Asia-Pacific Network for Global Change Research

Quantification of Land Use Urbanisation Level in Three Developing Asia Countries based on the Analysis of Scale Effects in Landscape Pattern

Final report for APN project:
（ARCP2008-06CMY-Li）

The following collaborators worked on this project:

P.I.: Jianlong Li, Professor and Director
The Global Change Research Institute,
College of Life Science, Nanjing University, Nanjing city, P.R.China.
Email: jlli2008@nju.edu.cn.

C.I.: Prof. Flaviana Hilario
Philippine Atmospheric, Geophysical and Astronomical Services,
Administration (PAGASA) 7th Floor, ATB Building 1424 Quezon
Ave, Quezon City, Philippines.
Email: cab@philonline.com, flavyh@hotmail.com.

C.I.: Prof. Hoang Minh Hien
Dept. for Dyke Mgmt., Flood and Storm Control
Ministry of Agriculture and Rural Development,
02 Ngoc Ha Street, Ba Dinh Dist, Hanoi city, Vietnam.
Email: hmh@netnam.vn.

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Final Report submitted to APN

Non-technical summary

The project was closely related to research theme 2 of APN Science Agenda: Ecosystems, Biodiversity and Land Use, and had an international research team that was composed of three leading developing country scientists (China, Philippines and Vietnam). The project clearly addressed existing gaps in the field of global change research, which ran for 2 years and received a total funding of US$40,000 from APN. We had built an international research team, a database and a project website at http://apn.ueplab.cn or http://www.usplab.cn/apn. In Mar.11-14, 2008, we have trained five young scientists (China, Philippines and Vietnam) on advanced methods of remote sensing technology and GIS and urban landscape pattern analysis. On the same month, we have also trained 20 young scientists and conducted a workshop meeting to conclude our work and present the project results at Nanjing University in China. We also conducted some research works on the quantifying urbanization level from the aspect of land use and connecting land use pattern with urbanization process in the three biggest cities of three developing countries and published three scientific papers. The results showed that urbanization leads to land use change and landscape pattern alteration, which responded obviously to the urbanization phases. As the urban ecosystem is a complex ecosystem, it is important to consider both landscape metrics and social-economic factors in urban ecosystem studies. The sustainable problems of urban ecosystem can also be revealed using RS and GIS technology and CA model.

Main Objectives

The main objectives of the project were:

1. Build an international research team and database.
2. Provide accurate land use / cover, ecological, social and economic useful data and information.
3. Train three young scientists on advanced methods of remote sensing technology and GIS and urban landscape pattern analysis.
4. Provide an integrated technical report of the quantifying urbanization level from the aspect of land use and connecting land use pattern with urbanization process in the three biggest cities of three developing countries for policy makers and international community and disseminate the findings.

Amount received and number years supported

The Grant awarded to this project was: US$40,000.

US$ 30,000 for Year1, 2007/2008

US$ 10,000 for Year 2, 2008/2009

Activity undertaken

1. Research works on "Quantification of land use urbanization level in three developing Asia countries based on the analysis of scale effects in landscape pattern" by means of the project timeline & plan.
2. Research works on the Landscape Ecology Pattern Gradient Analysis and Comparison of Desakota Regions Features in three Asian-Pacific region major cities.
3. Gathered data from three experimental sites and writing three papers.

4. Collected some ground experimental station data and research materials in Shanghai and Zhangjiagang cities. Remote sensing films made in China were checked in the ground work by the Chinese team.
5. Prof. Li participated in NEESPI meeting and activities and reported the progress of APN programme in Xinjiang in Feb. 2-4, 2009.
6. The last workshop and training meeting was held in Nanjing City from March 6-9, 2009. Collaborators from China, USA, Viet Nam and Philippines as well as the young scientists participated.

Results

Results of the project showed that the desakota region of the three cities have different characteristics and different stages of urbanization, in which Metro Manila was found in the highest stage of urbanization, and the earliest suburb urbanization. Shanghai demonstrated a high degree of urbanization and obvious suburb urbanization and Hanoi has a lower level of urbanization and unobvious suburb urbanization. Quantifying urban landscape pattern and its change is essential for monitoring and assessing of ecological consequences of urbanization. Changes of urban spatial patterns with increasing grain size were mainly caused by segmentation of roads patches. The more road percent coverage indicated higher urban fragmentation, which is an important fact to link landscape pattern with processes in urban ecological studies. During urbanization, regional landscape pattern of the three cities had changed remarkably, with an increasing of patch density and strengthening of fragmentation. The desakota region of the three cities was found out to have different characteristics and different stages of urbanization, which was typical in Asia.

Ecological environment protection for the desakota area should be paid enough attention and put into practice. Urbanization leads to land use change and landscape pattern alteration, which responded obviously to the urbanization phases. As the urban ecosystem is a complex ecosystem, it is important to consider both landscape metrics and social-economic factors in urban ecosystem studies. The sustainable problems of urban ecosystem can also be revealed using RS and GIS technology and CA. model.

Relevance to APN's Science Agenda and objectives

Our project enables activities that generate and transfer knowledge on the physical and human dimensions of change in the Earth System with a focus on: the APN Science Agenda "**2.Ecosystems, Biodiversity and Land Use".**

Urbanization, as a major driving force of land use and land cover change, has been a significant cause of global change. This process will undoubtedly continue as more and more people are swarming into cities. Urban area occupies less than 2% of the earth's land surface, while urban population accounted for 50% of world population in 2000.Urbanization affects land use elsewhere through the transformation of urban–rural linkages. Given that 60% of the people in the world will live in urban area by 2025, urban land use change will draw more attentions from scientists interested in global change. At present, the world is experiencing a tide of urbanization, especially for the developing countries of China, Vietnam, and the Philippines. Urbanization, as a major driving force of land use and land cover change, has been a significant cause of global change. Quantifying urbanization level from the aspect of land use and connecting land use pattern with urbanization process is a new attempt integrating natural and social sciences in change of land use and cover studies in three developing countries.

Self evaluation against project objectives

All project objectives were completely addressed. The project team was able to publish nine scientific papers. During the final workshop at Nanjing City, China on March 6-9, 2009, the team was able to finalise the integrated technical report of the project for dissemination to policy-makers and international community. The project clearly addressed some existing gaps in the field of global change research using the analysis of scale effects in landscape pattern and constructed Geo-CA model.

We were able to develop two new methods to simulate the future expansion of the cities namely: 3S technologies and BP neural network and the new model of GIS-based cellular automata (CA) modeling approach. GIS-based CA modeling is capable of using multiple factors into the modeling process, and is thus realistic in simulating urban development. We had trained 28 young scientists in two training meeting and held two workshops at Nanjing University, in China. We had finished all work activities and researching tasks, hence all project objectives are met.

Potential for further work

We have received the letter and first stage reviewing letter from the APN Secretariat regards our intent to continue the project through a proposed study on "Analysis on urban land-use changes and its impacts on food security in different Asian cities of four developing countries using modified CA model". Our project team from China, USA, Vietnam, Philippines and Indian scientists will aim continue our researching plan and works.

Publications

1. Huang JS, **Li J.L,** Flaviana DH, Hoang MH et al. Urbanization Study and Comparison of Three Asian Megacities: Shanghai, Metro Manila and Hanoi. *International Journal of Sustainable Development & World Ecology, 15 (2009) (Revised).*
2. Liangmei Huang, Jianlong Li et al. A fieldwork study on the diurnal changes of urban microclimate in four types of ground cover and urban heat island of Nanjing, China. *Building and Environment,* 2008, 43:7-17.
3. Liangmei Huang, Jianlong Li,et al. Scale impacts of land cover and vegetation corridors on urban thermal behavior in Nanjing, China. *Theor.Appl.Climatol., 2008, 94(3-4):241-257.*
4. Cinco TA, Flaviana DH, Li JL et al. Philippine Climatology and Climatic Trends in the Philippines . *J. Philippine Weather, 2009, 35 (1):29-46.*
5. Ming Zhu, Jianlong Li et al.Effects of varied remote sensor spatial resolution and grain size on urban landscape pattern analysis. *Acta Ecologica Sinica, 2008,28(6):2753-2763.*
6. Dehua Zhao, Jianlong LI, et al. A comparative analysis of broadband and narrowband derived vegetation indices in predictive LAI and CCD of a cotton canopy.*ISPRS.J.of Photogrammetry & Remote Sensing 62(2007):25-33.*
7. Jianlong LI, Ming ZHU, and Yamin FAN. Impacts of road patch analysis on urban ecological landscape patternes: a gradient analysis with changing grain size in Shanghai, China. *Proceeding of the 4th International Symposium on Intelligent*

Information Technology in Agriculture, Oct.26-29, 2007 in Beijing, China. China Agricultural Sciences & Technology Press, 2007,10. 779-788.

8. Ming Zhu, Liangang Xu, Nan Jiang, Jianlong Li et al.Impacts of road corridors on urban landscape pattern: a gradient analysis with changing grain size in shanghai, china. *Landscape ecology , 2006, (4):4-15.*
9. Ming Zhu, Nan Jiang, Jianlong Li et al. The effects of sensor spatial resolution an changing grain size on fragmentation indices in urban landscape. *International Journal of Remote Sensing , 2006, (4):1111-1123***.**

References

Please see the detailed technical report

Acknowledgment

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Technical Report

PREFACE

Megacities in Asian developing countries nowadays are facing with a more rapid urbanization actuality and increasingly pressure from population growth, land use pressure, and environment problems. Understanding the features of Asian urbanization will be unassailably important for the sustainable development decision and the urban planning by the government. Three mega-cities in Asia-Pacific region: Shanghai (China), Manila (the Philippines) and Hanoi (Vietnam), were selected in the study. In support of remote sensing technology and gradient analysis method, the landscape pattern dynamics in recent twenty years were studied, using six landscape matrix indexes: contagion index, largest patch index, landscape shape index, perimeter-area fractal dimension, patch density, and Shannon's diversity index. The result showed that: (1) During urbanization, regional landscape pattern of the three cities had changed markedly, with an increasing of patch density and strengthening of fragmentation; (2) In land use transects, patch density and Shannon diversity index had a high correlation with the absolute distance to the city center. Landscape index can detect the gradient of the city and show the direction of urbanization; (3) The desakota region of the three cities were discovered with different characteristics and different stages of urbanization, which was typical in Asia. Metro Manila was found in the highest stage of urbanization, and with the earliest suburb urbanization. Shanghai was demonstrated a high degree of urbanization and an obvious suburb urbanization. In contrast, a lower level of urbanization and unobvious suburb urbanization was discovered in Hanoi. Ecological environment protection for the desakota area should be paid enough attention and put into practice.

1.0 INTRODUCTION

Urban area occupies less than 2% of the earth's land surface, while urban population accounted for 50% of world population in 2000[1]. High population density of urban area leads to its intensified intervention to the environment. Urbanization has profoundly transformed natural landscapes throughout the world, which inevitably has resulted in various effects on the structure, function, and dynamics of ecological systems at a wide range of scales. Nowadays urbanization is sweeping the entire world, particularly in developing countries. All aspects of the impact on the regional landscape pattern have been brought, leading to a profound impact on the city's ecological environment, biological diversity and human life.

In recent years, landscape pattern analysis has been used to the study of urbanization and urban land-use change analysis and simulation. Landscape indexes, simple indicators but with clear ecological significance, contribute to a better understanding of the composition and space allocation of landscape pattern. Besides, it can be used to quantitatively describe the characteristics of the structure of the landscape and to monitor changes over time. Landscape pattern on the domestic and international research focused on the regional landscape pattern analysis, multi-temporal pattern of dynamic changes in the matrix of transpose landscape, and so on[2-4].

Gradient analysis originated from vegetation analysis, and it is found that gradient analysis based on landscape metrics is useful and effective for studying the urbanization[2]. In gradient analysis, gradient of urbanization and trend of urbanization level can be detected from landscape pattern index. Landscape pattern dynamic analysis is the basis to understand urban form, structure and ecological processes in the process of urbanization [1, 5, 6]. However, integrating temporal data with gradient analysis is still rarely used in practice[2, 6]。 Landscape Ecology, as a cross-geography and ecology of science, highly concerned about the relationship between the landscape pattern and ecology process. Conclusions in short period and small space were always difficult to explain the ecology pattern and process occurred in large temple and spatial scale, such as the regional landscape level or higher. However, the phenomenon in large scale is usually very important [7]. As a result, it is necessary to obtain data in long time, to the study of urbanization, a process with large temple scale.

After the Second World War urbanization had entered all-round development stage and speeded up, causing a huge gap of urbanization between each country. Asia has become a region where urbanization is the fastest in the world and major cities emergence most. Urbanization in Asian largest cities is quite different from that in the west. Megacities in Asian developing countries are facing with a more rapid urbanization actuality and sustained pressure from population growth, and ecological and environmental problems in the process of rapid urbanization, which is increasingly complex. In support of the APN organization (The Asia-Pacific Network for Global Change Research, apn-gcr.org), combined with Climatology and Agrometeorology Branch, PAGASA, Philippines and Dept. for Dyke Mgmt., Flood and Storm Control Ministry of Agriculture and Rural Development, Vietnam, we carried out a series of studies, including urbanization, ecosystems , land use / cover change and so on. The research selects Shanghai, China, Metro Manila, Philippines, and Hanoi, Vietnam as its study area, and lasts for two years.

Three major cities in Asian developing countries, Shanghai, Manila and Hanoi, were selected as the study areas. Based on the gradient analysis in landscape ecology, important regions in the three cities were studies, which compared the landscape pattern dynamics and its related features of desakota regions.

2. THE STUDY AREA

The study area is located in the Asia-Pacific region, where three mega cities in Asia developing countries Shanghai (China), Metro Manila (the Philippines) and Hanoi (Vietnam) are selected (Fig. 1). (1) Shanghai, with latitude from 30 ° 40 ' to 31 ° 53'N north, and longitude from 120 ° 51' to 122 ° 12' east, is located in the front edge of the Yangtze River Delta, the west bank of Pacific Ocean and the east part of Asian continent, and has a subtropical monsoon climate, with annual mean temperature of 16 . Annual mean precipitation of Shanghai is approximately 1200 mm, with 60% of rainfall occurring during May–September. Shanghai is the center city of the Yangtze River Delta city group and the largest city in China. With a population of 1, 379 million (2007), Shanghai is now the fastest growing city among all major Chinese cities. Land use of Shanghai has changed dramatically since the 1980s.

(2) Metro Manila (Manila), with latitude from 14 ° 21 ' to 14 ° 47'north, and longitude from 121 ° 09'E to 120 ° 53'east, is located in the west bank of Manila Bay. It covers an area of 620 km^2, and has a population of 11,550,000 (2007). Metro Manila consists of eight contiguous cities, including Manila city, and nine other municipalities. It is not

only the capital city and the country's largest city, but also the national economy, culture and transport center.

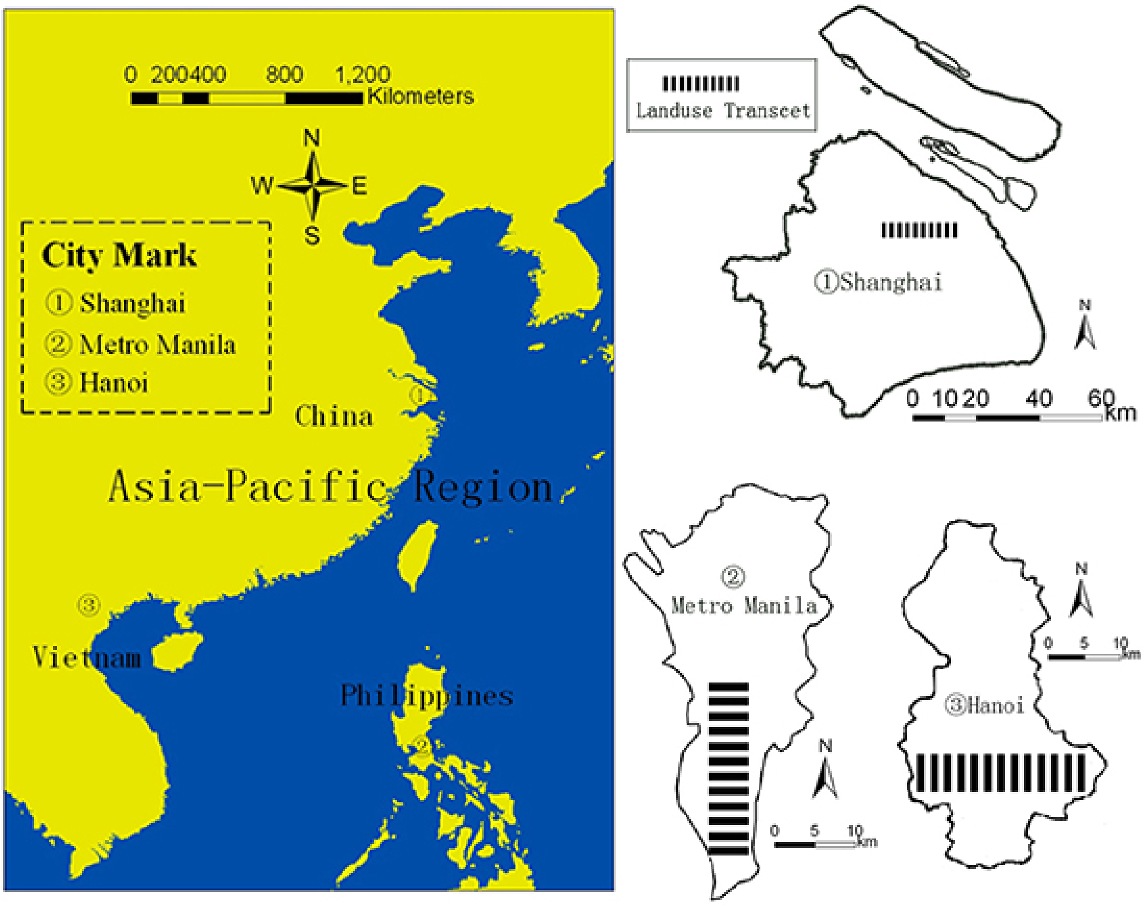

Figure 1. The contour map of the study cities and the transect location

(3) Hanoi (Hanoi), with latitude from 20 ° 53 ' to 21 ° 23'N, and longitude from 105 ° 44' to 106 ° 02'E, is located in the northwest of the Red River Delta. Hanoi is an ancient city with nine urban districts and five rural districts, which has been developing for almost 1,000 years, viz. since establishment in 1010. With an area of 921 km^2 and a population of 3, 450, 000 (2007), Hanoi is the capital of Vietnam and the country's second largest city. It is also the political, economic, cultural, scientific and technological center of the whole country

3. OBJECTIVE

The study conduces to understanding the interaction of landscape pattern gradient analysis and mega cities in various economical and social backgrounds, as well as characters of land use change in different urbanization conditions. In addition, this study will supply with mode for the ecological city construction.

4. METHODOLOGY

Three periods were selected in this research for the three cities: Early Stage (ES, the end of the 1980s to the early 1990s), Medium Term (MT, 2000 ~ 2001) and Short

Term (ST, 2006 ~ 2007). For each term, one remote-sensing image was used, totally 9 remote sensing images in use (Table 1):

Table 1. Study stages and remote sensing data used of Shanghai, Manila and Hanoi

	Early Stage(ES)	*Medium Term(MT)*	*Short Term(ST)*
Shanghai	1989 Landsat-5 TM	2001 Landsat-7 ETM+	2007 IRS-P6 Pan (5m)
Manila	1993 Landsat-5 TM	2001 Landsat-5 TM	2006 Spot-4(12.5m)
Hanoi	1993 Landsat-5 TM	2000 Landsat-5 TM	2007 Landsat-5 TM

Geometric correction, radiometric correction and radiometric enhancement were performed for all the remote sensing images, in support of Erdas Imagine (Version 9.0, ERDAS, Atlanta, GA, USA). Images of Shanghai and Manila were georeferenced to the Universal Transverse Mercator (WGS_1984_UTM_Zone_51N) coordinate system, and images of Hanoi were georeferenced to the Universal Transverse Mercator (WGS_1984_UTM_Zone_48N) coordinate system. Integrated with groundwork, images were interpreted into 5 classes: urban land, transportation land, green land, farm land, and water area, by combination of human and computer recognition (Figure 2). The classification precision is above 80%. All the land use classification maps were then transformed from raster to vector format. It is not convenient that images of multiple sources were used in this study, whose resolution was not unified. To avoid this problem, Kong's method [8]was performed, and land use maps of Shanghai and Manila were output into raster format with the resolution of 12.5m, and Hanoi with the resolution of 25m.

Landscape pattern gradient analysis was used in this study. Spatial extent was first studied to search for a best extent. As extent is an important effect for gradient analysis, it is helpful to analysis the behavior of landscape pattern index changed with spatial extent for landscape pattern analysis and the complexity reduction of scaling in space[9]. Extent test showed that extent of 5~7km can meet the need of pattern analysis, and 6km was chose in this study. Three transects were select from each city in the three period, each was 23×6 km^2 (Figure 1 and Figure 2): transect in Shanghai was from west to east and passed through People's Square which was defined as the city center; transect in Manila was from north to south and G. T. International Building was selected as the center of the city; transect in Hanoi was also west-east and Hanoi Opera House was the city center.

In landscape pattern analysis, generally transects were cut into small pieces to use the software Fragstats[10] to calculate for the landscape indexes, or were directly calculated by the moving window method in Fragstats. Each moving step in the moving window method is always less than the value of extent to generate some overlap areas, to obtain a smoother curve effect for the landscape index. The selection of step is based on the purpose of the given research. For example, Luck and Wu, in the study of landscape pattern analysis for the Phoenix, USA, performed a gradient with a 15 km extent and 5km step[1]. While Kong used a 500m moving window radius (1km extent) and 200m step studying spatial-temporal gradient analysis of urban green spaces in Jinan, China[8]. In this article, we use a 3km radius of moving window (6km extent) and a 100m step. All transects for the three cities were transformed to Ascii code in a text file using ArcGIS (Version 9.0, ESRI, Redlands, CA 92373-8100, USA). Supported by Fragstats 3.3, the following 6 Indexes were computed: contagion index (CONTAG), Largest Patch Index (LPI), Landscape Shape Index (LSI) , Perimeter-Area Fractal Dimension (PAFRAC), , Patch Density (PD) , Shannon's diversity index (SHDI) (Xie et al., 2006; Kong & Nakagoshi, 2006) [8, 11].

5. RESULTS AND DISCUSSION

5.1 COMPARISON ON OVERVIEW OF SHANGHAI, MANILA AND HANOI

Shanghai and Manila are both mega-cities with population of over tens of millions; while the city level of Hanoi is lower (Table 2). The land area of Shanghai is the largest, which is more than 10 times of Manila, and Manila and Hanoi's land area is in the same order of magnitude. In Per capita land area, Shanghai and Hanoi are high, while Manila is only 50 ~ 60m^2, which shows that Manila in the Philippines is a highly urbanized city and very tight in space. In the level of GDP, the highest is Shanghai, followed by Manila, and Hanoi is the minimum. And in per capita GDP, the highest is Shanghai, Hanoi lowest.

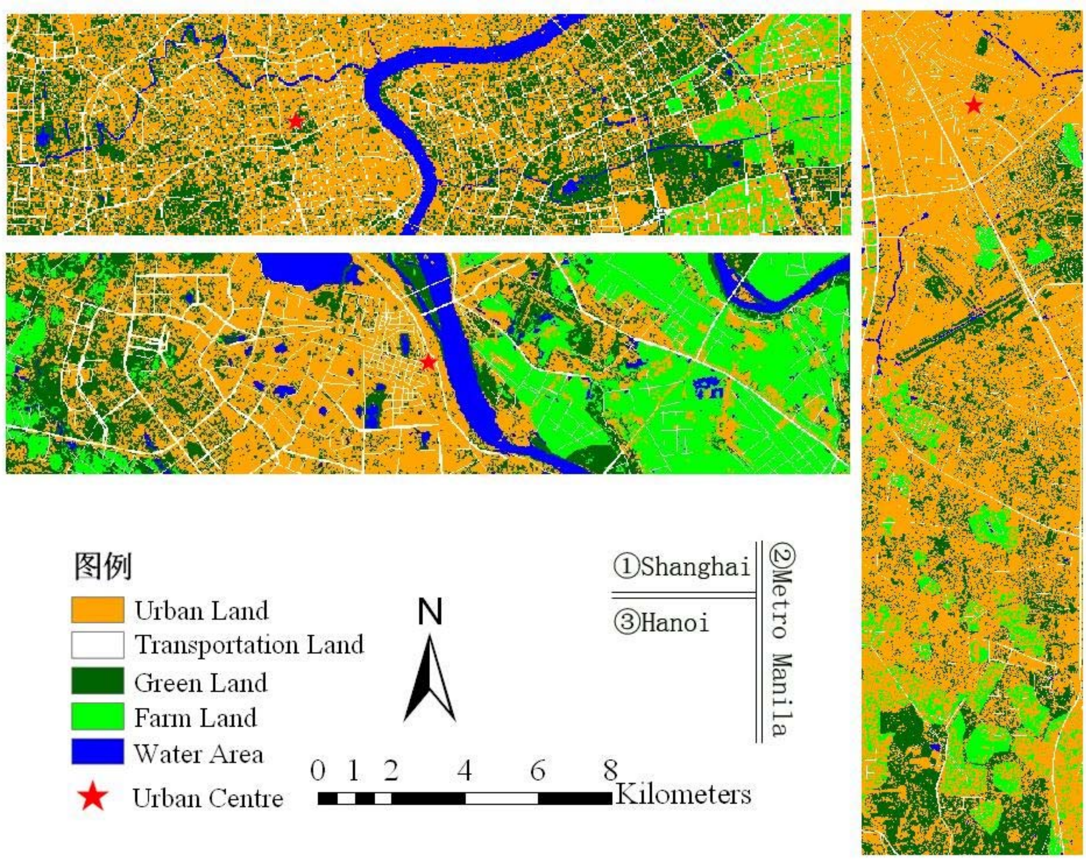

Figure 2. Land use classification map of Shanghai, Manila and Hanoi transect

Table 2. Human population, city area and economic indicators of Shanghai, Manila and Hanoi in 2006 and 2007

	2006			*2007*		
	Shanghai	Manila	Hanoi	Shanghai	Manila	Hanoi
Population (million)	1 3.6808	10.9443	3.2167	13.7886	11.5534	3.4480
Area (km^2)	6340.50	619.5	920.97	6340.50	619.50	920.97
GDP (billion USD)	159.839	48.579	5.683	187.940	53.644	6.734
Per Capita Area (m^2)	463.46	56.60	286.00	459.84	53.62	267.00
Per Capita GDP (thousand USD)	11.7	4.4	1.8	13.7	4.6	2.0

5.2 LANDSCAPE PATTER CHANGE IN TRANSECTS OF SHANGHAI, MANILA AND HANOI

Presently, landscape indexes describing landscape pattern are numerous, but many of them lake the nature of the independent in statistics. Therefore, the usage of dependent landscape indexes is not convincing enough[12]. An ideal landscape index system should be sufficient to describe the landscape pattern but not redundant. In this paper, correlation of landscape indexes in the transect of Shanghai, 2007 selected can be seen in table 3. Because of the edge density (ED) is completely positively correlated with landscape shape index (LSI), only one can be chose to avoid redundant. Other landscape indexes have low correlation, thus can form a well landscape index system to describe the landscape pattern change in gradient.

Table 3. Correlation of landscape indexes in the 2007 Shanghai transect

	CONTAG	*LPI*	*LSI*	*ED*	*PAFRAC*	*PD*	*SHDI*
CONTAG	0.231	-0.567	0.368	-0.568	-0.668	0.040	0.113
LPI	1	-0.013	-0.096	-0.013	-0.222	0.383	-0.584
LSI	-0.013	1	-0.520	1.000	0.907	0.665	-0.327
PAFRAC	-0.096	-0.520	1	-0.520	-0.281	-0.328	0.345
PD	-0.013	1.000	-0.520	1	0.907	0.664	-0.327
SHDI	-0.222	0.907	-0.281	0.907	1	0.395	-0.012

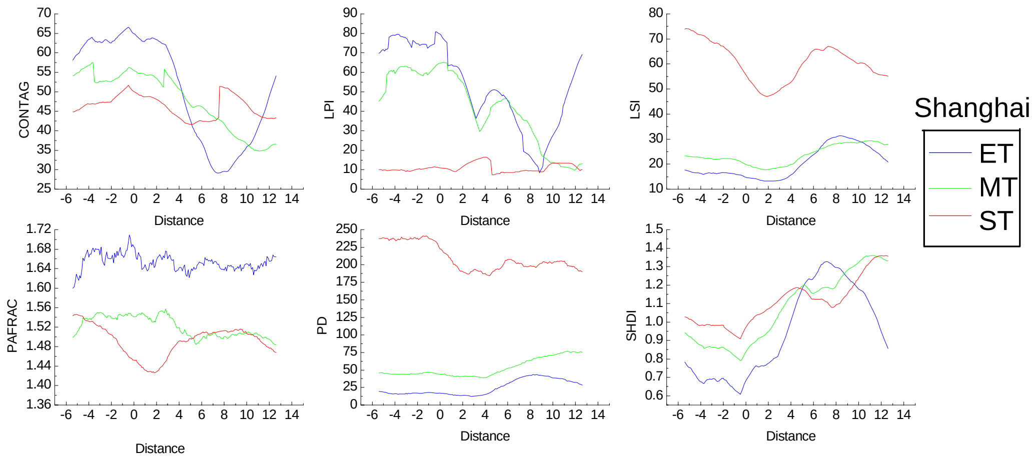

Figure 3. Land use pattern in land use transects of Shanghai

Landscape pattern of Shanghai transects were showed in Figure 3. Along the direction of the gradient, there existed obvious characteristics of the gradient: urban areas-urban and rural transitional zone - rural areas from west to east. Contagion index, patch density, Shannon's diversity index can reflect the spatial heterogeneity of the gradient. In the 1989 transect, the grain size is high, and landscape index curve can only show the dominant gradient feature, such as urban centre and urban-rural transitional zone. In 2001, with a higher resolution and tiny grain size, PD value clearly increased. And the distribution of the gradient also changed. In 1989, the urban location can be obtained from the curve for-0.5km (see contagion index curve), and the location of urban-rural transitional zone was at 7.5km. But in 2001, the two locations both showed displacement, moving to -0.4km and 11.1km. While in 2007, the two positions has been turned into a number of locations. The urban center had moved to -1.2km, and the urban-rural transition zone occurred in a number of positions: 5.3km, places in 8.5 ~ 11.2km. These values were geographic typical in Shanghai. -1.2km is the center of Shanghai, and 5.3km is the interchange (Century Avenue Station) of Shanghai Subway2, 4 and 6. The existence of these two peaks show that, the city expansion of Shanghai is in concentric circle model with Shanghai People's Square as its centre, and a small concentric circle is also exist in Pudong region. Transect from 8.5 ~ 11.2km is urban and rural transitional zone. From the analysis of three periods, we can see that, continuous expansion occurred in Shanghai in recent twenty years. Particularly in the latter period, city expanded from the city center to the suburbs, and formed a smaller city center in Pudong.

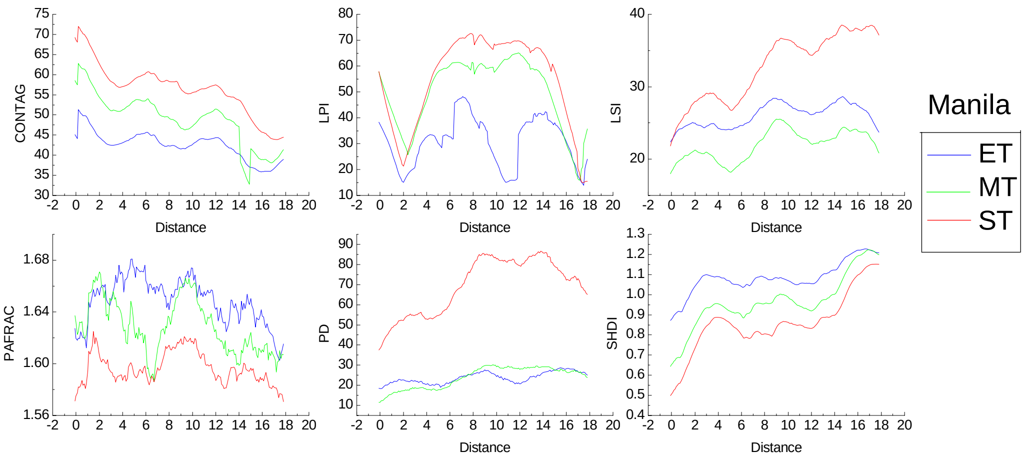

Figure 4. Landscape pattern in land use transects of Manila

Similar to Shanghai, transect of Manila can reflect the main characteristics of the gradient (Figure 4). From north to south, there are urban, urban and rural transitional zone, rural areas, and natural areas. It can be seen from the curve, largest patch index did not change significantly along the gradient, perimeter-area fractal dimension showed strong jagged form, contagion index decreased from urban center to the suburb along the gradient, and landscape shape index, patch density and Shannon's diversity index showed an upward trend. In 1993, 2001 and 2006, the trend showed by the landscape index curve was similar, indicating the grain size 12.5m did not reverse the trend that the disturbance in urban-rural transitional areas is higher than urban centre. Although in city center the landscape had a high degree of fragmentation, a high degree of similarity among the adjacent landscape mainly caused by roads incision effect also existed, which leaded to a high level of contagion. In the curve, patch density curve which can characterize the degree of disturbance showed multi peaks and valleys. In 1993 the peak occurred at 3km, 9.3km and 16.7km. In 2001, the peak appeared at 3.9km, 9.4km and 17km. And in 2006 there are four peaks at 4.0km, 9.6km, 14.6km and 17km. A continuous increasing of the peak location showed that urbanization in Manila expended from the city center towards the suburban areas, from high urbanization areas to low urbanization areas.

Transects of Hanoi is a bit different from Shanghai and Manila, as the grain size in the three period is the same and quantitative comparison can be achieve. Landscape pattern change condition along the direction of the gradient in Hanoi in nearly 20 years is shown in Figure 5. Gradient from west to east in Hanoi is rural area, urban and rural transitional area, and rural area. Patch density decreased first and then increased from west to east. And it is larger in the suburbs than downtown. This anomaly phenomena is similar with Manila. In the city center, landscape shape index, perimeter-area fractal dimension, patch density, Shannon's diversity index showed a downward trend. However, contagion index showed an upward trend. In urban centre the aggregation effect is obvious at the grain size of 25m in TM image, and diversity decreased. While in rural areas, distinction among various types of landscape is clear, and fragmentation can be well reflected. In patch density curve large peaks can be found. In 1993, the peaks were at -7.4km,-0.2km and 6.6km. In 2000, there are four peaks at -7.9km,-1.5km, 2km and 6.8km. And in 2006 peaks were at -7.9km,-3.3km, 2km, 4.2 km and 6.8km. It shows that it is different between the two periods from 1993 to 2000 and from 2000 to 2007. Larger displacement of peaks movement occurred in the former, which showed stronger urban expansion and more intensive landscape fragmentation. While main character in the latter is the increase in the curve width of the expanding area and an improvement in the urban expand ability. In summary, urban expanding tension in Hanoi is less than Shanghai and Manila, and urbanization in urban-rural transitional area is not obvious.

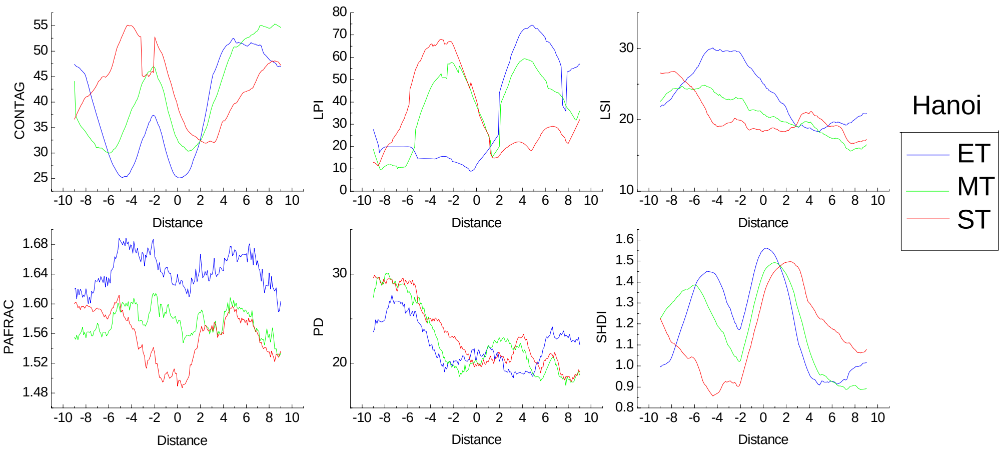

Figure 5. Landscape pattern in land use transect of Hanoi

5.3 DESAKOTA REGIONS FEATURE COMPARISON BETWEEN SHANGHAI, MANILA AND HANOI

Relationship between landscape pattern index and the gradient feature can be reflected in the correlation between the landscape index and distance. Contagion index, patch density and Shannon's diversity index in transects of the three major cities have a high degree of positive or negative relevance with the absolute distance (see Table 4), and they are strongly dependent with the gradient of urbanization. Correlations between patch densities and the absolute distance are all more than 0.7 for the city of Manila in the three periods, over 0.8 for Shanghai in 1989 and 2001, and a bit lower in Hanoi. The higher Shannon's diversity index is the greater the landscape diversity is. That is to say the more abundant the landscape elements are, the higher the degree of fragmentation is[13]. Shannon's diversity index is positive related with the absolute distance in Shanghai and Manila in Table 4, while negative in Hanoi. It shows that in Shanghai and Manila the there is greater change and stronger fragmentation in the landscape of urban-rural transition areas, and in Hanoi the opposite. The phenomena can also be seen from the curve of landscape shape index and contagion index. In summary, contagion index, landscape shape index, patch density, and Shannon's diversity index can reflect the dependent between the landscape fragmentation and urban gradient. Landscape fragmentation obviously increases from urban centre to suburban areas for Shanghai and Manila, but only clearly in the major urban areas for Hanoi.

Table 4. Correlation of landscape index and absolute distance in the transects of Shanghai, Manila and Hanoi

City	*Year*	*CONTAG*	*LPI*	*LSI*	*PAFRAC*	*PD*	*SHDI*
Shanghai	1989	-0.754	-0.595	0.817	-0.382	0.829	0.686
	2001	-0.940	-0.919	0.907	-0.824	0.928	0.914
	2007	-0.402	0.070	0.136	0.386	-0.423	0.850
Manila	1993	-0.813	0.039	0.666	-0.399	0.742	0.811
	2001	-0.869	-0.109	0.679	-0.507	0.835	0.867
	2006	-0.899	0.086	0.939	-0.206	0.770	0.838
Hanoi	1993	0.601	0.326	-0.325	-0.244	0.629	-0.673
	2000	0.352	-0.395	-0.120	-0.413	0.345	-0.455
	2007	0.224	-0.368	0.420	0.634	0.351	-0.340

Gradient analysis for the landscape pattern of the three cities shows that, urbanization stage and desakota regions feature are different in Shanghai, Manila and Hanoi. It is obvious in the late period of the study in Shanghai that, the outward expansion and suburban urbanization jointly speed up the expansion of urban space. Urbanization in Manila is expanding in far suburban areas, and high urbanization areas continuously expand to low urbanization region. While in Hanoi, the expanding is not that intensively as the previous two, and desakota regions phenomena is not obvious.

6. CONCLUSION

(1) There is a certain relationship between landscape pattern index and scale, and indexes such as patch density are sensitive to the grain size [14, 15]. High-resolution images is suitable for the analysis of urban landscape pattern particularly the fragmentation analysis, and the appropriate grain size is 5 ~ 10m [15]. While TM images have a special resolution to highlight the heterogeneity and disturbance of urban-rural transitional areas, they are suitable for the analysis of agricultural

landscape influenced by urban expansion. However, in a different size, the trend of many landscape indexes is not changed, such as landscape edge density and mean fractal dimension [16]. Therefore, if we have known the location of urban centre and suburban area, the rule reflected by many landscape pattern indexes can not be affected by the grain size. Comparison of images under different resolutions (three images of Shanghai, the latest period image and the two previous ones of Manila) is only qualitatively, while images of Hanoi can perform quantitative comparison.

(2) In transect, landscape index can detect gradient of urbanization and show the process of urbanization. The position of peak can reflect the direction of urbanization independent of grain size. The gradient of the landscape dynamics in the gradient of Shanghai and Manila can show the fragmentation brought by urbanization and its increasing trend at the direction of the city center to the suburbs, as well as the expanding of urbanization, suburban rapid urbanization, and obvious desakota features. While in Hanoi, urbanization reflected by the gradient analysis mainly exist in urban area and urban edge. The potency of urban expansion is not so high, and suburban urbanization as well as desakota is not clearly.

(3) Since the middle 20th century, economic in East Asia and Southeast Asia with high population density grew fast, and industrialization and urbanization turned fast there. Rapid expansion of central cities leads to large-scale of urban-rural transition areas[18]. Since the early 1990s and Pudong Region in Shanghai had been developed, international manufacturing capital rushed in and leaded to the entrance of Shanghai industry into the global production system[17]. In the period 1990-2000, the outskirt of Shanghai developed rapidly, and after 2000 urbanization and anti-urbanization combined, which promoted the urbanization in outskirts of the city[18] and gave rise to the tremendous change of urban space and structure of Shanghai. It is one of the most important driving factor in forming desakota region in Shanghai. In Philippines, "Local Government Act, 1991" prescribes that, normal city with a population of 200,000 and revenue over 50,000,000 pesos in the past year can transform into highly urbanized city. There are 25 highly urbanized cities including Manila existing in Philippines. To relax the disadvantages brought by overage accumulation in mega city, urbanization in Manila expanded to suburbs rapidly and formed desakota region. Land area per capita in Hanoi is relatively high (Table 2), less pressure on the land. GDP per capita in Hanoi is lower (Table 2), while in Shanghai and Manila per capita GDP is more than 3,000 U.S. dollars. The general experience from abroad tells us that, only when the economic reaches 3,000 dollars per capita, there can be a possibility population and a large number of industrial enterprises move out in the outskirt of mega cities[19]. The stage of urbanization in Hanoi still has a distance with Shanghai and Manila, and in Hanoi desakota regions phenomena is not obvious.

(4) Desakota region is a special type of urbanization, where agricultural activities and non-agricultural activities co-exist, and it is non-urban and non-rural, but it contains both urban and rural characters. It is "gray area" belongs to the transitional area of urban and rural area in the sense of landscape, internal components, systems management and so forth [20]. Desakota region is complex than single urban or rural landscape, thus need more effort in management. When planning and construction are carried out, we should consider enough the protection of the easily broken ecology system, to build the security ecological pattern and protect biological diversity, and construct scientific, harmonious environment.

ACKNOWLEDGEMENTS

Financial support from Asia-Pacific Network for Global Change Research (APN), Skip Kaufmann of START, Linda Stevenson of APN and other staff are gratefully acknowledged.

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Appendix 1 : Detailed Project timeline and activities conducted

Date	**Activities conducted**
2006-2-16	Our project wrote the application pre- proposal book and set up the plan to the APN.
2006-5-20	Our project had sent the official application proposal on the APN and three Appendix documents to the APN.
2006-7-15	The project team began to collect some data and research materials on the proposal works.
2006-10-25	Prof. jiaguo Qi in USA visited the Nanjing University and gave the scientific lectures on the global change and climate changes.
2006-11-7	Prof. jianlong Li had joined the international meeting "the First Regional NEESPI Focus Research Center on Dry Land Processes Studies Workshop in Nov.7-11 , Beijing, China." and was selected a peer-reviewed scientist of the NEESPI.
2006-11-25	The project had set up an international research team and a database from China, Vietnam and Philippines in Nanjing University, China.
2007-2-5	Prof. Jianlong Li wrote the answering letters and sent the revised the proposal and first report to the APN.
2007-2-25	Prof. tiangong Liang in China visited the Nanjing University and tr ten young Chinese scientists on advanced methods of remote technology and GIS and urban landscape pattern analysis.
2007-3-20	The project team began to write the research papers and bought the some remote sensing films in ETM or P6 or SPOT and processed them.
2007-5-22	Prof. jianlong Li had taken part in the international conference "The Eco Summit : Ecological Complexity and Sustainability: Challenges and Opportunities for 21st-Century's Ecology" and made a report of "Quantification of land use urbanization level based on the analysis of scale effects in Shanghai."
2007-5-30	The project team had begun to set up the field stations to collect some research materials on the "Quantification of land use urbanization level in three developing Asia countries based on the analysis of scale effects in landscape pattern " under the three countries.
2007-6-8	The project team began to work for the objectives of the project and investigated data and to collect some research materials for the project.
2007-6-20	Prof. jiaguo Qi in USA visited the Nanjing University and gave the second scientific lectures on the global change and climate changes.
2007-6-26	Prof. jiaguo Qi in USA and Prof. Jianlong Li in China had visited the Shanghai city and investigated the fields and collected some materials on the project and begun the project activities that generated and transfered knowledge on the physical and human dimensions of change in the Earth System with a focus on: the APN Science Agenda "2.Ecosystems, Biodiversity and Land Use".
2007-8-2	Our project team began to train five young Chinese scientists and

Date	Activities conducted
	discussed the project works and worked for the project objectives.
2007-10-26	Prof. jianlong Li had joined in the international meeting "The 4th International Symposium on Intelligent Information Technology in Agriculture" and made a report "the Theories and Progress of 3S Technology in the Application of Grassland and Agriculture Sciences".
2007-12-3	Prof. jianlong Li had joined the international conference "The Third International Conference on Natural Resources and Sustainable Development in the Mongolian Plateau and Surrounding Regions in Beijing, China" and made a report of "Advances on the remote sensing and GIS and GPS integration systems in dynamic monitoring urban ecosystem changes in Shanghai, China. ".
2007-12-26	The project team had set up the APN project website at http://apn.ueplab.cn or http://www.usplab.cn/apn.
2007-12-28	The project team had begun to process a lot of data and write the Interim Report for ARCP Project and Progress Report for APN Project.
2008-1-14	The project leader had sent two inviting official letters to Vietnam and Philippines scientists to join the workshop in Nanjing University, China.
2008-1-23	The project leader of prof. Li had written the two reports on the Interim Report for ARCP Project and Progress Report for APN Project.
2008-1-25	Our project team will begin some research works on "Quantification of land use urbanization level in three developing Asia countries based on the analysis of scale effects in landscape pattern" by means of the project timeline & plan.
2008-3-9-14	Our project team from China, USA, Vietnam and Philippines scientists will have a workshop in Nanjing University, China to discuss the research work progress and write the result reports on our proposal and begin a lot of research works next year on the "Quantification of land use urbanization level in three developing Asia countries based on the analysis of scale effects in landscape pattern" by means of the project timeline & plan.
2008-6-28	An output of this project will be the submission of at least three scientific papers to peer reviewed journals based on the case study analyses and assessments in the three core project countries. In addition, the research team will publish a series of technical and "policy-relevant" research papers to be distributed to scientists and policy makers throughout the region. These publications will also be made available through the proposed project web site. Finally, this team will submit a project report to the APN, and IPCC for possible inclusion in the IPCC Fourth Assessment Report.
2008-9-29	Our project team from China, USA, Vietnam and Philippines scientists have done some researching works on the Landscape Ecology Pattern Gradient Analysis and Comparison of Desakota

Date	Activities conducted
	Regions Features in Three Asian-Pacific Regional Major Cities
2008-10-10	Our project team from China, USA, Vietnam and Philippines scientists have done some researching works and getting data from three experimental sites and writing three papers.
2008-11-15	Our project team from China have some researching works and to collect some ground experimental station data and research materials on the proposal works in the Shanghai and Zhangjiagang cities. And the remote sensing films made in China had checked in the ground work in the same time by the Chinese team.
2008-12-28	The Chinese team have begun to write the ARCP Interim Report and progress Report and made in the Financial report and arranged the next year project work plan and send the those reports to APN Secretariat and other project teams from USA, Vietnam and Philippines.
2009-2-2	Pro. Li have taken part in the NESSIP meeting and activities and have reported the progress of APN programme in Xinjiang in Feb. 2-4, 2009.
2009-3-6	The last workshop and training meeting have set up by the Our project team from China, USA, Vietnam and Philippines scientists and twenties younger men in the Nanjing city in March 6-9, 2009.
2009-5-10	Our project team from China, USA, Vietnam and Philippines scientists have done some researching works and continued to getting data from three experimental sites and finished the last research works and begun the last activity by the three country teams.
2009-6-30	Our project team from China, USA, Vietnam and Philippines scientists have begun to write the last scientific documents and papers and final project activity report and progress reports and the last financial reports from June 30 to July 31.
2009-7-3	Our project team from China, USA, Vietnam, Philippines and Indian scientists have begun to write the applying proposal of 2009 Annual Regional Call for Proposals (ARCP) and Proposal title “Analysis on urban land-use changes and its impacts on food security in different Asian cities of four developing countries using modified CA model”.
2009-7-24	We have received the letter and first stage reviewing letter from the APN Secretariat about our apply proposal title “Analysis on urban land-use changes and its impacts on food security in different Asian cities of four developing countries using modified CA model”, and now, we have begun to revise the our apply proposal and written summary proposals and submit the report to the APN secretariat in the Deadline: Friday, 14 August 2009.
2009-7-31	Our project team from China, USA, Vietnam, Philippines and Indian scientists will continue our researching plan and works according to the time line and contract in 2009-2010.

Appendix 2 : Project photographs, figures, tables etc

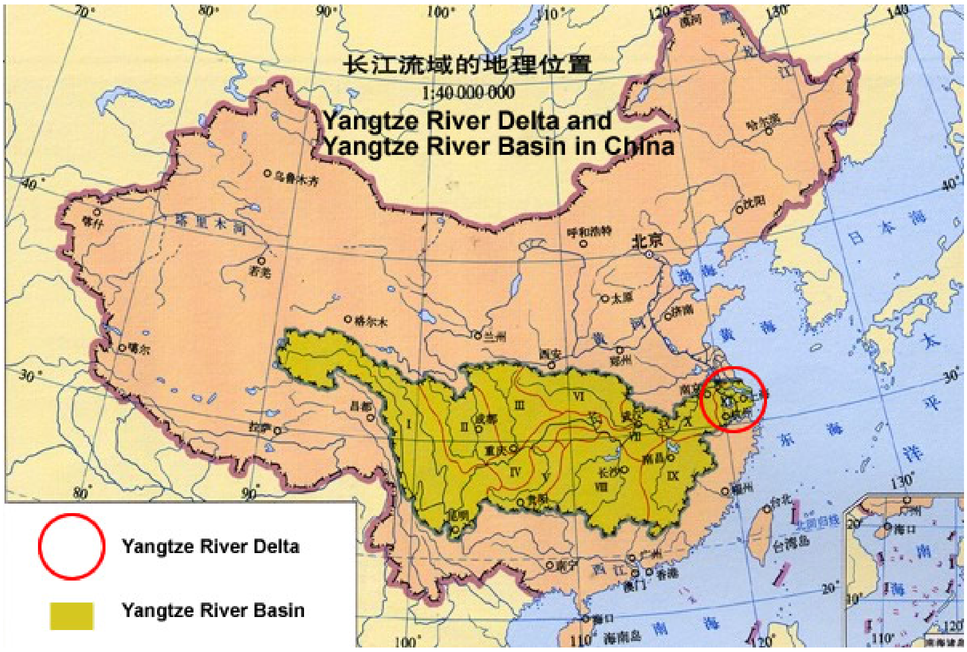


Fig 1. Location of the Yangtze River Delta in project area, China

Table 1. Comparison of relevant indices of land resources between the Yangtze River Delta and Whole China (1998)

	Population (10^4p)	Land		GDP			Cultivated land		Grain yield		
		Total area (10^4km^2)	Density (p/km^2)	Total (10^8RMB)	Unit area (RMB/m^s)	Per capita (RMB/p)	Total area (10^4hm^2)	Per capita (hm^2/p)	Total (10^4t)	Unit area ($10^4/hm^2$)	Per Capita (㎏/p)
Yangtze River Delta	7,606	9.961	764	12,322	12.37	16,200	325.4	0.043	2,879	8.84	378.4
Whole China	124,810	960	130	79,396	0.83	6,392	9497.1	0.076	51,474	5.42	412.4
Percentage (%)	6.09	1.04	-	15.52	-	-	3.43	-	5.59	-	-

Table 2. Urbanization level of the cities in the Yangtze River Delta in our project area in 2001

City	Total Population (10^4)	Urban Population (10^4)	Urbanization Level* (%)	City	Total Population (10^4)	Urban Population (10^4)	Urbanization Level (%)
Shanghai	1327.14	1264.41	95.27	Taizhou	503.10	60.57	12.04
Nanjing	553.04	371.89	67.24	Hangzhou	629.14	379.49	60.32
Wuxi	435.90	213.07	48.88	Ningbo	543.35	126.13	23.21
Changzhou	341.52	89.47	26.20	Jiaxing	331.93	79.11	23.83
Suzhou	580.53	209.46	36.08	Huzhou	256.49	107.52	41.92
Nantong	782.46	79.54	10.17	Shaoxing	433.27	59.92	13.83
Yangzhou	451.59	109.66	24.28	Zhoushan	98.10	68.85	70.18
Zhenjiang	266.58	62.82	23.57	Total	7534.14	3281.91	43.56

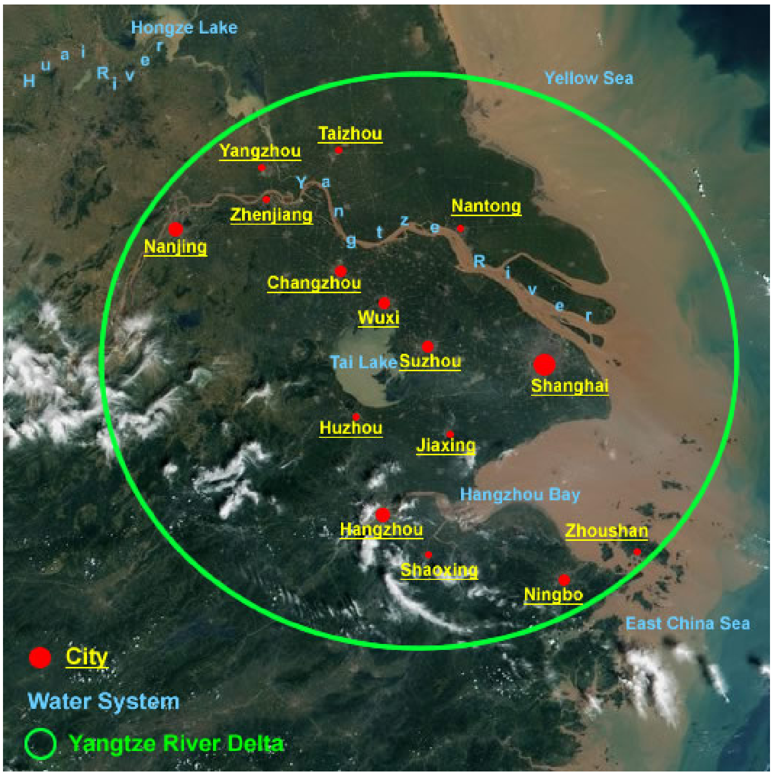


Fig 2. Major cities in the Yangtze River Delta in our project area, China.

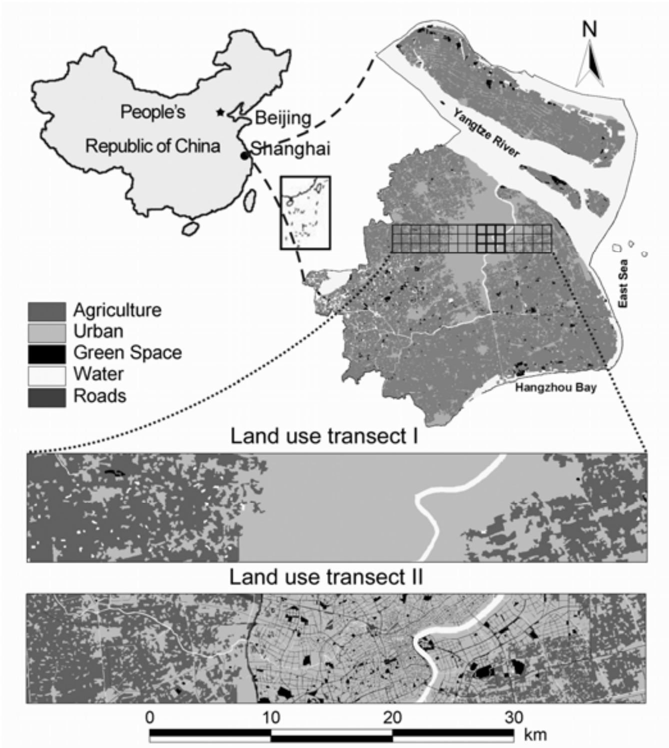


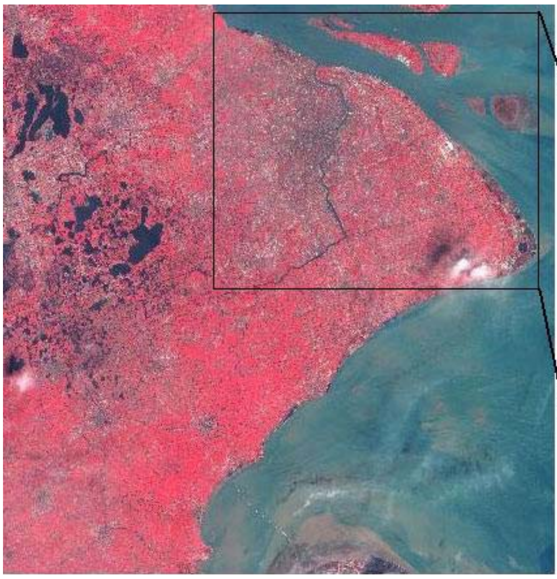
Fig 3. Land use transects I (2006) and II (2007) and their locations in Shanghai, China.

Table 3. Land use reclassification scheme of two land use maps in Shanghai, China in 2006-2007.

Reclassified patch type	Original land use type	
	Land use transect I	**Land use transect II**
Agriculture	Paddy field	Aquiculture
	Dry field	Cropland
		Poultry farm
Urban	Urban or build-up Area	Airport
	Rural Residential	Business Park
	Construction Area	Construction Area
		Garbage Disposal
		Harbour
		Industrial
		Other Public Facility
		Public Construction
		Sewage Disposal
		Rural Residential
		Urban Residential
		Warehouse
Green Space	Forest	Forest
	Shrubbery	Industrial Green
	Orchard	Public Garden
	Lawn	Residential Green
		Transportation Green
Water	Pond/Lake	Pond/Lake
	River	River
Roads		Railway
		Road

Table 4. Urbanization level comparisons of the three cities: Shanghai , Manila and Hanoi in 2007.

City	Total Population (10^4)	Urban Population (10^4)	Urbanization Level* (%)
Shanghai	**1327.14**	**1264.41**	**95.27**
Manila	**993.26**	----	----
Hanoi	**300.70**	----	----



IRS-P6 imagery of the study area in 2007.4.9 with the resolution 23m

IRS-P6 imagery of the study area in 2007.4.9 with the resolution 5.8m

Location of study area in the Shanghai metropolitan region

Fig 4. Imageries and the location of studying field in Shanghai, China

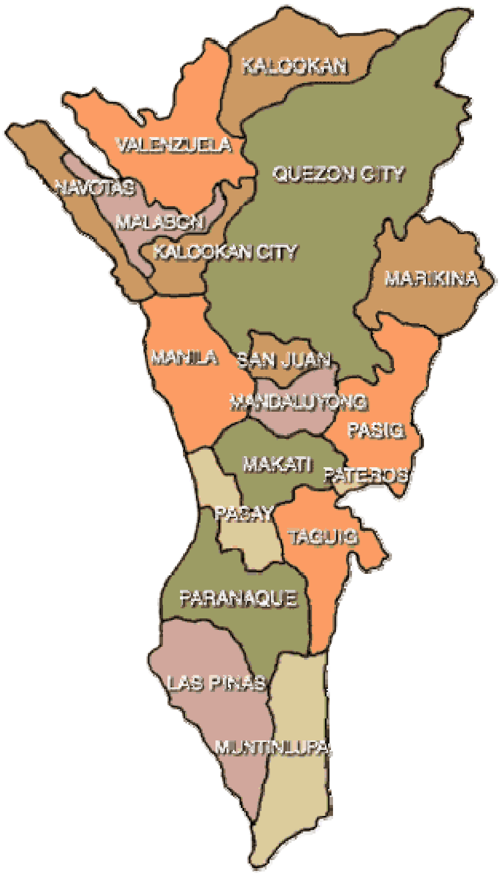
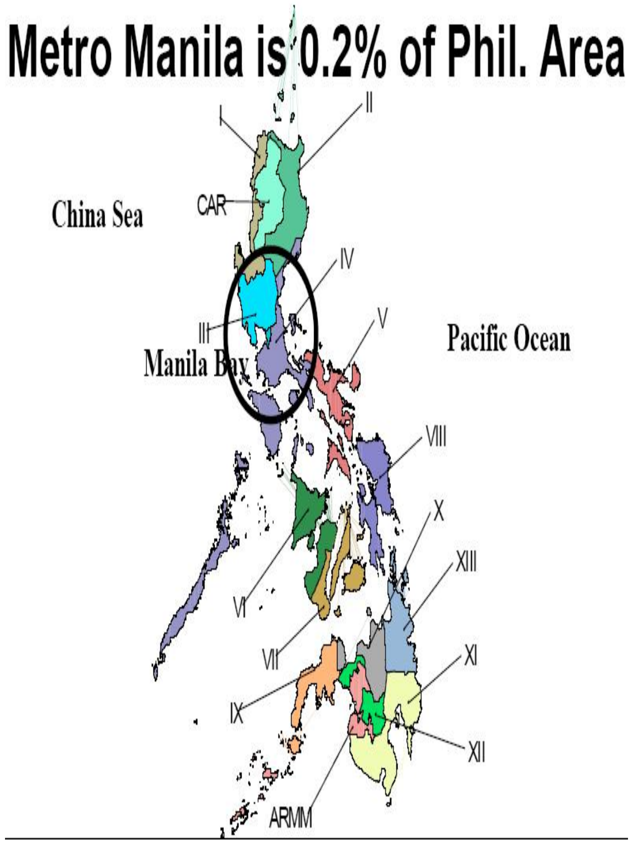


Fig 5. The official constructions of Metro Manila City in Philippines (2007).

Fig 6. Location of studying area in Metro Manila, Philippines



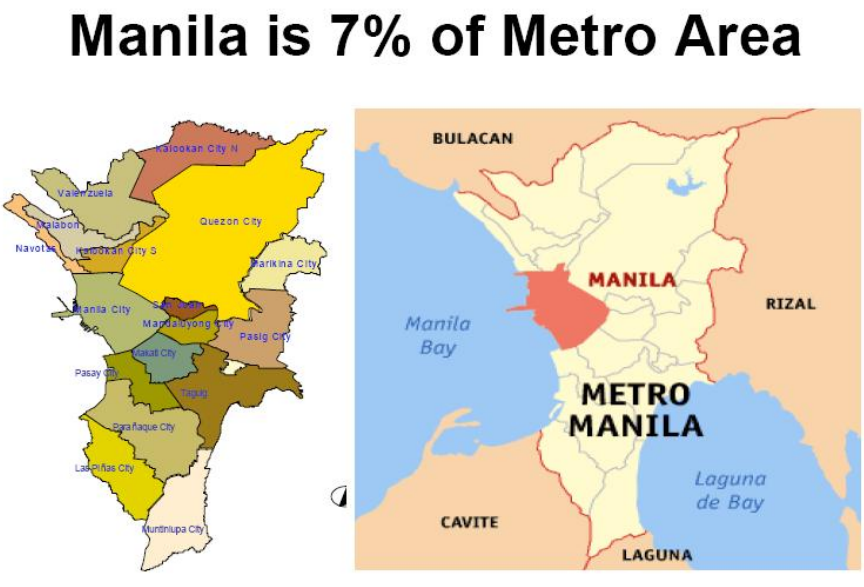


Fig 7. Location of the manila city in project area, Philippines.

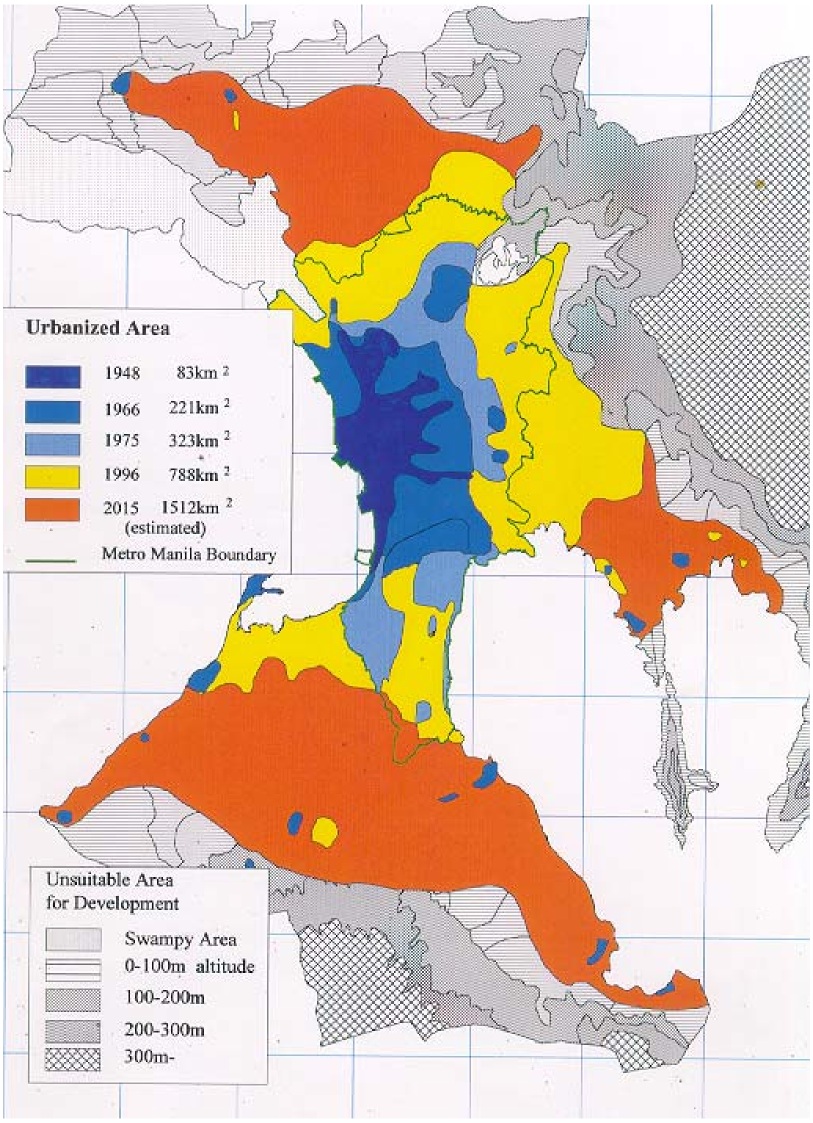


Fig 8. Urbanization level and images in Metro Manila, Philippines.

Fig 9. Location and image of the studying area in Hanoi, Vietnam.

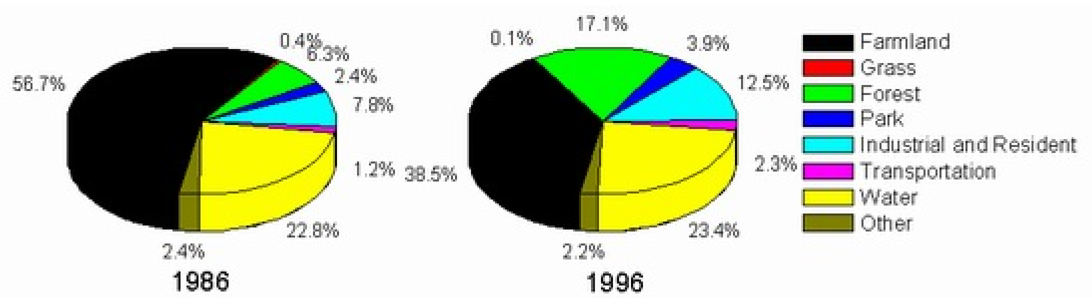


Fig 10. Comparisons of the land use structure in the Yangtze River Delta, China in 1986 -1996.

Table 5. Statistic data of the three cities: Shanghai , Manila and Hanoi (2004).

City	GDP	Average Person Per year (10^4p)	Per Capita GDP (USD)	Government Revenue (million RMB)	Government Expenditure (million RMB)	Area (km^2)	Population Density (p/km^2)	Cultivated Area (10^4ha)	Cultivated Area Per Capita(mu*)	Area of Parks and Green Areas(ha)	Coverage Rate of Green Area Developed (%)	Area of Road (10^4m^2)	Operating Public Vehicles
Shanghai	495084.00 million RMB	1324.39	5340.29	61385.00	71544.00	6341	2093	281	0.32	14771	25.8	13411	18083
Manila	835.60 billion PHP	\	\	\	\	636	15617	\	\	\	\	\	\
Hanoi	55996.00 billion VND	\	1200.00	\	\	921	3264.93	\	\	\	\	\	\

Appendix 3：Abstract of selected publicatiosn

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Desakota Regions Study of Three Mega-Cities in Asia Developing Countries Based on Landscape Pattern Gradient Analysis[1]

Jiasheng Huang[1], Jianlong Li[1**], Flaviana D. Hilario[2], Hoang Minh Hien[3], Xiaoyu Gan[1], Qi Yang [1], Cinco Thelma Acebes[2], Nguyen Thanh Tung[3]

（1 School of Life Sciences, Nanjing University, Nanjing, China, 210093；2 Climatology and Agrometeorology Branch, PAGASA，1424 Quezon Ave., Quezon City, Philippines；3 Dept. for Dyke Mgmt., Flood and Storm Control Ministry of Agriculture and Rural Development, 02 Ngoc Ha Street, Ba Dinh Dist, Hanoi, Vietnam）

Abstract: Three mega-cities in Asia-Pacific Region: Shanghai, China, Manila, the Philippines and Hanoi, Vietnam, were selected as our research region. In support of 3S（GIS-GPS-RS） technology, the landscape pattern dynamics and desakota regions features related with urbanization of the three cities in recent twenty years were studied, with gradient analysis using six landscape matrix indexes: contagion index, largest patch index, landscape shape index, perimeter-area fractal dimension, patch density, and Shannon's diversity index. The results showed that: (1) In the process of urbanization, regional landscape pattern of these three cities had changed markedly, with an increasing of patch density and strengthening of fragmentation; (2) In land use transect, patch density and Shannon diversity index had a high correlation with the absolute distance to the city center. Landscape index can detect the gradient of the city and show the direction of urbanization; (3) The desakota region of the cities were discovered with different characteristics and different stages of urbanization development features. It was typical in Asia. Metro Manila was found in the highest stage of urbanization, and with the earliest suburb urbanization. Shanghai was demonstrated a high degree of urbanization and an obvious suburb urbanization. In contrast, a lower level of urbanization and unobvious suburb urbanization was discovered in Hanoi. Ecological environment protection for the desakota region should be strengthened and put into practice.

Key Words: Landscape Pattern, Gradient analysis，Urbanization，Desakota regions，Shanghai，Hanoi，Metro Manila

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[1] Foundation item: The project was financially supported by the International APN Foundation（ARCP2007-13NMY-Li）

Biography: Jiasheng Huang, M. Sc Student, mainly engaged in remote sensing and urban landscape ecology. E-mail: huangjiasheng@gmail.com

[**] Corresponding Author. E-mail: jlli2008@nju.edu.cn

Impacts of Spatial Resolution and Classification Themes on Urban Landscape with Changing Scale Size in Shanghai, China

Xiaoyu Gan[1], Ming ZHU[2], Jianlong LI[1,*], Jiasheng Huang[1] and Qi Yang[1]
[1]Department of Biology, Nanjing University, Nanjing, 210093, P.R. China;
[2]Department of Urban and Resources Science, Nanjing University, Nanjing, 210093, P.R. China; * Author for correspondence
Abstract: Urbanization, as a major driving force of land use and land cover change, has been a significant cause of the changing of urban landscape. As the largest city in the country, Shanghai is now the fastest growing city in China. The impacts of resolution of imagery and classification themes on urban landuse analyse have rarely been reported. To better understand the characteristics of urban landscape, landscape pattern of Shanghai was analysed using land use maps produced from TM and IRS-PAN images with increasing grain size and extent size. Landscape metrics were computed along a 51 × 9 km^2 transect cutting across Shanghai with a moving window. The results showed that road corridors could greatly affect urban landscape and such effects can be detected by both changing grain size and changing extent size. The optimal grain size and extent size was 7.5m and 5km for urban landscape analyse in ShangHai. Improper resolution and classification themes may leed to inforamtion losing on urban landscape analyse. Impacts of resolution and classification themes on urban landscape analyse were not fully similar with each other. Classification themes were more significant in fine resolution imagery than in course imagery, and linearity corridors should pay more attention when landscape analyse was executed using such imagery.

Keywords: Fragmentation, Grain size, Extent size, Gradient analysis, Spatial resolution, Classification theme

Land Use / Cover Change Study of Zhangjiagang City Used Cellular Automata Based on Rules Extraction by Geographic Information Statistics

HUANG[2] Jiasheng LI Jianlong** GAN Xiaoyu Yang Qi (School of Life Science, Nanjing University, 22 Hankou Road, Nanjing 210093, China)

Abstract: In this paper, a new method of Cellular Automata (CA) is developed, which is defined as Geographic Spectrum Cellular Automata, and county land use/ cover changes (LUCC) is simulated. Integrated with land use database of Zhangjiagang City, two years of land use map was derived from interpretation of two remote sensing images. From statistics and analysis of all the geographic data in these two land use map, distribution probability relationships of seven types of land use in Zhangjiagang City (Geographic Spectrum) was extracted. And this Geographic Spectrum is the rule of the cellular automata. The method develops Geographic Cellular Automata (Geo-CA), and constructs Geographic Spectrum Cellular Automata (GS-CA). Using this model, the LUCC of Zhangjiagang City in the future 10 years was simulated. And the result showed that urbanization is one of the major driving force, and urban area will increase 8369.815 hectares in the next 10 years. At the same time, 8567.1875 hectares of arable land and 965.8125 hectares of other agricultural land would be converted to urban land to meet the need of growing urbanization. The absolute value of the deviation based on land area for each type was below 0.5%, and the indicator of Fuzzy Kappa was well achieved. According to the result of the simulation, LUCC process could be effectively simulated by the Cellular Automata we constructed, and the subjective factors on the impact of rules were eliminated.

Key words: Remote Sensing, Land Use / Cover Changes, Geographic Spectrum Cellular Automata，Zhangjiagang City

[2] About the first author: HUANG Jiasheng, M. Sc Student. His research interests include remote sensing and urban landscape ecology. E-mail: huangjiasheng@gmail.com About the corresponding author: LI Jianlong, Professor, Ph. D Candidate Supervisor. His research interest is urban ecology. E-mail: jlli2008@nju.edu.cn