.70***	***60.76***	***2,220.87***	***72.21***	***2,209.42***	***101.21***	***2,180.43***
Total	***2,693.94***	***57.00***	***2,726.22***	***73.58***	***2,711.31***	***110.55***	***2,674.35***	***182.48***	***2,602.41***	***215.65***	***2,569.24***	***267.79***	***2,517.11***

*: Non-developable land, **: Developed land, ***: Undeveloped land. Unit: Km^2

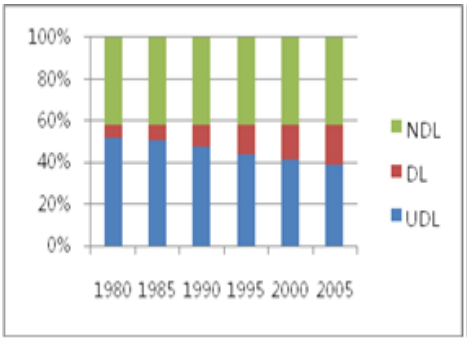

Figure III. Land Use: Daegu

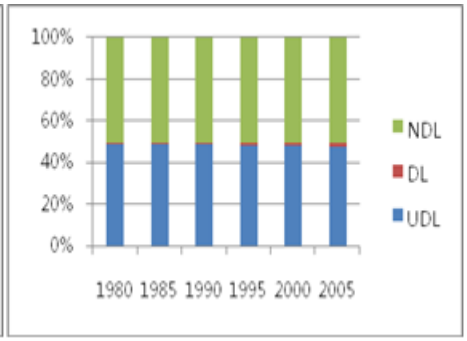

Figure IV. Land Use: Hinterlands

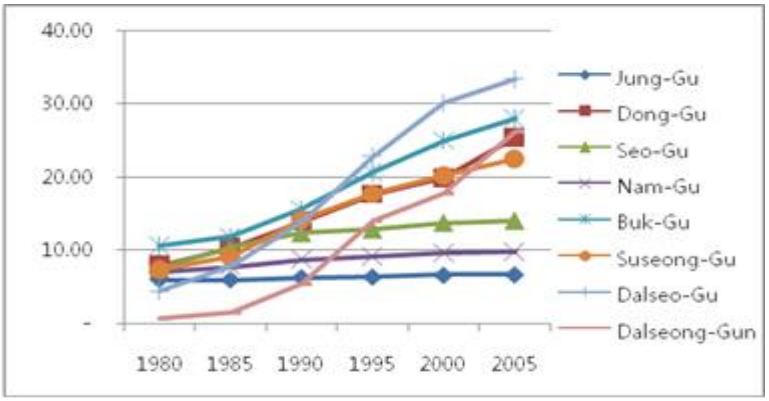

Figure V. Land Development Area by District: Daegu

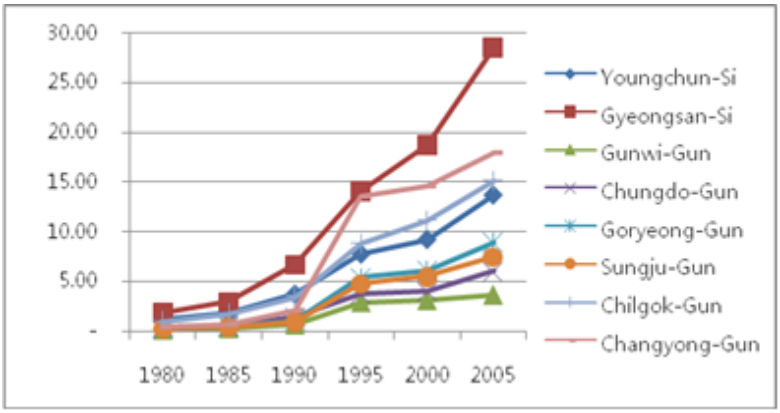

Figure VI. Land Development Area by city (town): Hinterlands

3.3. Urban Growth

Figure VII shows urban extent of 1980-2005 in five year interval. The figure tells us that new developments have been occurred near existing developed lands and suburban areas, as explained earlier.

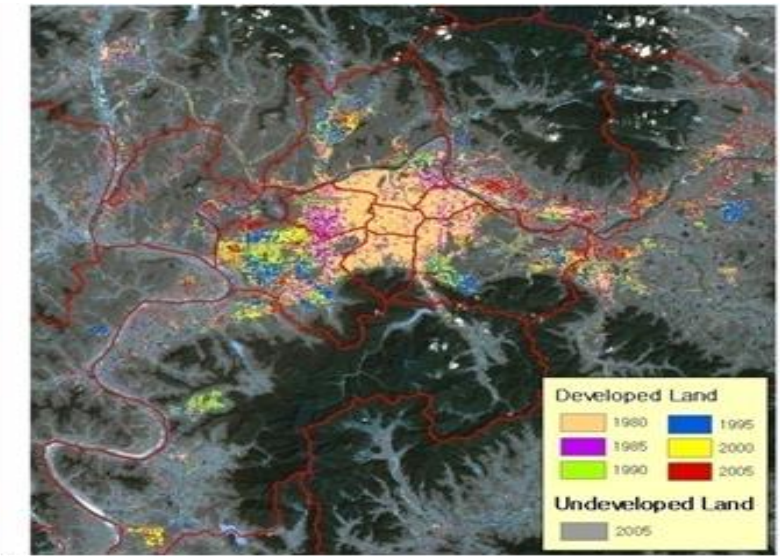

Figure VII. Spatial Distribution of Developed Land and Undeveloped Land

3.4. Land Development by Land Use

Land area by land use restrictions are shown in Table III. Table III, along with Figure VIII and Figure IX, shows that the main land use of new development during this period is residential, commercial and manufacturing use. Consequently, UDLs of these uses have decreased significantly, from 95.9 Km^2 in 1980 to 20.7 Km^2 in 2005, in the case of Daegu, and those of

hinterlands have declined from 54.0 Km^2 in 1980 to 30.7Km^2 in 2005. Needless to speak, this result is quite normal since these lands are designated for development. However, we can derive three distinctive development features.

First, a special attention should be given to the development trends between developable land in inner city region and outer city regions (especially green area and greenbelt) after 1990. Even though there are some developable lands available in the inner-city area, considerable lands in green and greenbelt area, where only public authorities can develop the lands for public purposes, have been developed since 1990. This tells us that recent land development since 1990 is driven by the public sector.

Second, green area, forest and agricultural lands have been converted into urban uses rapidly in the hinterlands. The speed of agricultural lands and management area development is faster than residential, commercial and manufacturing use.

Third, the increase rate and total quantity of development activities in agricultural use overtook the residential, commercial and manufacturing use in 2005. The land development in greenbelt and green area show a similar trend with Daegu city.

Table III. The Trend of Land Development by Land Use (1980-2005)

Land use	NDL	1980		1985		1990		1995		2000		2005	
		DL	UDL	DL	UDL	DL	UDL	DL	UDL	DL	UDL	DL	UDL
Residential/Commercial/ Industrial Area	*3.7*	*49.0*	*94.9*	*61.5*	*83.3*	*81.5*	*63.4*	*101.8*	*43.1*	*117.4*	*27.5*	*124.1*	*20.7*
Green Area A	*27.9*	*2.1*	*82.2*	*2.3*	*81.2*	*5.8*	*77.6*	*11.1*	*72.4*	*14.4*	*69.1*	*19.6*	*63.9*
Green Area B	*21.3*	*0.0*	*22.2*	*0.0*	*22.0*	*0.1*	*21.9*	*0.9*	*21.2*	*1.3*	*20.8*	*2.4*	*19.6*
Management Area	*0.7*	*-*	*0.4*	*-*	*0.4*	*-*	*0.4*	*0.0*	*0.4*	*0.0*	*0.4*	*0.1*	*0.4*
Agricultural Area	*31.6*	*-*	*16.3*	*-*	*16.6*	*0.0*	*16.6*	*0.6*	*16.0*	*0.7*	*16.0*	*1.4*	*15.2*
Green Area C	*0.0*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Other Restriction Area	*80.1*	*0.0*	*24.7*	*0.0*	*24.6*	*0.1*	*24.6*	*0.4*	*24.3*	*0.5*	*24.2*	*0.6*	*24.1*
Greenbelt	*200.3*	*0.5*	*210.5*	*1.1*	*210.1*	*3.0*	*208.1*	*6.9*	*204.2*	*9.2*	*201.9*	*18.4*	*192.8*
Daegu city (868.8 Km^2)	***365.6***	***51.7***	***451.2***	***65.0***	***438.3***	***90.6***	***412.7***	***121.7***	***381.5***	***143.4***	***359.8***	***166.6***	***336.7***
Residential/ Commercial/ Industrial Area	*2.1*	*4.4*	*54.0*	*6.5*	*52.5*	*11.2*	*47.9*	*20.1*	*38.9*	*24.6*	*34.5*	*28.3*	*30.7*
Green Area A	*46.8*	*0.5*	*127.4*	*1.0*	*126.3*	*2.8*	*124.4*	*6.8*	*120.5*	*8.6*	*118.6*	*11.7*	*115.6*
Green Area B	*1.5*	*0.0*	*11.5*	*0.0*	*11.8*	*0.1*	*11.7*	*0.4*	*11.4*	*0.6*	*11.3*	*1.6*	*10.3*
Management Area	*366.4*	*0.3*	*763.5*	*0.8*	*761.7*	*3.8*	*758.7*	*16.1*	*746.5*	*18.2*	*744.4*	*23.9*	*738.7*
Agricultural Area	*1,600.3*	*0.1*	*1,166.3*	*0.1*	*1,169.4*	*1.2*	*1,168.3*	*15.2*	*1,154.3*	*17.2*	*1,152.4*	*29.7*	*1,139.9*
Green Area C	*40.6*	*-*	*2.1*	*0.0*	*2.3*	*0.0*	*2.3*	*0.1*	*2.3*	*0.1*	*2.3*	*0.1*	*2.3*
Other Restriction	*221.0*	*0.0*	*70.3*	*0.0*	*69.8*	*0.3*	*69.5*	*0.9*	*68.9*	*1.0*	*68.8*	*1.5*	*68.3*

Area													
Greenbelt	*49.8*	*0.0*	*79.8*	*0.1*	*79.1*	*0.4*	*78.8*	*1.2*	*78.1*	*2.0*	*77.3*	*4.5*	*74.7*
Hinterlands* (4,610 Km²)	***2,328.4***	***5.3***	***2,275.0***	***8.6***	***2,273.0***	***19.9***	***2,261.7***	***60.8***	***2,220.9***	***72.2***	***2,209.4***	***101.2***	***2,180.4***
Total (5,478.8 Km²)	***2,693.9***	***57.0***	***2,726.2***	***73.6***	***2,711.3***	***110.6***	***2,674.4***	***182.5***	***2,602.4***	***215.7***	***2,569.2***	***267.8***	***2,517.1***

*: Non-developable land, **: Developed land, ***: Undeveloped land. Unit: Km²

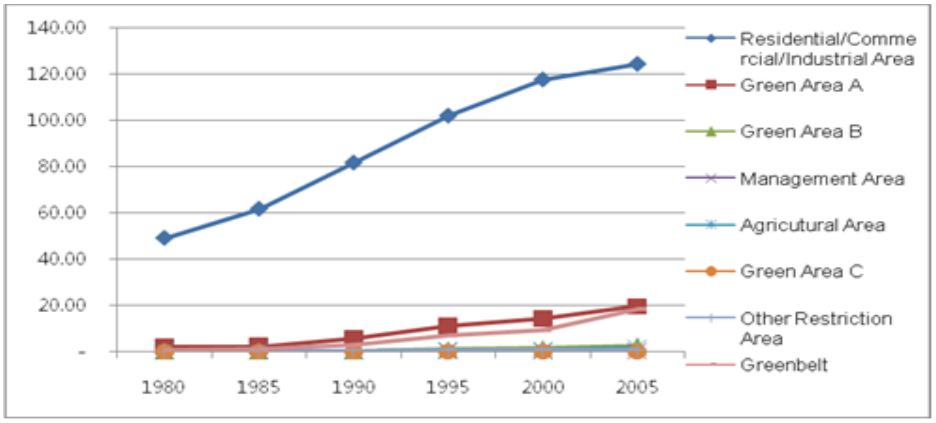

Figure VIII. Land Development Area by Land Use: Daegu

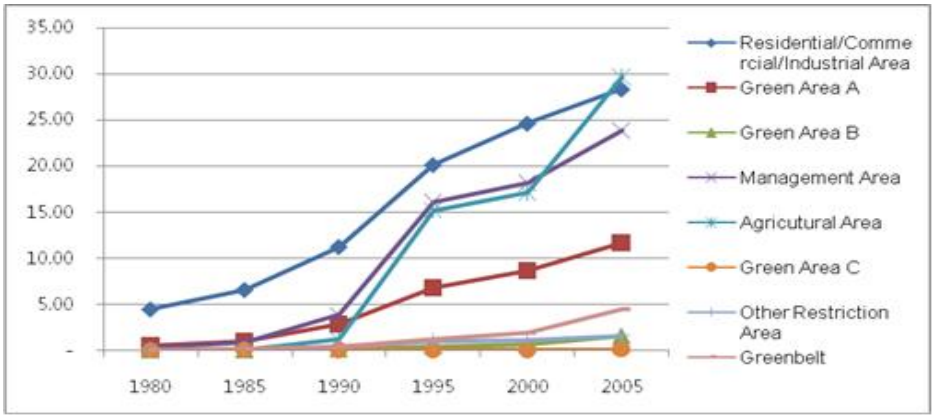

Figure IX. Land Development Area by Land Use: Hinterlands

4. CONCLUSION

So far, this study suggests methods and approaches of land monitoring for urban growth management, and analyzes land development by land use and by region.

The main finding of this study can be summarized as follows. First, the main land developments have been occurred near edge of core city and neat existing urbanized area. Second, considerable amount of natural green area and greenbelt area have been developed in inner city areas by public sector. Meanwhile, agricultural lands and management areas have

been developed in hinterlands, even though there are developable lands in inner city side of core city. By summing these findings together, we suggest that more refined and advance way of managing urban land development are required urgently.

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