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Urban Land Use Change Detection over Daejon Metropolitan Area using Bi-temporal Landsat TM image with the Integration of GIS*

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원격탐사와 GIS를 이용한 대전광역시 토지이용 변화 검출*

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요 약

지난 몇 십 년 동안 한국에서는 도시의 확장으로 인해 인구 밀집지역에서의 토지이용이 급속하게 변화되었으며, 그 결과 도시의 환경은 악화되었다. 도시화는 도시민에 필요한 녹지의 크기와 수를 감소시킬 뿐만 아니라, 서식처 파괴의 원인이 되며, 적절한 녹지의 배치 또는 배열이 이뤄지지 않을 경우 도시내 생태적 기능의 결핍을 초래한다.

경관변화의 증명과 분석은 토지이용변화의 환경 요소의 인과관계 파악에 중요하다. 원격탐사와 지형정보체계는 토지이용 변화의 경향과 영향을 이해할 수 있어 녹지공간변화 파악에 사용된다. 원격탐사는 동일대상지의 다른 시기에서의 영상자료를 이용해 토지이용의 경년변화를 파악하며 지형정보체계는 이를 저장, 분석에 활용되고 있다. 본 연구는 원격탐사와 지형정보체계를 이용하여, 1989년부터 1998년 동안, 대전광역시의 토지이용 변화를 파악하며 그 원인을 살펴보는데 있다.

주요어 : land use, change detection, remote sensing, GIS

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I. Introduction

The land use in the metropolitan area has been changed rapidly due to the urban expansion in Korea during the last few decades. And such changes result in environmental problems (Yokohari *et al.*, 2000). Human activity is not only reducing the size and number of remaining natural areas but also causing habitat fragmentation, which result in configurations, or arrangements of these areas that are poorly suited to maintaining ecological function(Smith and Hellmund, 1993). Planning always requires information and it is also true of landscape planning based on land information. Since the first launch of Landsat in 1972 land information has been updated periodically. Identification and analysis of landscape change have become key components in dealing with the environmental consequences of the land use change. Remote sensing(RS) and geographical information systems (GIS) can be used for land use change detection to understand the impact and trend of the land use change. Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times(Singh, 1989). It can provide a quantitative and comparative information. The basic premise in using remote sensing data for change detection is that changes in land cover must result in changes in radiance values. It must be large with respect to radiance changes caused by other factor(Ingram *et al.*, 1981). The purpose of this study is to detect and quantitatively evaluate urban land use changes in Daejon metropolitan region for the last decade.

II. Methods

The study area is Daejon. Figure 1 shows Daejon metropolitan area located in the central part of South Korea. The area of Daejon metropolitan area is 540.1km^2 and it consists of five districts, Yoosung-ku(17,504.7ha), Taedok-ku (6,870.3ha), Tohng-ku(13,790.8ha), Seo-ku (9,637.7ha), and Chung-ku(6,208.4ha). The popu-

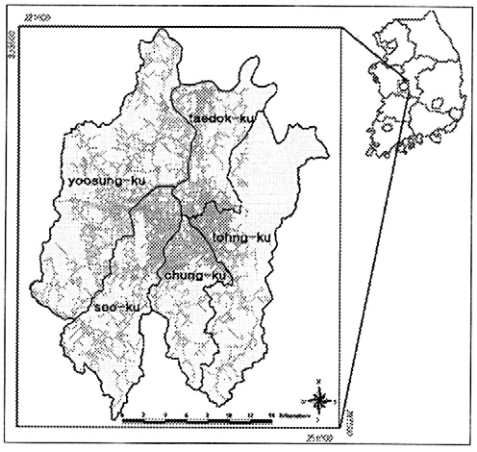

Figure 1. Study Area

Table 1. Area of each district in Daejon and population change between 1989 and 1998

(unit: person)

Administration	Yoosung-ku	Taedok-ku	Tohng-ku	Seo-ku	Chung-ku	Sum
PO_1989	80,148	151,259	302,293	206,037	312,058	1,051,795
PO_1998	151,399	209,369	261,248	463,903	259,765	1,345,684
Changed population	71,251	58,110	-41,045	257,866	-52,293	293,889
Area(ha)	17,504.7	6,870.3	13,790.8	9,637.7	6,208.4	54,011.5

lation increased from 1,051,795 (1989) to 1,345,684 (1998). Table 1 shows the population change between 1989 and 1998.

Two Landsat TM scenes acquired on October 9, 1989, and October 2, 1998, respectively were used to detect land cover change in the study area. Korea Multi-Purpose Satellite-1(KOMPSAT-1) Electro-Optical Camera(EOC) image with 6.6m resolution and aerial photographs (1/20,000) were also used as reference data. In terms of RS and GIS softwares, PCI(RS) and ArcView(GIS) were used in this study. PCI was used for image rectification, resampling, training area selection and classification and so on. ArcView was used for storing and analyzing land cover classification data statistically. All scenes were rectified to the Korean Transverse Mercator coordinate system and geometrically corrected. In geometric correction, ground control points(GCP's) were selected by referring to dominant features in the topographic map such as bridge, reservoir and highway intersections. Then, the first order nearest neighbor resampling scheme was used to preserve the original digital numbers. After the land cover classification of each year, classification accuracy assessment was done by referring to KOMPSAT EOC image and 1:20,000 aerial photographs. For the 1989 accuracy assessment, 1:20,000 aerial photos were used as reference data while KOMPSAT image was used for 1998 classification accuracy assessment. After generating both year land use maps, the land use change detection was done by comparing the land cover maps of 1988 and 1998. Figure 2 shows the study procedure.

III. Results and Discussion

The classification accuracy assessment was obtained for the study site and there were five classes classified as forest, agriculture, barren, urban and water. Classification accuracy assessment was done using PCI software based on three hundred random samples. The classified pixel was compared with the enhanced image by visual interpretation. However, the edge

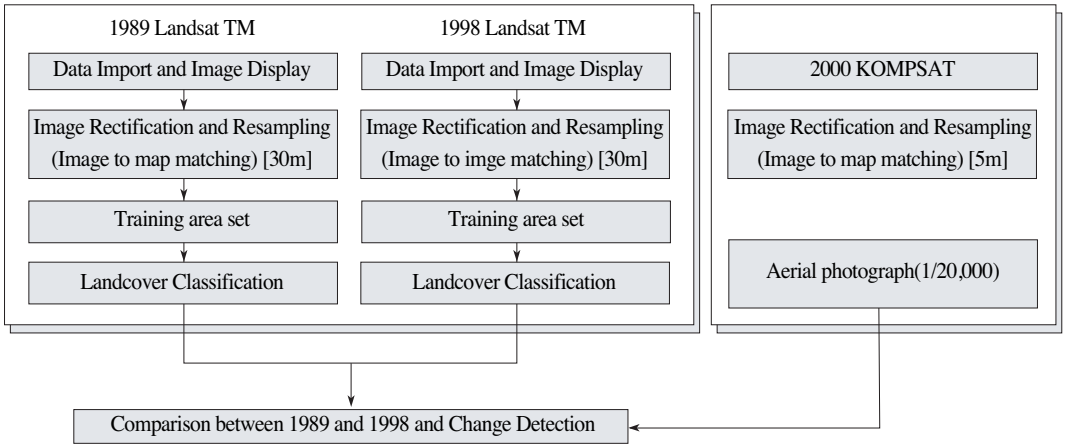

Figure 2. Flowchart of classification and change detection for satellite data

Table 2. Confusion Matrix of classification image(1989)

		Reference Data						
		Forest	Agriculture	Barren	Urban	Water	Totals	User's Accuracy[b]
Classified data	Forest	186	20	0	2	1	209	98.0
	Agriculture	1	37	2	7	0	47	78.7
	Barren	0	0	3	1	0	4	75.0
	Urban	0	3	3	19	0	25	76.0
	Water	4	0	0	0	11	15	73.3
	Totals	191	60	8	29	12	300	
	Error (%)	5 (2.6)	23 (38.3)	5 (62.5)	10 (34.5)	1 (8.3)	44 (14.7)	
	Producer's Accuracy[a]	97.4	61.7	37.5	65.5	91.7		

[a], [b]: Producer's accuracy and user's accuracy mean measure of omission error and commission error respectively.
Overall Accuracy : 85.3%

Table 3. Confusion Matrix of classification image(1998)

		Reference Data						
		Forest	Agriculture	Barren	Urban	Water	Totals	User's Accuracy[b]
Classified data	Forest	174	16	1	7	2	200	87.0
	Agriculture	5	29	3	16	0	53	54.7
	Barren	0	7	2	6	0	15	13.3
	Urban	0	0	1	19	0	20	95.0
	Water	0	0	1	0	11	12	91.7
	Totals	179	52	8	48	13	300	
	Error (%)	5 (2.8)	23 (44.2)	6 (75.0)	29 (60.4)	2 (15.4)	65 (21.7)	
	Producer's Accuracy[a]	97.2	55.8	25.0	39.6	84.6		

[a], [b]: Producer's accuracy and user's accuracy mean measure of omission error and commission error respectively.
Overall Accuracy : 78.3 %

area like lake or forest were not easy for discrimination. Most of the study area was checked in the field from the spring 2000 to the summer 2002.

Tables 2 and 3 show the confusion matrices for the accuracy of 1989 and 1998 year. Overall accuracy of the 1989 image classification was 85.3%(Table 2) and that of the 1998 image classification was 78.3%(Table 3) based on the selected three hundred random sample pixels.

Figure 3 and Table 4 show the trend of land cover changes between 1989 and 1998. As we can see in Table 4, the largest changed(sum of decreased area and increased area) land use type is green space - agricultural field and forest - . Of the green spaces, agricultural field decreased by 6,592.3ha and the forest increased by 4,402.1ha. The main reason of forest increase is the growth of seedling tree forest which were classified as pasture(5,113.9 ha) in 1989 image. For the non-green space type, the urban area increased by 2,643.2ha, and the barren area decreased by 564.4ha.

The common trend of land cover change at

Table 4. Land cover changes in Daejon metropolitan area

(unit : ha)

			1989 land cover						
			green space			non-green space		total	increased area
			forest	water	paddy/grass	barren	urban		
1998 land cover	green space	forest	28,265.4	156.2	5,113.9	126.9	812.9	34,475.2	6,209.8
		water	92.3	1,851.8	91.9	58.3	133.3	2,227.5	375.8
		agricultural field	732.3	16.3	5,108.3	282.2	632.0	6,771.1	1,662.8
	non-green space	barren	272.1	1.2	597.2	267.0	203.1	1,340.6	1,073.5
		urban	711.0	90.8	2,452.1	1,170.5	4,773.2	9,197.6	4,424.5
	total		30,073.1	2,116.2	13,363.4	1,904.9	6,554.4	54,012.0	
	decreased area		1,807.7	264.4	8,255.1	1,637.9	1,781.3		
changed area			+4,402.2	+111.3	-6,592.3	-564.4	+2,643.2		

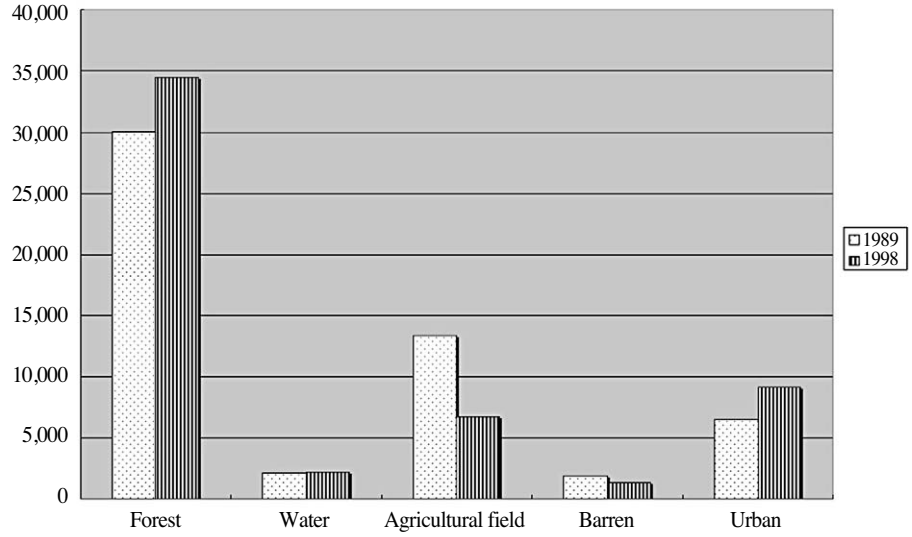

Figure 3. land use change in Daejon between 1989 and 1998

each district is the decrease of agricultural field and increase of forest area. Figure 5 and Table 5 show land cover change for five districts, Yoosung-ku, Taedok-ku, Tohng-ku, Seo-ku, and Chung-ku. As we can see in Table 5, the forest area at each district increased by 1,609.8ha, 343.4ha, 1,370.3ha, 652.1ha, and 426.6ha respectively while agricultural field at each district decreased by 2,298.3ha, 924.2ha, 1,487.2ha, 1,347.5ha, and 535.1ha respectively. The most important reason of decreasing agricultural field is the urbanization(2,643.2ha). The urban area increased 743.8ha, 613.6ha, 131.9ha, 944.6ha, and 209.4ha respectively. As we can see in Figure 5, the urbanization occurred mostly at Seo-ku(944.6ha), Yoosung-ku(743.8ha), and Taedok-ku(613.6ha) while the other two districts - Tohng-ku(131.9ha) and Chung-ku(209.4ha) - increased less. It is also true of barren land(1,170.5ha). At Seo-ku the urbanization were caused mainly due

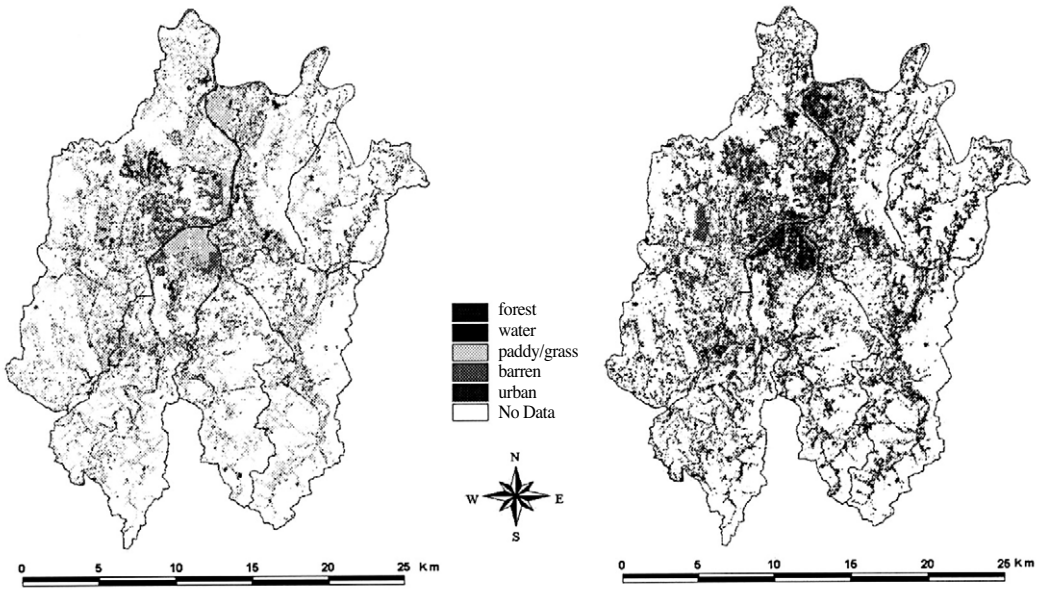

Figure 4. land use change area for five districts between 1989(left) and 1998(right)

Table 5. Land cover change for each district

(unit : ha)

	year	forest	water	agricultural field	barren	urban	total
Yoosung-ku	1989	9,275.7	132.2	6,247.6	793.7	1,055.5	17,504.7
	1998	10,885.5	198.7	3,949.3	671.9	1,799.3	
	changed	(+)1,609.8	(+)66.5	(-)2,298.3	(-)121.8	(+)743.8	
Taedok-ku	1989	3,191.6	552.2	1,484.1	302.0	1,340.6	6,870.3
	1998	3,535.0	552.2	559.9	269.0	1,954.2	
	changed	(+)343.4	(+)0.1	(-)924.2	(-)32.9	(+)613.6	
Tohng-ku	1989	8,796.0	1,350.2	1,962.0	145.0	1,537.7	13,790.8
	1998	10,166.2	1,379.5	474.8	100.7	1,669.5	
	changed	(+)1,370.3	(+)29.3	(-)1,487.2	(-)44.3	(+)131.9	
Seo-ku	1989	5,059.6	66.2	2,755.2	496.9	1,259.8	9,637.7
	1998	5,711.7	87.6	1,407.7	226.4	2,204.4	
	changed	(+)652.1	(+)21.3	(-)1,347.5	(-)270.5	(+)944.6	
Chung-ku	1989	3,750.2	15.4	914.5	167.4	1,360.9	6,208.4
	1998	4,176.8	9.5	379.4	72.5	1,570.3	
	changed	(+)426.6	(-)5.9	(-)535.1	(-)95.0	(+)209.4	

(+) : increased area, (-) : decreased area

to the development Doonsan new town. It is also true of development of military area(Jaundae) and Noheun Distrcit at Yoosung-ku and the development of industrial area at Moonpyung-dong, Taedok-ku.

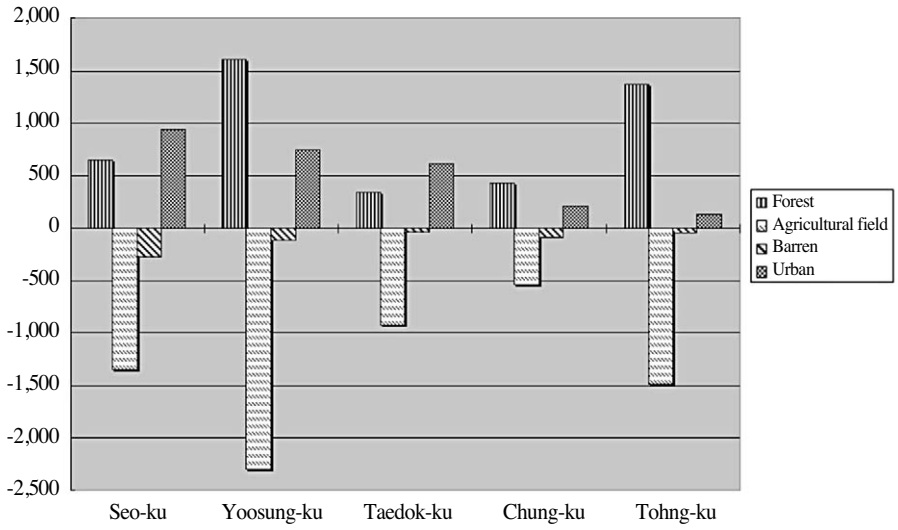

Figure 5. Land cover change for each districts between 1989 and 1998

In summary, the urban land use change in Daejon is mainly due to the urbanization.

IV. Conclusions

After the comparative analysis approach of independently produced land cover classifications between 1989 and 1998 was done, the following conclusions are derived for the land use change.

First, there is a significant increase of forest land(4,402.2ha) which is mainly due to the growth of seedling forest during this period.

Second, the agricultural field area decreased by 6,592.3ha. Yoosung-ku and Tohng-ku occupies the major portion of that increase. It is mainly due to the urbanization. The urban area increased by 2,643.2ha while the barren land decreased by 564.4ha. Yoosung-ku, Seo-ku, and Taedok-ku occupies the major portion of that increase.

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