Paper presented at the 22nd Asian Conference on Remote Sensing, 5 - 9 November 2001, Singapore.

OBSERVING THE EXPANSION OF THE BUILT-UP AREAS OF REGIONAL CAPTAIL CITIES IN YANGTZE RIVER DELTA BY SATELLITE IMAGES

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KEY WORDS: Satellite images, construction of industrial estate, Suzhou city, Yangtze River delta, expansion of built-up area.

ABSTRACT: Yangtze River centering the present Shanghai is the place where a full scale development of a vast delta was performed for the first time in the mankind history. We attempted to elucidate the history and mechanism of the development, which accompanied construction of industrial estate by focusing on the existing urban area in this district. For this, we chronologically collected and analyzed satellite images in 5-year intervals from 1980 and reviewed them in relation to the land-use, social and economical data in corresponding district. Suzhou city has been developed in three parts divided parts; the old town is preserved as it is while its western part has been developed into a new urban area and eastern part into an industrial estate. In correspondence with this transverse axis, construction of an industrial part with emphasis on high-technology industry is expected in near future by forming a north-to-east axis connecting Taicang port and Wuxian city.

INTRODUCTION

Sozhou city is located almost in the center of Changjiang delta in China and it is adjacent to Shanghai on the east side and Wuxian city on the west. This area has achieved a remarkable development in the 1990s being stimulated by the development in Puthong District of Shanghai and is now the city attracting attention most in the whole China. We selected Suzhou in the narrow sense as our study area to discuss the state of and the reason for the expansion of urban areas in the coastal cities in east China as well as the trend in future development. We are trying to verify the state of expansion of urban areas by collecting satellite images covering this area in 5-year intervals. Here, we give the findings obtained in the course of study.

CHARACTERISTICS OF THE EXPANSION OF URBAN AREAS IN SUZHOU CITY

We defined urban area as follows.
1) Areas where urban buildings and structures continued.
2) Those where urban infrastructures were provided as one body with an urban area even though they were separated by agricultural lands and vacant lands.
3) Prefectural, local and village urban areas connected to the city urban area were also included.

Table-1 shows the areas with respect to the use obtained from aerial photographs.

Table 1 Landuse change in urban area of Suzhou city

	1957		1963		1973		1982		1992		1997	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Industrial	163.0	8.5	197.4	10.2	798.9	21.9	851.3	30.3	1,618.8	25.9	2,193	29.0
Storage	24.2	1.2	6.0	0.3	48.8	2.2	125.5	4.5	21.4	3.4	245	3.2
Trunk road	9.8	0.5	10.2	0.5	21.1	0.9	81.1	2.0	195.8	3.1	353	4.6
Residential	1,536.6	79.9	1,534.7	79.1	1,532.1	67.4	1,455.5	51.8	3,364.4	53.4	2,613	34.0
Local road	55.8	2.9	56.8	2.9	61.6	2.7	124.5	4.4	449.7	7.2	562	7.3
Park/grass	41.5	2.2	42.1	2.2	36.9	1.6	67.3	2.4	123.4	2.0	1,324	17.2
Others	92.0	4.8	93.8	4.8	74.0	3.3	102.0	3.7	279.1	5.0	367	4.7
Total	1,922.9		1,941.0		2,573.4		2,807.2		6,052.6		7,657	

1. Two-dimensional expansion of Suzhou urban area: According to Table 1, expansion was slow until 1980s but was accelerated since then. The area of Suzhou city, which was 1922.9 ha in 1957, increased to 2807.2 ha in 1982. The area expanded in these 25 years was 884.3 ha and this meant that the increase in the urban area was about 46%. In the 10 years from 1982 to 1992, however, urban area of 3438 ha was formed newly. This area was more than 1.2 times of the area in 1982 and the mean annual increase in these years reached 8% with the speed 7.4 times of the mean expansion rate between 1957 and 1982. Entering 1990s, the area expanded all at once from 4920 ha in 1991 to 6052 ha in 1992 by more than 1000 ha. Furthermore, construction of industrial estate was started in 1994 and the urban area expanded to 7657 ha in 1997. The population also increased by 240,000 from 840,000 in 1990 to 1,080,000 in 1998.

2. Change in land-use composition: Suzhou city was a consumer city until 1949 with emphasis on traditional handicrafts and business. In the land-use composition in 1957, the residential areas and public buildings were overwhelming as 79.9% while the industrial area was as small as 8.5%. As a result of concentration on industrial development in 1970s, the industrial land reached 30.3% in 1982 with the increase of 21.8% in comparison to 1952. In contrast, the ratios of houses and public buildings decreased by 21.8% indicating a change in the city function from consumption to production. In and after 1980s, the expansion rate of living sites (residential areas, public buildings, green belts) exceeded the increase in industrial sites again. The area occupied by houses and public buildings in these years corresponded to 2.5 times of the area for industrial sites expanded in the same period.
It is also possible to guess reinforcement of transport function in the urban area from the increase of the land for transportation (inter-city and intra-city roads) from 7.4% in 1982 to 10.3% in 1992 and 12% in 1997.

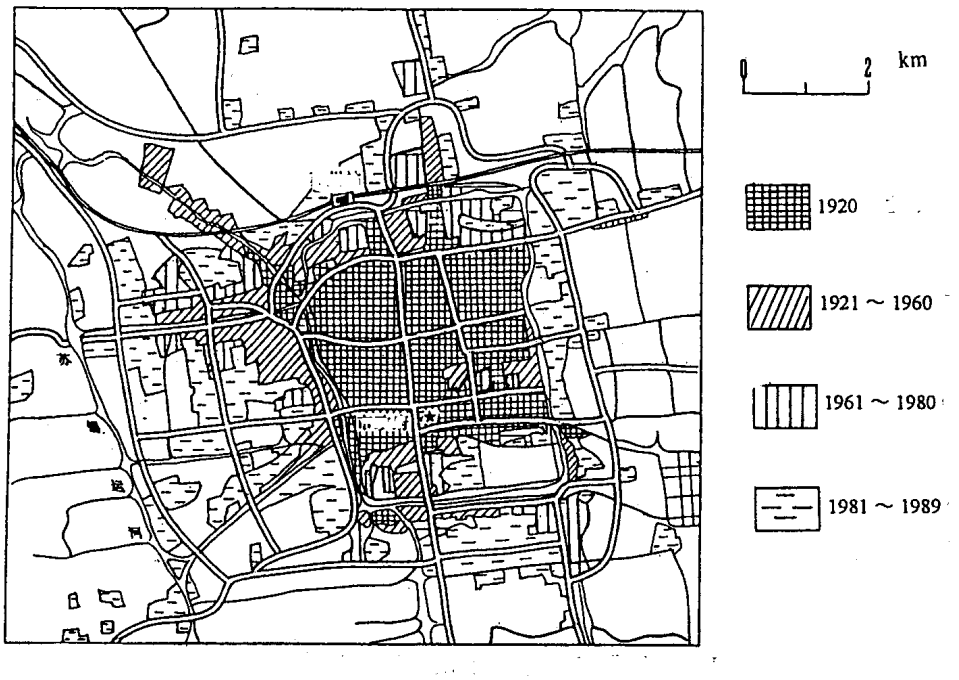


Figure 1 Chronological development of the urban area in Suzhou city

3. Change in the pattern of urban expansion: By 1980s, the urban area expanded outward with the old city area surrounded by the outer moat as the nucleus (Fig. 1). There was no clear change in the basic spatial structure as the lump city. In 1980s, the urban area started to extend in 6 directions along Shanghai-Nanjing railway and trunk roads such as National Highway route 312. From 1990, division of various functions including occupation, living, recreational (sight-seeing) and transport and localization accompanying the division progressed. With advancement of high-technology industries to the east and west ends, the area of the industrial estate increased from 1618 ha in 1992 to 2193 ha in 1997 and the productive function was reinforced again. On the other hand, medium and high rising of houses progressed in the new urban area and the residential area per person increased from 7.8 ? 9n 1992 to 9.05 ? in 1997. Based on the concept of “construction of a rural city surrounded by green”, forest and green areas by tree planting in industrial sites and along roads and providing parks increased 10 times in these years with a remarkable increase in the ratio of area from 2 to 17.2%.

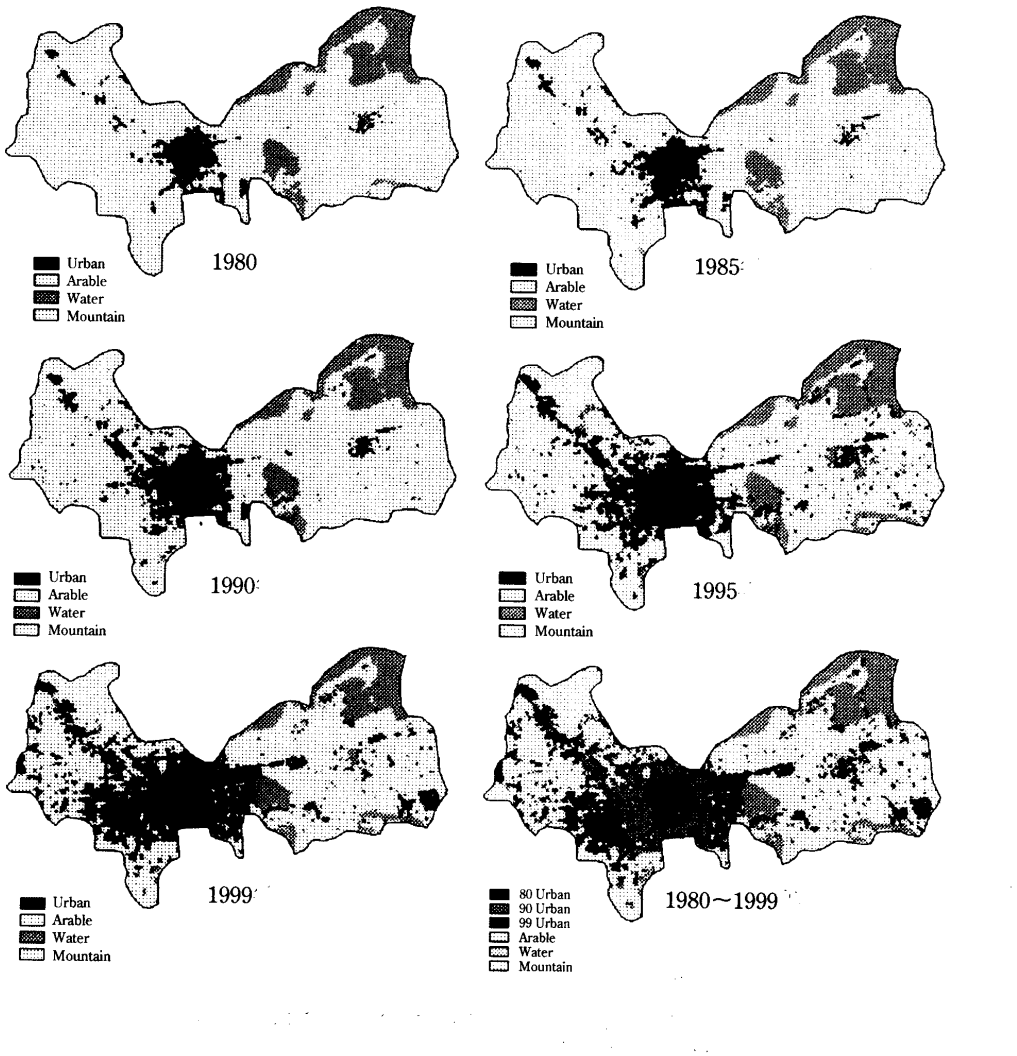
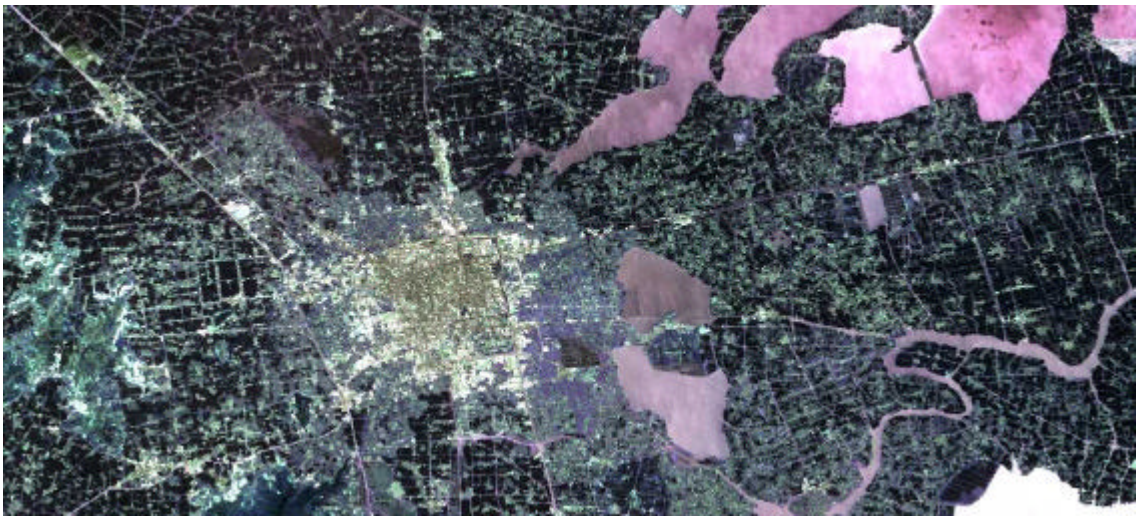


Figure 2 Land-use changes in Suzhou in 1980, 1985, 1990, 1995 and 1999

QUANTITATIVE ANALYSIS BASED ON SATELLITE IMAGES

We attempted to use satellite images to overcome the problem of insufficient spatial data related to expansion of urban areas. As the basic land cover patterns, four classifications including urban, arable, water and hill were adopted.

Figure 1 shows the chronological development of the urban area up to 1989 while Figure 2 shows the land-use changes in Suzhou city in 1980, 1985, 1990, 1995 and 1999. According to these figures, urbanization progressed basically in the form of filling vacant lands and agricultural lands left in the old city (so-called inside the castle, about 14 km^2) sandwiched by the castle wall and outer moat until 1980 except a part of the area on both sides of the road to the north-west part of the city. It can also be seen that urbanization in the north part near Shanghai-Nanjing railway preceded that in the south part with industrialization of the area. In 1990, the forefront of urbanization reached near Beijing-Hangzhou Great Canal running from the northwest to southeast in 1990. Figure 3 shows the Landsat TM images observed in 1984, 1995 and 2001. These images show long and narrow expansion of the urban area in east and west directions in Suzhou with the old urban area as the core. In the south, the urban area is connected to the urban areas of adjacent cities and the economic technical development district built independently by Suzhou while, in the north, it is extended in belts along the national roads unifying with the economical technical development district in the northwest. Another notable change is the construction of road network corresponding to the expansion of the urban area. It can be seen that the direction and range of urban expansion were guided and decided by the construction of the road network. In the city, opening of a trunk road connecting the new urban area in the west and the industrial estate in the east to the old urban area was legible.



Landsat 5 TM image observed on August 4, 1984

Landsat 5 TM image observed on August 3, 1995

Landsat 5 TM image observed on November 28, 2000

Figure 3 Chronological changes in urban areas of Suzhou city depicted by satellite images

While the urban area expanded, creeks that were prepared and improved continuously from Sogen era about 1700 years ago and became the basic condition supporting rice cultivation were reclaimed as well as lakes and marshes and disappeared from the images year by year. It can also be seen that the villages along canals running all directions gradually moved on both sides of newly constructed roads.

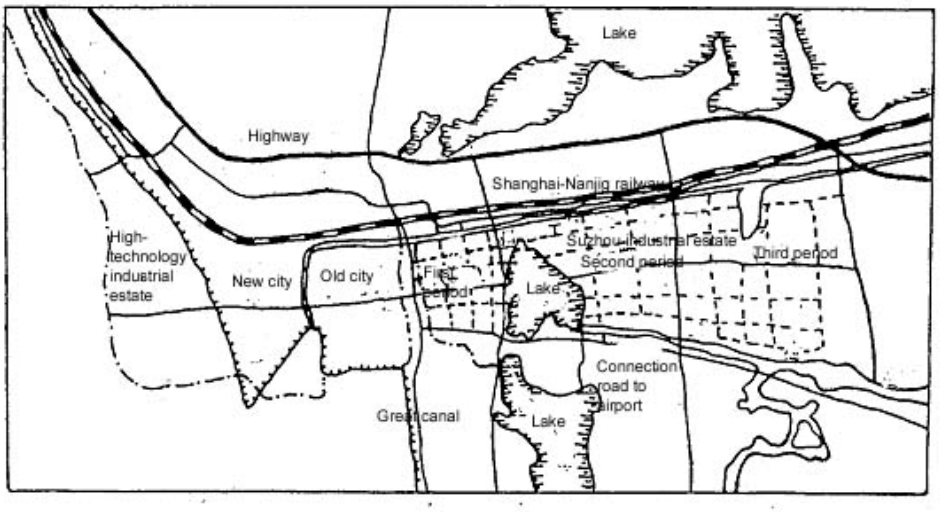


Figure 4 Outline map of Suzhou city coinciding with the satellite image in Figure 3

FUTURE TREND

It is predicted that the urban area of Suzhou city will expand along the east-west axis in the 21st century. Trunk lines including Shanghai-Najing railway, highways, National Highway route 312 and the new Shanghai-Beijing railway started in 2001 all pass Suzhou city from east to west or vice versa. New towns and high technology industrial estates are all being developed in the east and west of the old urban area utilizing the trunk lines in the east and west directions. Moreover, two big cities in the Sunang, Wuxi and Chanzhou, both show the tendency of expanding along the east and west axis and it is conceivable that Suzhou city authority is definitely planning to expand the city to the east and west directions with the emphasis on widening and improvement of the roads running in these directions. The planned area of the new Suzhou district on the west side of the old urban area (Suzhou high and new technology development district) is 52 km^2 and that of Sozhou industrial estate (Singapore Suzhou industrial city) is 70 km^2 to be developed in 10 years. Provided that these two big national projects progress as scheduled, an urban area of 100 km^2 shall be constructed newly and Suzhou city in a belt form of about 40 km from the east to west shall be completed in the beginning of the 21st century.

VERIFICATION BY SATELLITE IMAGES

Statistical data in this are is seldom provided. Therefore, it is very useful if land-use data is estimable from satellite images. Here, we collected satellite images of Landsat 5 TM chronologically by supplementing with the images of JERS-1 and Landsat MSS and Landsat 7 ETM+. For the time being, we extracted the images around Suzhou city to correspond to Table 1 and Figures 1 and 2 for analysis. In future, we are considering to establish a method for analyzing changes in land use accurately using more image data and taking the boundary of the built-up area into consideration.

ACKNOWLEDGMENT

The data used in this paper was obtained as a result of participating in the field survey conducted by the study group of “Earth Environment Preservation and Land Uses” in the National Institute of Environment. The satellite images were supplied by the National Space Development Agency of Japan. This study was a part of the cooperative studies conducted as General Research A (Torii, Kyoto University) and General Research B (Sato, Tokyo University) under the grant-in aid for scientific researches by the Ministry of Education and Science. We express our thanks to those concerned.

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