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The impact of urban planning on land use and land cover in Pudong of Shanghai, China

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Abstract: Functional zones in cities constitute the most conspicuous components of newly developed urban areas, and have been a hot spot for domestic and foreign investors in China, which not only show the expanse of urban space accompanied by the shifts both in landscape (from rural to urban) and land use (from less extensive to extensive), but also display the transformation of regional ecological functions. By using the theories and methods of landscape ecology, the structure of landscapes and landscape ecological planning can be analyzed and evaluated for studying the urban functional zones' layout. In 1990, the Central Government of China declared to develop and open up Pudong New Area so as to promote economic development in Shanghai. Benefited from the advantages of Shanghai's location and economy, the government of Pudong New Area has successively built up 7 different functional zones over the past decade according to their functions and strategic goals. Based on the multi-spectral satellite imageries taken in 1990, 1997 and 2000, a landscape ecology analysis was carried out for Pudong New Area of Shanghai, supported by GIS technology. Green space (including croplands) and built-up areas are the major factors considered in developing urban landscape. This paper was mainly concerned with the different spatial patterns and dynamics of green space, built-up areas and new buildings in different functional zones, as influenced by different functional layouts and development strategies. The rapid urbanization in Pudong New Area resulted in a more homogeneous landscape. Agricultural landscape and suburban landscape were gradually replaced by urban landscape as the degree of urbanization increased. As a consequence of urbanization in Pudong, not only built-up patches, but also newly-built patches and green patches merged into one large patch, which should be attributed to the construction policy of extensive green space as the urban development process in Pudong New Area. The shape of green area of 7 functional zones became more and more regular because of the horticultural needs in Shanghai urban planning. Some suggestions were finally made for the study of future urban planning and layout.
Keywords: functional zone; landscape ecology; Pudong; urbanization

Introduction

The United Nations (UN) identified Asia as one of the urbanizing continents, but the UN failed to realize that the Asian urbanization process is fundamentally different from that of the developed countries (Sui, 2001). The 21st century might be a prosperous era for Asia (Yokohari, 2000). Market forces influence urbanization and urban systems in most countries. Government generally has little direct influence on the development of the urban system. Since World War II, especially in the past two decades, urban systems in the western countries have been influenced by the regional shift in production as a result of restructuring the economy.

Before the adoption of the open policy in 1978, however, the Chinese government played an important role in urban system development. Politics and public policies were the two most important factors shaping urban development in China (Lo, 1987). They exerted a strong influence upon the growth of the urban population (Xu, 1984a), urban system development (Xu, 1984b; Yeh, 1990), and the provincial distribution of the urban population (Yeh, 1984). However, the government's role in shaping urban development has become less important since the adoption of economic reform and the open policy in 1978.

The idea of developing Pudong into a new city was put forward as early 1984. The master plan of Shanghai prepared in 1982 proposed a multimode urban system to decentralize population. In 1988, the development of Pudong was the key theme of a high-level international symposium organized by the Shanghai Municipal Government (Wu, 2000). In 1990, the State Council designated Pudong as a new economic development zone with favored tax policies to attract investment. At the same time, the State Council announced the establishment of the Pudong Development Office and Pudong Development Committee, and approved Shanghai Pudong Development Plan. On April 18, 1990, the Central Government declared to develop and open up Pudong New Area to the world. The move is a strategy to reinvigorate Shanghai as an international trade and financial center, and to turn the city into a locomotive

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in the development of Yangtze River Valley. Since then, the area of 522 km^2 has changed to developing zones beyond recognition. In the 14th CCP congress in 1992, the central government formulated a strategy to "seize the opportunity of developing and opening Shanghai Pudong, and to build Shanghai as the dragon head and one of the international economic-finance-trade centers, so as to drive the growth of the Yangtze River Delta and in turn the take-off of the whole economy of the Basin". The creation of Shanghai's new urban space and function serves the national strategic needs to engage in economic globalization (Wu, 2000; Yang, 1997).

Before 1990, Pudong, had been neglected for centuries, was largely an area consisting of shanty houses, dusty factories and farmland (People's Daily, 2000-4-18). The development of Pudong was different from Shenzhen or Hainan Special Economic Zones in southern China. Pudong was developed in an area bordering a booming town, known as Shanghai, while Shenzhen was developed from a fishing village and Hainan from an underdeveloped island. In addition, Pudong's development is focusing on finance, trade and other service industries. Furthermore, Pudong enjoys three advantages: support from Shanghai, the development and construction of Pudong at an unprecedented high speed and comprehensive functions in Pudong such as export processing, finance and trade, and high technology industry, comprehensive advantages of preferential treatment and policies to accommodate investment from home and abroad. Pudong's development serves to revitalize Shanghai as an economic, finance and trade center and make it a linkage between China and overseas markets. In terms of economic growth, few places in the world could rival that of Pudong, whose gross domestic production increased 21 percent annually, from six billion RMB Yuan (about USD 720 million) to 80 billion RMB Yuan in a decade (Wu, 2000).

The changes in Pudong include not only a profound restructuring of many aged industries and infrastructure, but also the physical form and appearance of the city (Olds, 1997; Wu, 1999). Proclaimed one journalist on a recent visit, "1990s' Shanghai is one of the great urban renewal storied of all time" (Yatsko, 1997).

Over the past few decades, satellite data have become one of the primary sources for obtaining information on the earth's land surface (DeFries, 2000). Regional design, as the forefront in large scale landscape architecture and urban planning, shapes the physical form of regions and takes a regional perspective in guiding the arrangement of human settlements, preferably in communities (Neuman, 2000). Supported by GIS technology, this study was intended to analyze human-induced changes in landscape of Pudong New Area over time. The aims are to quantify changes in spatial and temporal pattern of the landscape and to seek the connection between these changes and the forcing factor, and to create a basis for

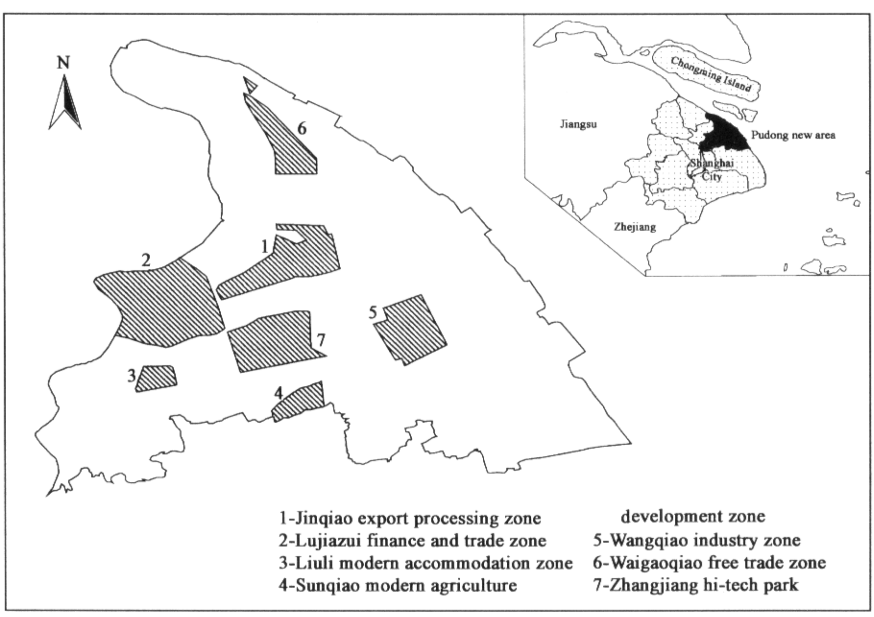

Fig.1 Location of study area: 7 functional zones in Pudong New Area, Shanghai, China

conducting landscape planning or setting up a regional sustainable development strategy in these areas.

1 Study area

Pudong is situated at the estuary of the Yangtze River, and separated from the downtown of Shanghai by the Huangpu River. Pudong New Area is a triangular area adjacent to the city, stretching to the east of the Huangpu River, to the southwest of the Yangtze estuary and to the north of the Chuanyang River. It covers an area of 522.82 km^2, most of which is within a radius of 15 km from the old downtown.

As it belongs to the northern subtropical maritime monsoon climate, Pudong enjoys four distinct seasons, generous sunshine and abundant rainfall. Its spring and autumn are relatively short compared with summer and winter. The average annual temperature is 16℃. It has a frost-free period of up to 230 days a year, and receives an average annual rainfall of 1200 mm. However, about 60% of the precipitation occurs during the May—September flood season.

Most of Pudong belongs to the alluvial plain of the Yangtze River Delta and is flat. The average sea level elevation is about 4m. To meet the standards of the modern metropolis, the government of Pudong New Area has successively built up 7 different functional zones, i.e. Lujiazui Finance and Trade Zone, Waigaoqiao Free Trade Zone, Zhangjiang Hi-Tech Park, Jinqiao Export Processing Zone, Wangqiao Industry Zone, Sunqiao Modern Agriculture Development Zone, Liuli Modern Accommodation Zone over the past decade(Fig.1; Table 1) according to their functions and strategic goals.

Table 1 7 Functional zones in Pudong New Area

Functional zone	Code	Area, km^2	Setup, year	Function description
Jinqiao Export Processing Zone	JQ	20	1990	Export processing, trade, commercial service and dwelling
Lujiazui Finance and Trade Zone	LJZ	28	1990	A financial and trade center of China, even of the world
Liuli Modern Accommodation Zone	LL	3	1995	Modern residential, commercial and trading service, cultural entertainment, travel and official business
Sunqiao Modern Agriculture Development Zone	SQ	9.5	1994	Production, processing and distribution of a wide range of agricultural products
Wangqiao Industry Zone	WQ	4.2	1992	Free trade, export processing, logistic warehousing and bonded commodities' displaying
Waigaoqiao Free Trade Zone	WGQ	10	1990	International trade, processing for export, commodity flow and warehousing and exhibition and trade of duty-free commodities
Zhangjiang Hi-Tech Park	ZJ	17	1992	Manufacturing, research and educational commercial and residential facilities

The "functional zone-promotion strategy" has led to the formation of "investment marshland" in the functional zones, which become the main battlefield for Shanghai's economic development. The various functional zones have begun to give prominence to their roles of promotion, radiation and demonstration exerted in the city's economy. This "new and high-tech zone" has become a hot spot for domestic and foreign investors. The 7 functional zones currently have the great potential to grow rapidly in Pudong. The construction of these functional zones provides us excellent opportunities to carry out research on the landscape patterns and their changes, as influenced by different functional layouts and development strategies.

2 Material and methods

2.1 Data collection

The data used here were extracted from Landsat Thematic Mapper (TM) imageries for three years: 1990, 1997, and 2000. The TM scene includes six bands at 30m resolutions(TM-1: 0.45—0.52 μm, TM-2: 0.52—0.60 μm, TM-3: 0.63—0.69 μm, TM-4: 0.76—0.90 μm, TM-5: 1.55—1.75 μm, and TM-7: 2.08—2.35 μm). Only bands 2, 3, and 4 were used in this study because of their sensitivities to our landscape classification. All information related to the landscape changes in our study area was extracted from these TM imageries. Routine images processing, including enhancement, geometric correction, geo-referencing, classification, and information extraction, were performed for these images.

Other data layers include a topographic map of Shanghai at the scale of 1:100000 (provided by Shanghai Municipal Institute of Surveying and Mapping), and Pudong functional zoning map for drawing the boundary of 7 functional zones.

2.2 Classification of land use types

The conventional multispectral classification methods have been successfully used for the detection of area objects from satellite images. However, they are still problematic for the detection of object classes in urban areas. There are at least two reasons for that. First, the objects in urban areas are very complicated. They can be characterized well through their structure than through their spectral reflection properties. Second, the conventional multispectral classification methods extract the object classes only according to the spectral information of the individual pixels, while a large amount of spatial information is neglected (Zhang, 1999). In order to classify urban objects accurately, it is necessary to include the spatial (or structural) information in the classification as well as the spectral information. However, the methods of modeling, enhancing, and extracting spatial information from digital images are still immature.

Separation of green area and build-up area is one of the most popular uses of remote sensing data because they can be easily recognized with a high resolution. Although the date and the region of the above data sets are different, it is assumed that the results can still be comparable to some degree if the same extraction technique is used.

From satellite perspective, the land use types in this study were simply classified into 5 categories based on above conceptions:

- Water area: Natural or man-made water bodies including rivers and ponds.
- Green area: The lands were used for growing vegetables, agminate plantations (urban green lands and greenbelts), and crops for agricultural products.
- Built-up area: Built-up areas are one of the most important classes in urban land cover and land use classification. The distribution of current building in a city is essential information for urban environmental investigation and urban planning.
- Newly built area: Newly developed area (less than 10 years) was grey or white in TM images.
- Unused area: The lands were not reclaimed or planted with crops or tree at that time. This type of land use existed only in 1990.

The classification approach was a combination of unsupervised (ERDAS, 1997) and supervised classification techniques using a high degree of human interpretation and expert knowledge about the location. More than 30 training sites were collected through extensive fieldwork in July 2001. Fourteen ground control points were collected using GARMIN-12 Global Position Systems (GPS).

2.3 Map preparation and map digitization of land use types

The land use classification for three periods was digitized by using digital instrument with the assistance of GIS database. The information on area and perimeter of each patch was obtained up from the database using Arc View 3.2a. The image processing was performed using software ERDAS IMAGINE 8.4 developed by RDAS, Inc., and Raster 2 Vector developed by Able Software Corp.

2.4 Indices and measures of landscape pattern

The landscape pattern and structural analyses were employed using the software Patch Analyst Extension 2.0 for Arc View developed by Dr. Rob Rempel. Based upon these classified data layers, we first calculated the area percentage, the path area, and the number of patches for each type of landscapes (i.e. urban built-up areas, newly-built areas, waters, and green areas, etc.) extracted from remote sensing images. These simple indices give us good measures of landscapes changed during the study period considered.

An extensive set of indices or metrics had been developed for qualifying composition and configuration at the landscape and patch levels of analysis (Young, 1996; Johnsson, 1995; Ritters, 1995). In the past years, more than 60 landscape indices have been proposed, and used to characterize landscape spatial structure (Turner, 1990; Simpson, 1994; Hunsake, 1994; Moody, 1994; Riitters, 1995). Landscape metrics have been successfully applied to a variety of situations including the measurement of environmental change caused by beaver activity (Townsend, 1996), the analysis of landscape patterns resulting from logging clearcuts (Ripple, 1991), and the examination of long-term urban and rural landscape changes caused by human activities and policies (Diaz, 1996; Medley, 1995).

No single landscape metric captures all aspects of fragmentation (Davidson, 1998); a suite of selected metrics may be useful in interpretation of landscape change and must be carefully considered relative to the type of change and the background matrix (Hansen, 2001). On the other hand, many of the available metrics are correlated (Tischendorf, 2001). A study conducted by EPA found a subset of pattern metrics comprising a minimum set to adequately describe landscape pattern (Griffith, 2000). We only need several relative metrics in a specific study. Seven indices were selected in this study and the various landscape indices used were grouped into three classes:

Structural indices

(1) Number of patches of each land use type (N); (2) Total area of each land use type (A); (3) Proportion of each land use type (P); (4) Mean patch area of each land use type (MPA).

Shape index

(5) Mean shape index (MSI; Gardner, 1987; Burrough, 1986).

Pattern indices

(6) Shannon's diversity index (SDI; McGari, 1995); (7) Shannon's evenness index (SEI; O'Neill, 1988; Turner, 1990)

3 Results and discussion

The data sources used in this study were TM imageries, in which each pixel covers an area of approximately 30 × 30m. However, the buildings in Shanghai are approximately 12 to 20m in average width (Zhang, 1999). Therefore, if an area of 30 × 30m covers mainly buildings, the mixed pixel in TM image will show a built-up landscape. On the other hand, when vegetation takes up the major part of the area, the mixed pixel will show a green area landscape. So, what a mixed pixel stands for is completely dependent on which land cover type takes a high proportion (> 0.5). As a result, there are some mixed pixels representing built-up area in 1997 changed to green area pixels in 2000 because many gardens and horticultural plants around buildings during this period.

Fig.2 shows that the green area in JQ, LJZ and LL decreased from 1990 to 1997, but increased from 1997 to 2000. While built-up area in the three zones showed an inverse trend, i.e., the area increased from 1990 to 1997 and then increased because some old buildings were demolished and replaced by new buildings. Newly built area increased in all seven zones within the study period. This could be explained by the fact that the urban development in above study areas was accelerated in the past 10 years.

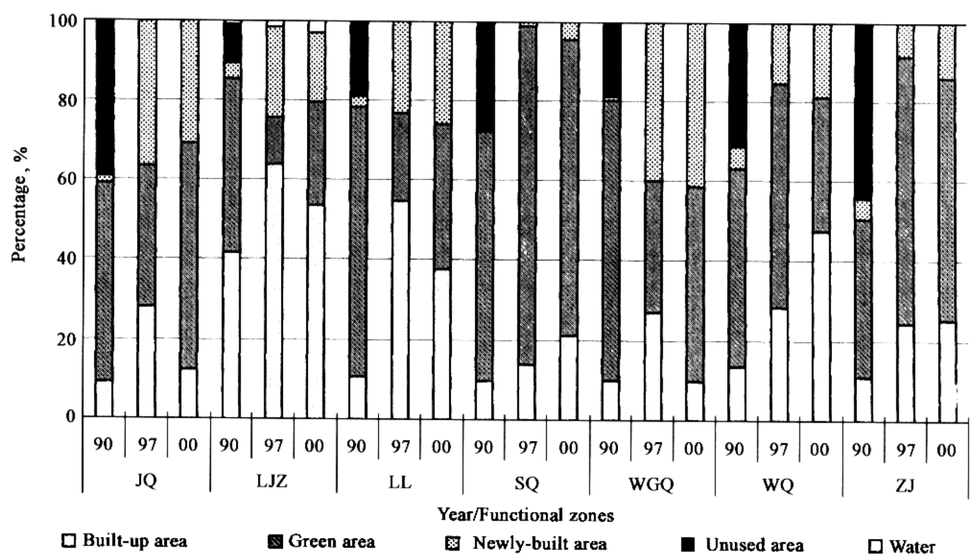

Fig.2 Land use dynamics in 7 functional zones of Pudong, Shanghai, China

Detailed land use data are also needed to analyze green space generally. However, it is well known that the amount of green space in a city is not equal to the area of parks and open spaces defined in land use. It should be noted that the amount of green space by remote sensing is not equal to that by land use data, not only because of the difference between the concepts of land cover/use but also because of the definitions of green space or open space in land use at different times. In this study, the green area was defined as the land that is used for growing vegetables, agminate plantations (urban greenlands and greenbelts), and crops for agricultural products. According to this concept, the "green coverage" percentages of JQ, LJZ, LL, SQ, WGA, WQ and ZJ were 56.7%, 25.8%, 36.5%, 74.2%, 48.8%, 33.8% and 60.6% in 2000, respectively. Compared with 1997, the green coverage percentage increased in 2000.

The changes of land cover/use were quite different among 7 functional zones. For example, the land cover types of JQ in 1990 were mainly consisted of crop vegetation(49.8%) and wilderness(39.2%) in 1990, and was replaced by urban buildings(64.5%)(manufactories, shops and residences) in 1997; LJZ had been already developed by the end of 1980s and the major land use was havens and warehouses (41.4%) surrounding Huangpu River. This zone was changed to the landscape covered with skyscrapers after 5 years; SQ was changed from traditional agricultural plantation (62.5%) to modern vegetable greenhouses(74.2%) and agricultural factories(4.6%). As for the other functional zones, WGQ was changed from crop fields to modern business and trade zone, ZJ and WQ to garden factories, and LL to modern residential center.

Patch area is an attribute but not a genuine index. It is not normalized, and thus is not applicable straightway when compared to descriptive statistics such as mean and variance. Mapping the thematic classification of the patch area enhances the heterogeneity of the landscapes(Fig.2) and is useful when many small patches are involved whose individual size is indiscernible in the image (Antrop, 2000). However, the method of thematic mapping largely determines the outcome; the following choice of the number of classes and mean patch size are essential.

Mean patch area and patch number for 3 land-use types(built-up area, green area, and newly-built area) are summarized in Fig.3. Mean patch area of both built-up and green areas in all zones increased while patch number decreased, implying that many small built-up or green patches merged into large patches due to urbanization in Pudong. This pattern of patch dynamics might be attributable to the construction policy of extensive green space as the urban development process in Pudong New Area. At the same time, the mean patch area of newly-built area increased, but the number of newly-built patches reached the maximum in 1997, which indicated that from 1990 to 1997, the infrastructure projects were performed scatteredly and not only the number of built-up patches but also the average area of patches increased. However, this developmental mode was altered during 1997—2000, i.e. some dispersive and isolated newly built patches were united to form one larger patch, leading to a decrease in patch number.

Shannon diversity index(*SDI*), Shannon evenness index(*SEI*), mean shape index(*MSI*), and patch number for the landscapes in various zones of Pudong are shown in Table 2. Landscape diversity depends on the number of patch and harmonious proportion of land cover/use type, and finally affects the stability and productivity of the system. In the studied area, the landscape diversity varied with the changes of land planning and management. The larger the value of landscape patch diversity, the more variable the landscape. Large values of *SEI* indicate that the landscape is more equally shared by different types of land use, while low values mean that the landscape is dominated by one or a few types of land use. Increasing *SDI* of landscape patches means landscape replacement by occupation of other elements.

Table 2 Shannon diversity index(*SDI*), Shannon evenness index(*SEI*), mean shape index (*MSI*) and patch number(*PN*) of each functional zone in Pudong from 1990 to 2000

Functional zone	*SDI*			*SEI*			*MSI*			*PN*		
	1990	1997	2000	1990	1997	2000	1990	1997	2000	1990	1997	2000
JQ	4.526	4.956	4.212	0.770	0.835	0.786	1.266	1.257	1.298	692	728	322
LJZ	4.528	4.527	4.416	0.723	0.746	0.749	1.188	1.258	1.256	1606	931	633
LL	3.606	3.532	3.806	0.776	0.787	0.871	1.250	1.297	1.291	153	121	94
SQ	3.061	2.636	2.580	0.680	0.639	0.694	1.257	1.259	1.272	155	83	53
WGQ	3.661	4.417	3.824	0.681	0.827	0.780	1.227	1.252	1.263	392	372	211
WQ	4.500	4.101	3.837	0.804	0.789	0.778	1.222	1.254	1.315	678	348	195
ZJ	5.055	4.307	3.843	0.850	0.787	0.734	1.277	1.255	1.277	791	465	289

There was no significant difference of landscape diversity between the total landscape types in these zones. On the whole, the change of *SDI* in the functional zones decreased from 1990 to 2000 except for WGQ and LL, which was a result of implementing "diversification" and "marked-driven economy"

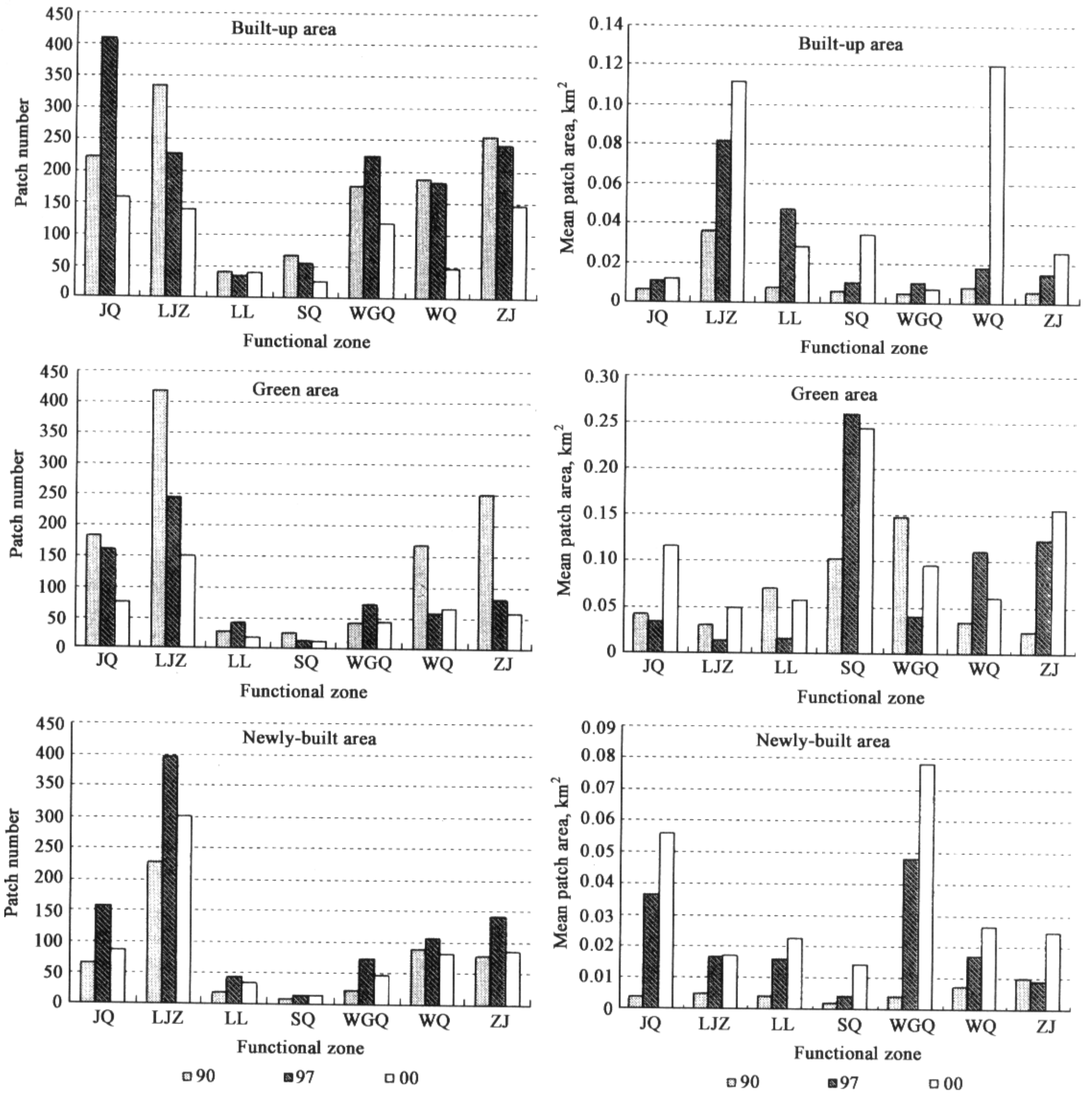

Fig.3 Mean patch area and patch number for built-up area, green area and newly built area of Pudong functional zones, Shanghai, China(from 1990 to 1997)

management decision. Therefore, decreased *SDI* values of some patches here reflect the extension of fragmented landscape from the mixture of agriculture landscape and urban landscape to single urban landscape, especially the decreased number of agricultural patches. The change of *SEI* had the same tendency as *SDI*, and the decrease in the value reflects the loss of agricultural plantations and increase in urban landscape. However, the *MSI* of overall land use types ranged from 1.188 to 1.315, indicating that the shape of land use type is simple in the study period. Moreover, the *MSI* of land use types seems to increase over time, but there was no significant difference between different years. In early 1990s, the Pudong New Area was dominated by agricultural landscape and suburban landscape. After the development of Pudong, these landscapes were gradually replaced by urban landscape, mainly built-up landscape and green area.

In general, the landscape is changed from simple to complex due to the natural and human disturbances, which is called landscape fragmentation (Zhou, 2000). The fragmentation is positively related to the patch number. However, on the contrary to our initial assumption, the patch number decreased over time (Table 2), which might be the limitation of resolution capacity (30m × 30m) of TM imagery, because the size of the counted patches on the TM imagery is normally larger than the actual size in these zones as a result of ignoring the patches less than 30m × 30m. In an urban area, however, a high proportion of urban landscape is represented by the small patches. Therefore, there is a need to do more intensive field survey to ascertain what kind of small patches in these areas were ignored.

Table 3 Mean shape index for built-up, green and newly-built areas of each functional zone in Pudong from 1990 to 2000

Functional zone	Built-up area			Green area			Newly-built area		
	1990	1997	2000	1990	1997	2000	1990	1997	2000
JQ	1.189	1.239	1.237	1.370	1.299	1.357	1.170	1.262	1.358
IJZ	1.254	1.302	1.271	1.185	1.212	1.241	1.130	1.267	1.233
LL	1.221	1.353	1.241	1.350	1.263	1.315	1.101	1.286	1.334
SQ	1.194	1.253	1.285	1.427	1.364	1.341	1.131	1.175	1.186
WGQ	1.187	1.231	1.210	1.441	1.273	1.326	1.104	1.292	1.337
WQ	1.187	1.247	1.381	1.266	1.304	1.302	1.151	1.237	1.287
ZJ	1.188	1.270	1.277	1.328	1.297	1.306	1.233	1.204	1.257

Table 3 shows *MSI* of built-up, green and newly built areas of each functional zone in Pudong from 1990 to 2000. *MSI* of different types of land use were similarly low, ranging from 1.101 to 1.441. The green area type had the highest *MSI* in 1990, which might be attributable to the fact that this type was more natural and less disturbed. *MSI*s for built-up and newly built areas increased over time, while *MSI* for green area decreased in most zones. The results suggested that urbanization in Pudong resulted in a tendency to increase spatial heterogeneity in built patches and to decrease heterogeneity in green patches. The main reason for that may be that built-up patches sprawled out into countryside irregularly, especially real estate development on the borders of built-up area. In addition, the form of green area became more regular because of the horticultural needs in Shanghai urban planning.

4 Conclusions and suggestions

This study quantified the changeable spatial and temporal patterns of landscapes in 7 functional zones of Pudong, and examined the possible factors that are responsible for the change. From the viewpoint of the changeable features of developing landscape over time, land management decisions are the roots of periodic dynamic change of landscape patterns. Different management decisions in functional zones will lead to different spatial and temporal landscape patterns.

Compared to 1997, the green coverage percentage increased in 2000. However, it seems likely that the increase in vegetation cover is mainly the goal for the construction of urban greenbelts. Of course, the construction of large greenbelt in Shanghai has played an important role in increasing the green area. Thus, the area considered here could become more diverse at the landscape level and also at the species level. It is obvious that in this study it is still not high enough for a detailed investigation of urban vegetation, which was only classified into one type, which is not enough for a comprehensive urban landscape study. Nevertheless, the result of this study is very useful for a rapid developing zone, especially in metropolitan area of developing countries. Thus, the other further fieldwork needed to be done is to ascertain what kind of vegetation the modern horticultural vegetations replaced.

In terms of the above assessment for structural shape and pattern indices of landscapes, the landscape configuration of 2000 is superior to that of both 1990 and 1997. Nevertheless, the superior configuration is confronted with the challenge of the market economy. The landscape is gradually being changed. For promoting urban land sustainable development, more attention should be paid to the landscape diversity and systematic heterogeneity and stability. Land management decision should be made on the basis of social benefit, economic revenue and ecological effectiveness. If we just focus on the economic revenue, it is impossible to keep Pudong's development sustainable in these areas.

There is a need to maintain a great diversity at the level of the new developing landscape, and at the same time to practice urban in a sustainable and cost-effective manner for the benefit of future. Sustainability can be defined as the effective management of resources to satisfy human needs while maintaining and enhancing the quality of the environment and conserving resources. The landscape ecology offers great benefits when analyzing landscape changes as part of an ecosystem at different spatial and temporal scales. We need an increasingly multidisciplinary approach in order to gain results that can help us recognize the problems and link our solutions with the general aim of sustainability in society (Hietala-

Koivu, 1999).

The actuality of the land use data in highly dynamic urban landscapes is particularly important. Aerial photography and remote sensing are appropriate tools for updating land cover maps. A limiting factor in satellite imagery is the spatial resolution compared to the highly fragmented spatial structure of urban landscape, which results in a large proportion of mixed pixels and accordingly poor accuracy of objects' classification. Large-scale aerial photographs are more appropriate, but a more elaborate interpretation is needed to obtain digital thematic date layers. However, obtaining detailed thematic information about land cover is not a purely technical matter, but also implies important conceptual aspects(Antrop, 2000). For example, determining and monitoring the area of built-up land is a primary task in the study of urbanization processes. Is built-up land defined as a field parcel containing a building or as the footprint of actual building? How do we define a building? Must it have solid foundations or can it be simply a structure on the ground? How do we distinguish between them upon remote sensing images? It can be expected that such method will have an increasing applicability when satellite images with up to 1m spatial resolution will be available. Using the forthcoming satellite images of very high resolution, it should be possible that even smaller patches can be automatically extracted, and that buildings or types of vegetation in different sizes can be divided into different classes, so that the detection accuracy will be considerably improved.

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