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River Landscape Change Detection Using Digital Photogrammetry Combined with Visual Interpretation

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시각판독 및 수치사진측량을 이용한 하천경관 변화 파악

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ABSTRACT

1960년대 이후 빠른 도시화는 도시 자연환경, 그중에서도 도시 하천을 많이 변화 또는 훼손시켰다. 한강은 서울의 중심을 흐르는 강으로서 60년대 이후 도시화로 인해 유로변경, 천변백사장 망실 등 자연경관이 급격히 변화하였다. 오늘날 하천은 도시의 생태통로로서 뿐만 아니라 천변 녹지 및 오픈스페이스로서 그 가치의 중요성을 인정받고 있다. 따라서 변화된 하천자연경관은 환경복원의 주요 대상이며 이를 위해서는 훼손되기 전 하천경관의 원형파악이 필수적이다. 경관의 원형파악을 위해서는 촬영당시의 지형, 지물의 구체적인 정보들을 보유하고 있는 항공사진과 고해상도 위성영상 등의 원격탐사 자료를 이용, 대상지의 지형, 지질, 식생, 토괴 등을 판독하여 자연경관의 변화를 파악하는 것이 효과적이다. 최근에는 항공사진 외에도 IKONOS 위성 영상과 같은 고해상도영상을 판독한 후 이를 수치사진측량기법을 이용하여 경관변화의 계량적 파악을 시도하고 있다. 본 연구에서는 한강을 대상으로 1966년부터 2002년까지의 변화를 상기 방법을 이용하여 하천 자연경관변화를 파악하였다. 판독결과 대부분의 하천 변화는 모래사장과 곡류하천이 소멸돼 다른 용도로 전환된 것으로 나타났으며 모래사장은 하천 직강화로 인해 하천으로 변했으며 하천은 단지 및 택지개발에 따른 천변도로 개설로

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인해 소멸된 것이 가장 큰 원인으로 각각 나타났다.

Key Words : *River landscape, Change detection, Digital photogrammetry, Restoration.*

I. INTRODUCTION

The river corridor includes not only the channel and its adjacent banks but also a floodplain, hill slopes, and adjacent strips of land. The river floodplain landscapes are diverse and dynamic, yet little is known about long-term changes in land-cover patterns in these systems (Forman, 1995, Freeman, 2003). Since 1960s Han River water landscape has changed significantly mainly due to the stream straightening for housing site development. Once the riverside landscape was changed, the structure, function, and dynamics of the total riparian ecosystem would be destroyed. So, it requires careful site and urban planning in riverside area. Once destroyed, it would be very difficult to restore the landscape. However, it is still necessary to restore the urban river ecosystem. In order to restore Han River landscape, the first and most important requirement is to identify the original river landscape before change. Remote sensing (RS) technique has been widely used in identifying the original landscape before change (Yue, 2003). Of RS techniques, visual image interpretation of aerial photographs or high resolution satellite images can be useful in identifying and detecting landscape changes because these images contain a detailed record of features on the ground at the time of data acquisition. An interpretation is made as to the physical nature of objects and phenomena appearing in the images (Lillesand et. al., 2004). In addition to visual interpretation, digital photogrammetry is the science and art that get geometric, radiometric, symmetric information from digital images. Digital photogrammetry technique combined with visual interpretation was used in this study for acquiring high-quality digital orthophoto map from aerial photographs. Thus, this study aims to detect landscape changes of Han River between 1966 and 2002 using digital photogrammetry combined with visual interpretation of airphoto and high resolution satellite images and

Figure 1. Study Site (Han River in Seoul City, Left), Han River Watershed Area (Right).

eventually to provide reliable data for urban river environmental restoration.

II. MATERIALS AND METHODS

1. Study Site

The study site is Han River located in Seoul City, South Korea. The Han River is 497.5km long with watershed area of 26,219km^2. Its water courses cover extensive regions of the middle part of country including Gangwon Province, Chungcheongbuk Province, Gyeonggi Province, and Seoul City(http : //www.hrfco.go.kr/html/index.html, http : //english.seoul.go.kr/today/about/about_05han_01.html). Since 1960s, the water landscape of Han River has significantly changed mainly due to urbanization.

2. Study Methods

The drainage pattern and texture seen on aerial photographs are indicators of landform (Lillesand & Kiefer, 1979). It can be interpreted by human beings. In this study, aerial photographs taken from 1966 were scanned to digital images by using Ultrascan 5000 scanner at 30 micrometer per pixel. Both vector and raster data can be manipulated with computer-based, softcopy photogrammetric mapping and GIS systems that operate in a desktop computing environment (ASPRS, 1996). Each digital image from scanned aerial photographs was ortho-rectified by performing Bundle Adjustment technique. One hundred and fifty ground control points (GCP's) were selected from 1 : 1,000 scale digital road maps and 1 : 5,000 digital topographic maps. Vertical coordinates of GCP's were referred to 5m*5m resolution Digital Elevation Model (DEM) which was produced from 1 : 25,000 scale topographic maps. All digitally ortho-rectified images were mosaicked to a digital orthophoto map. Leica Photogrammetry Suite (LPS) V. 8.7 was used in this process. Finally, Han River landscape in 1966 was extracted from digital orthophoto map by using on-screen digitizing technique. On-screen digitizing technique can be useful in registering locational data and acquiring attribute data for good accuracy (Ahn, 2003). ArcView Ver. 3.2 was used in this process. On the other hand, Han River landscape in 2002 was extracted from Seoul Biotop Map (Seoul City Government, 2000) and changed area between 2000 and 2002 was corrected by referring to IKONOS (2002) image. Finally, Han River landscape between 1966 and 2000 was detected quantitatively using contingency table.

Table 1. The data, hardware, and software used in this study.

Input Data	aerial photographs(1966) IKONOS Image(2002.03.09) Digital Road Map(2002) Digital topographic map(1998) Seoul Biotop Map(2000)	1 : 33,000 Scale 1m spatial resolution 1 : 1,000 Scale 1 : 5,000 Scale and 1 : 25,00 Scale Seoul Development Institute
Hardware	UltraScan5000 Desktop PC	± 5 micron accuracy Pentium 2.3GHz
Software	Leica Photogrammetry Suit V. 8.7 ORIMA DP-M ArcView GIS V. 3.2	Leica Leica ESRI

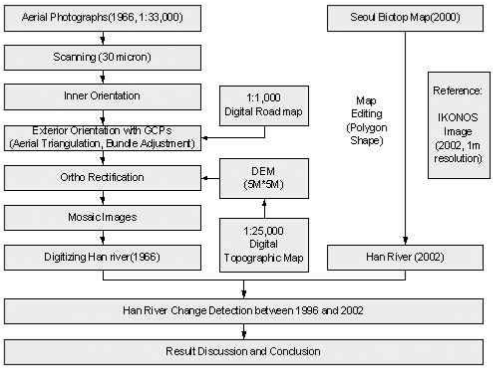

Figure 2. Han River Change Detection Work Flow.

Table 1 and Figure 2 show data used in this study and study procedure, respectively.

III. RESULTS AND DISCUSSION

Figure 3 shows Han River digital orthophotos in 1966 and Han River satellite image in 2002 (left), respectively and mapping process from Seoul Biotop Map (right). Aerial triangulation results using Bundle Adjustment technique show that root mean square error (RMSE) was 7.9m. It is mainly due to the registration error of GCP's and images. Some areas were changed greatly so that GCP's can be hardly selected. And topographic changes between 1966 and 2002 also might contribute to RMSE increase. Han River and tributary change results required more verification. Some tributaries were hardly detectable even if 1m*1m fine resolution images were used for interpretation. Han River landscape change between 1966 and 2000 was very clear. After the interpretation these change detection was arranged into quantitative results using contingency table in this study.

Table 2 shows Han River water landscape change between 1966 and 2002. The sandbar area decreased by 2620 ha while water area increased by 1030 ha during this period. Overall Han River water landscape area decreased by 1290 ha between 1966 and 2002 mainly due to the disappearance of sandbars. Water landscape has changed significantly by urbanization. Most of sandbars disappeared (99.8%) during this period. Irrespective of sandbar disappearance remnant of sandbars (4 ha) still remain at Bamseom and Eungbohng area in 2002.

Flood-control project and housing site development during the past half century resulted in the straightening of many streams (Brinford and Buchenau, 1993). Original hydrologic network and meandering streams in 1966 are destroyed and straightened in 2002. Many water courses are disappeared during this period. Figure 4 shows the land use change of water landscape between 1996 and 2000.

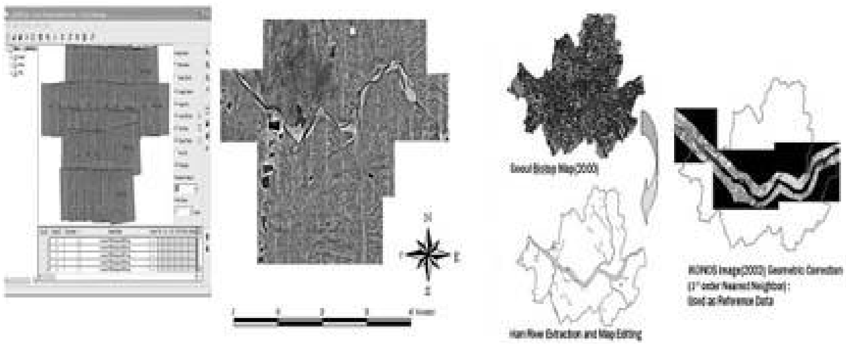

Figure 3. Digital orthophotos in 1966(left) and in 2002 from Seoul Biotop Map (right).

Table 2. Han River water landscape change between 1966 and 2000. (unit : ha)

Water landscape area	Water area	Sandbar and Other	Total area
2002	2930	4	2903
1966	1900	2620	4520
Changed area	(+)1030	(-)2620	(-)1290

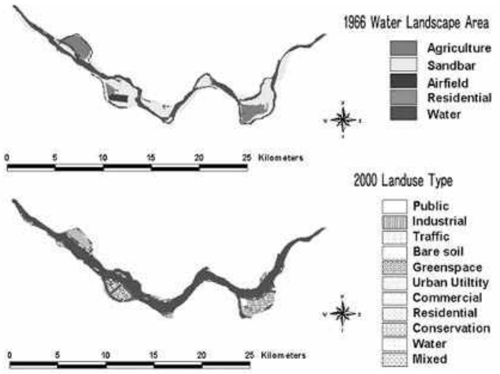

Figure 4. Land use change in 1996 water landscape area.

Table 3 shows the contingency matrix of land use change between 1966 and 2000. Sandbar area in 1966 were converted into river (1480.2 ha, 59.2%), green space (395.5 ha, 15.8%), transportation (236.9 ha, 9.5%) and residential area (156.2 ha, 6.3%). River in 1966 were converted into transportation (155.2 ha, 8.2%), green space (154.7 ha, 8.2%), and residential area (82.8 ha, 4.4%).

The main reason of sandbar and river disappearance in Jamsil is due to river straightening work for housing site development work (Figure 5). The surface of river was filled with earth materials to be converted into residential area as we can see in Figure 5. In Mapo area, sandbar was converted into sanitary landfill and meandering tributary and oxbars were gone. These areas are now park and golf courses. As we can see in these figures, most of riparian zones are gone and converted land was connected into riverside land. As a result, Han River was straightened and sandbars were filled with pave materials. It means

Table 3. Land use change contingency matrix between 1966 and 2000. (Unit : ha)

2000 \ 1966	Sand-bar	Water	Air-port	Agriculture	Residential	Total
Public use	53.7	16.2	5.1	70.7	7.8	153.3
Industrial	2.2	1.0	0.0	6.4	0.0	9.6
Transportation	236.9	155.2	32.0	86.4	8.3	518.8
Bare Soil	50.7	46.1	1.8	30.3	0.0	129.0
Green Space	395.5	154.7	28.1	89.6	9.5	677.4
Other Urban	27.9	17.6	0.0	181.4	0.4	227.3
Commercial	71.2	16.2	39.1	36.7	0.0	163.2
Residential	156.2	82.8	21.5	120.9	0.6	381.9
conservation	21.3	2.7	0.0	0.0	0.0	24.1
Water	1480.2	1385.8	0.3	34.9	0.0	2901.2
Mixed use	3.7	3.8	0.0	13.7	0.0	21.2
Total	2499.5	1882.1	127.8	671.0	26.5	5206.9

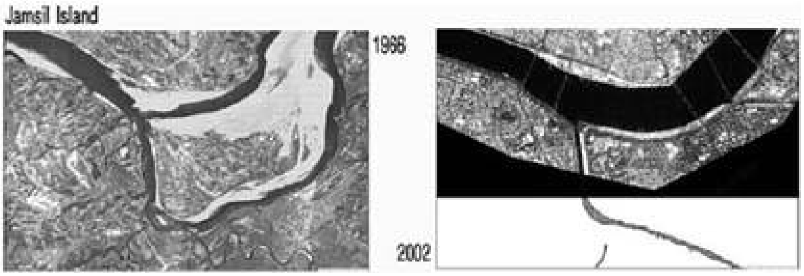

Figure 5. Jamsil Island water landscape change between 1966 and 2000.

the extinction of riparian ecosystem. However, these riparian zones are ecological filters controlling the flux of materials, and good sites to measure how environmental change may affect interactions between adjacent ecological systems (Decamps, 1993). So, these riparian landscape should have been conserved as we can see in the example of the United States. They changed the policy after it was recognized that the accumulation of coarse organic debris from forests leads to the greater incidence of ecologically beneficial cover, slow-water refugia and pools, and increased sediment storage. Thus, the strategies for the conservation of aquatic ecosystems emphasize the protection and restoration of streamside (riparian) forests (Montgomery, 1997). To restore the riparian ecosystem, the current urbanized land use cannot be possible to be converted into other land use. Because high rise collective apartments were built already like Lotte Complex, and Jamsil Redevelopment Work. So, the change of river bank materials and revegetatoning seem to be the possible alternative right now. However, Mapo area can be renewed as a open space because the park and golf course is being constructed after sanitary land fill.

IV. CONCLUSIONS

Han River water landscape change detection between 1966 and 2002 was performed using digital photogrammetry combined with visual interpretation and on-screen digitization technique in this study. After analysis, the following conclusions were derived.

1. Han River water landscape area decreased by 1290ha in total between 1966 and 2002 mainly due to the disappearance of sandbars. and other area which covers 2620ha.

2. Jamsil Island and Mapo Sandbar water landscapes have changed significantly between 1966 and 2002. It is mainly due to housing site

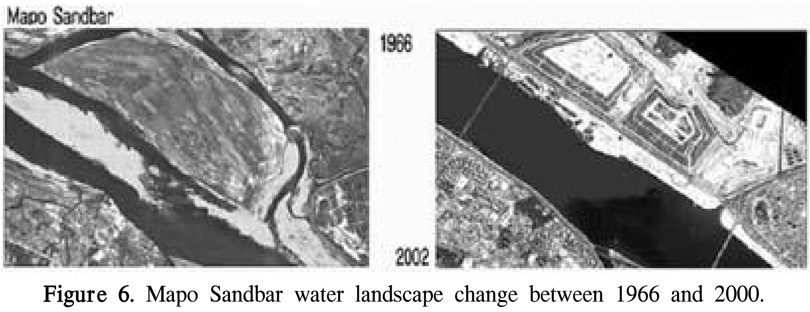

Figure 6. Mapo Sandbar water landscape change between 1966 and 2000.

development by urbanization.

3. Sandbar area in 1966 were converted into river (1480.2 ha, 59.2%), green space (395.5 ha, 15.8%), transportation (236.9 ha, 9.5%) and residential area (156.2 ha, 6.3%). Water area in 1966 were converted to transportation (155.2 ha, 8.2%), green space (154.7 ha, 8.2%), and residential area (82.8 ha, 4.4%).

4. Recovering Jamsil area is now impossible because of high rise collective apartment complexes. the change of river bank materials and revegetatoning seem to be the possible alternative right now.

5. Mapo area can be renewed as a open space because of less intensive land use after sanitary land fill.

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