Analysis of River Channel Morphology and Riparian Land Use Changes Using Aerial Photographs and GIS

Geun Ae Park1
Doctoral Candidate
1 Hwayang-dong, Gwangjin-gu, Seoul 143-701, Korea
dolpin2000@konkuk.ac.kr

Mi Seon Lee2
Master Candidate
1 Hwayang-dong, Gwangjin-gu, Seoul 143-701, Korea
misun03@konkuk.ac.kr

Hyeon Jun Kim3
Principal Researcher
2311 Daehwa-dong, Ilsan-gu, Goyang-si, Gyeonggi-do 411-712, Korea
hjkim@kict.re.kr

Seong Joon Kim4
Associate Professor
1 Hwayang-dong, Gwangjin-gu, Seoul 143-701, Korea
kimsj@konkuk.ac.kr

Abstract: This study is to trace the change of stream shape using the past series of aerial photographs, and to compare the land use changes of riparian area along the stream. For the Gyeongan national stream, aerial photographs of 1966, 1981 and 2000 were selected and ortho photographs were made with interior orientation and exterior orientation, respectively. As apparent changes of the stream, the consolidated reaches of stream with levee construction were straightened and their stream widths were widened. Especially the stream width of inlet part of Paldang lake was widened almost twice because of the rise of water level by dam construction in 1974. The land use maps (1966, 1981, 2000) of riparian areas were also made, respectively and classified into 6 categories (water, forest, agricultural land, urban area, road, sandbar) by digitizing. The area of forest and agricultural land decreased and urban area increased as the stream maintenance was performed.

Keywords: Change of stream shape, Aerial photographs, Change of land use.

1. Introduction

The riparian areas have been developed as the river works were carried out and the population of a region increased. This caused the areas exposed to flood risk. On the other hand, the necessity of preservation and restoration of stream environment and ecosystem has grown stronger. Thus it is necessary to make a historical data related to the stream, and to manage and evaluate the changes of stream itself and the riparian areas using GIS and/or RS techniques.

Generally, direct observation is the most reasonable to analyse the characteristics of some places and objects. But, this method consumes enormous money and time. Also, there are a lot of problems to understand the relationship of surrounding elements comprehensively. Aerial photograph can solve this kind of problem. High resolution of aerial photograph makes an easy understanding of some changed landforms and land use, and periodical filming for the same place is useful to analyse the temporal changes of landforms and land use.

This paper is to analyse the change of stream shape and riparian land use using the past series of aerial photographs for study area.

2. Study Area, Aerial Photographs Data

The study area as shown in Fig. 1 is Gyeongan-cheon watershed that traverses Yongin-gun and Gwangju-gun. The watershed is consisted of five standard watersheds (Water resources Unit Code by Korea Water Resources Corporation: 101601, 101602, 101603, 101604, 101605) as a part of Han river basin. During couple of decades, Gyeongan-cheon watershed has been urbanized gradually by the second and third industries.

Total 45 aerial photographs were used. Table 1 shows the information of selected aerial photographs of three selected years (1966, 1981, 2000). Because aerial photograph of 1966 did not have data for filming camera, information of another year (1983) with the same focal length was used.

3. Generation of Ortho Photographs

This study conducted ortho rectification of geometric correction. Ortho rectification consists of interior and exterior orientation.

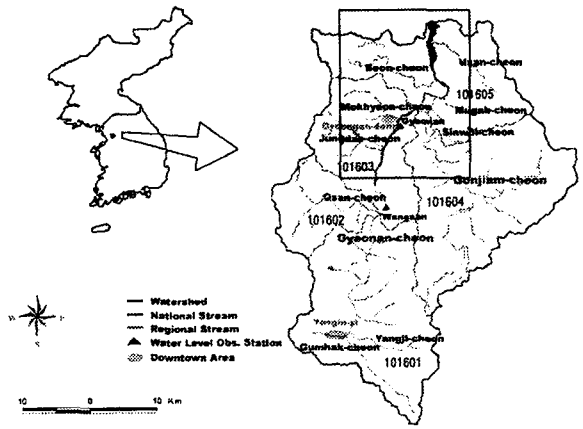


Fig. 1. The study area.

Table 1. Information of aerial photograph

Year	Scale	Number	Focal length (mm)	Orbital altitude (m)	Date	Type of camera
1966	1/37,500	11	152.48	5,737*	April	RC5/RC8*
1981	1/25,000	20	152.87	3,810	April	Wild UAG II 308
2000	1/37,500	14	152.54	5,715	April	RMK A 15/23

* used information of another year (1983) with the same focal length

1) Interior Orientation

This is the process of defining the internal geometry of the camera. Fiducial marks are measured on the image and subsequently compared to the calibrated positions of the camera to derive a solution. Once the fiducial marks have been measured, a 2D affine transformation is used to determine the origin of the photo coordinate system. The origin of the photo space coordinate system defines the location on the image where the optical axis intersects with the image plane. Once the photo coordinate system has been defined each subsequent image measurement is referenced to it.

2) Exterior Orientation

Exterior orientation describes the location and orientation of an image in the object coordinate system. A total of six transformation parameters per image are typically chosen for such an orientation, namely projection center coordinates (Xo, Yo, and Zo) and three rotations (omega, phi and kappa). The definition of the sequence of rotations has to be preserved. Also, exterior orientation used digital elevation model (DEM).

3) Digital Elevation Model (DEM)

Digital elevation model (DEM) available for ortho rectification is a digital file consisting of terrain elevations for ground positions at regularly spaced horizontal intervals (USGS, 1997a and 1997b). DEM was used to analyse topography, model and generate data. 5 m spatial resolution of DEM was created from the topographical layers (7111, 7114, 7217, 7311) of 1:5,000 NGIS digital map.

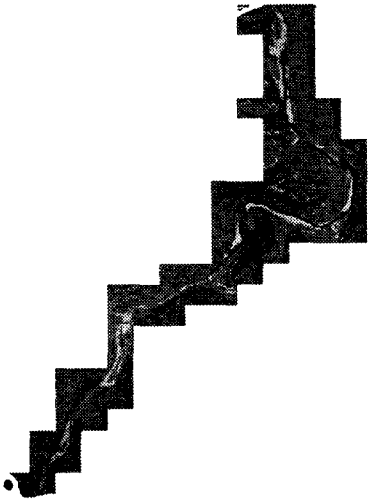
4) Creation of ortho photograph

Both interior and exterior orientation for all aerial photographs were executed to recompose same environment with the time of image capture geometrically. Ortho photos used Frame Camera Model of ERDAS (1999) IMAGINE OrthoBASE 8.5.

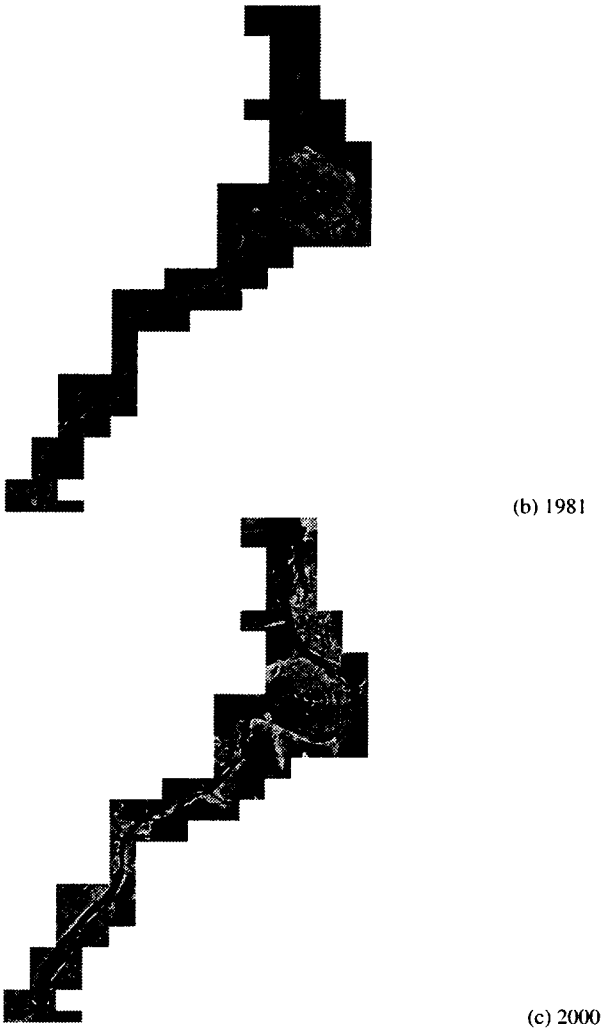
Ortho-rectification accuracy has separately average RMSE (root mean square error) 1.05, 0.54, 0.72 pixels for scanning resolution of 1966, 1981, 2000 aerial photographs. The next ortho photos were made to mosaic for extraction of stream shape and riparian land use.

4. Extraction of Stream Shape and Riparian Land Use

Three years (1966, 1981, 2000) of ortho photograph were masked by using map boundary of RIMGIS (river information management GIS) (Fig. 2).



(a) 1966



(b) 1981

(c) 2000

Fig. 2. Ortho photo.

1) Stream Shape

Fig. 3 shows the change of stream shape overlaying three years instream boundaries. At three parts, big change of stream shape was detected by the construction of stream bank (A: Jeongji-je, B: Jiwol-je, C: Ssanglyeong-je).

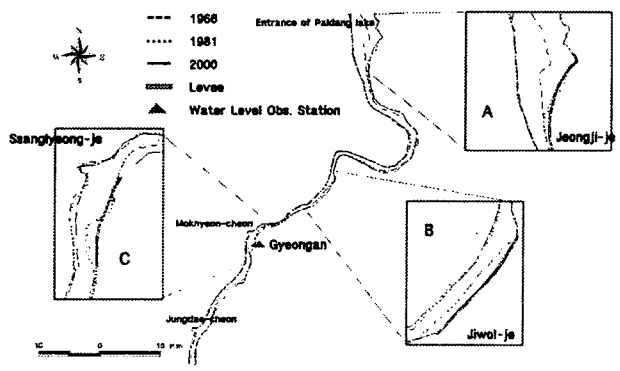


Fig. 3. Extracted stream shape.

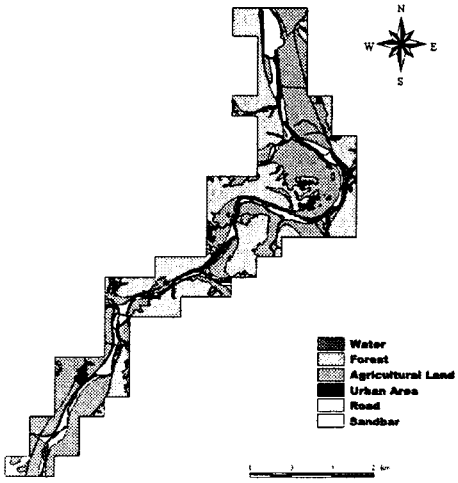
Basic plan of stream maintenance for Gyeongan watershed was established in the year 1987. Jeongji-je was constructed in December 1991, and Jiwol-je and Ssanglyeong-je were constructed in June 1998 and December 1989, respectively.

In part A, the average stream width of 1966 (340.9 m) was broaden almost twice in 1981. This is because Paldang dam was constructed in 1974 at the mouth of Gyeongan stream. In part B and C, the average stream width was broaden about 25.9 m and 24.4 m by the stream bank construction of Jeongji-je in 1998 and Ssanglyeong-je in 1989. The stream centerlines were extracted and compared. The length of stream was shortened from 14.58 km (1966) to 14.39 km (2000). The stream maintenance was conducted to prevent overflowing the bank especially in the bend part. The bank construction in the bend of stream changed the stream shape to be straight. In the past like in 1966, the flooded water was overflowed from the stream bend to form a natural inundation area. However, as the land value of the natural inundation area rises by residential use and land consolidation, stream maintenance by straightening the stream shape and broadening the stream width was conducted to prevent flood inundation. Stream bank construction causes the increase of urban land use within the riparian area. This is called a "levee effect".

2) Riparian Land Use

Land use map of riparian area was produced by digitizing method (Fig. 4). It was classified into 6 categories (water, forest, agricultural land, urban area, road, sandbar). Table 2 shows the area of each land use categories for three selected years.

Sandbar area decreased 0.75 ㎢ between 1966 (1.54 ㎢) and 1981 (0.79 ㎢). The reason is that the inlet part of Paldang lake (the lower reach of the stream) was submerged by the construction of Paldang dam in 1974. Forest and agricultural land decreased 2.7 % and 7.1 %, and urban area increased 3.2 % between 1966 and 2000. This is because of the construction of road and urbanization of riparian area by levee effect.



(a) 1966

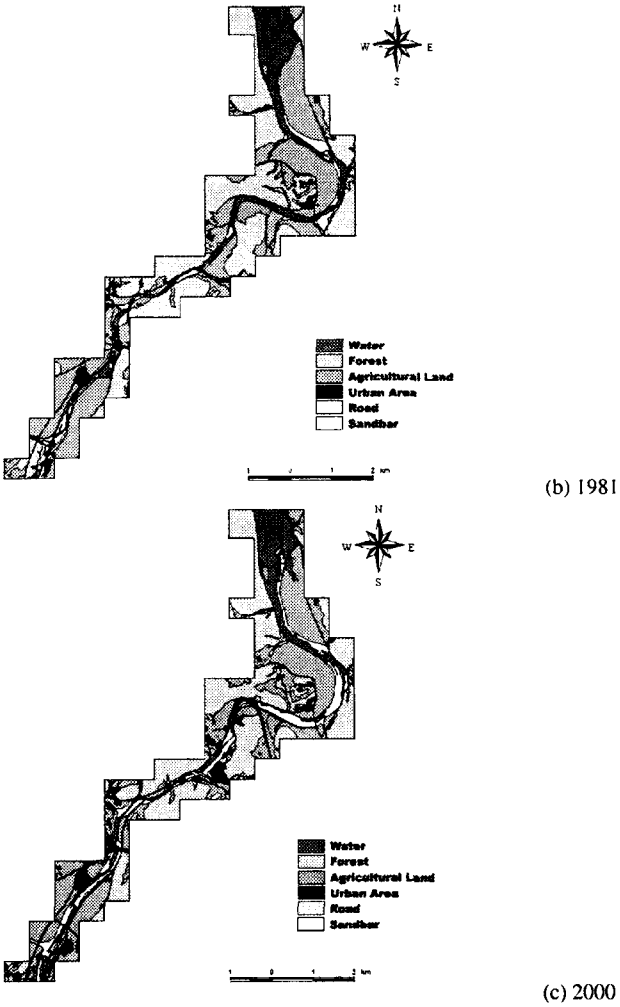


Fig. 4. Land use of riparian.

Table 2. Area of each land use for three selected years

Categories	Area (㎢)			Ratio of area (%)		
	1966	1981	2000	1966	1981	2000
Water	0.75	1.73	1.58	5.0	11.5	10.5
Forest	5.51	5.32	5.11	36.7	35.4	34.0
Agricultural area	6.92	6.76	5.85	46.1	45.0	39.0
Urban area	0.20	0.22	0.68	1.3	1.5	4.5
Road	0.08	0.19	0.35	0.6	1.3	2.3
Sandbar	1.54	0.79	1.45	10.3	5.2	9.7
Total	15.01	15.01	15.01	100.0	100.0	100.0

5. Summary and Conclusions

This study suggested a method to analyse the change stream shape and riparian land use using multi-temporal aerial photographs of 1966, 1981, 2000. Ortho photos were produced by image to image for each aerial photograph. After masking ortho photos using the map boundary of RIMGIS, change of stream shape was analyzed by comparing the stream centerline and levee boundary of each year. Bank construction between year of 1981 and 2000 for the purpose of flood prevention by stream maintenance changed the stream shape to be straight. For the land use change of riparian area, sandbar was reduced by the construction of Paldang dam in 1974. Forest & agricultural land decreased, and road & residential area increased by levee effect.

Acknowledgement

National Geographic Information Institute and Korea Institute of Construction Technology provided aerial photographs data.

References

[1] USGS, 1997a. *DEM Data User's Guide Version 5, Reston, VA*: United States Geological Survey.

[2] USGS, 1997b. *Standards for Digital Terrain Models, National Mapping Program Technical Instructions. Reston, VA*: United States Geological Survey.