Megalopolisation: An Effect of Large Scale Urbanisation in Post-Reform China

Siqing Chen

Abstract—Megalopolis is a group of densely populated metropolitan areas that combine to form an urban complex. Since China introduced the economic reforms in late 1970s, the Chinese urban system has experienced unprecedented growth. The process of urbanisation prevailed in the 1980s, and the process of predominantly large city growth appeared to continue through 1990s and 2000s. In this study, the magnitude and pattern of urbanisation in China during 1990s were examined using remotely sensed imagery acquired by TM/ETM+ sensor onboard the Landsat satellites. The development of megalopolis areas in China was also studied based on the GIS analysis of the increases of urban and built-up area from 1990 to 2000. The analysis suggests that in the traditional agricultural zones in China, e.g., Huang-Huai-Hai Plains, Changjiang River Delta, Pearl River Delta and Sichuan Basin, the urban and built-up areas increased by 1.76 million hectares, of which 0.82 million hectares are expansion of urban areas, an increase of 24.78% compared with 1990 at the national scale. The Yellow River Delta, Changjiang River Delta and Pearl River Delta also saw an increase of urban and built-up area by 63.9%, 66.2% and 83.0% respectively. As a result, three major megalopolises were developed in China: the Guangzhou-Shenzhen-Hong Kong-Macau (Pearl River Delta: PRD) megalopolis area, the Shanghai-Nanjing-Hangzhou (Changjiang River Delta: CRD) megalopolis area and the Beijing-Tianjing-Tangshan-Qinhuangdao (Yellow River Delta-Bohai Sea Ring: YRD) megalopolis area. The relationship between the processed of megalopolisation and the inter-provincial population flow was also explored in the context of social-economic and transport infrastructure development in Post-reform China.

Keywords—Megalopolisation, Land use change, Spatial analysis, Post-reform China

I. INTRODUCTION

MEGALOPOLIS was originally used by Gottmann to describe the urbanized northeastern seaboard of the United States [1] [2] [3] [4], which envelopes the string of the "Big Four" central cities-Boston, New York City, Philadelphia, and Washington D.C. - and constellations of the suburbs and satellites [5]. Gottmann's study became a landmark in urban geographic analysis, and only after that the term Megalopolis found its way into the jargon of media, planning and politics. Subsequently, the term has been applied in the United States to the urban southern California, the urbanized southern Great Lakes region, and sometimes to smaller metropolitan clusters [5]. More widely, megalopolis was used to describe many urban regions over the world, such as the London, Berlin, Amsterdam, Moscow megalopolises in Europe [6] [7], the St. Paulo megalopolis in Brazil [7], the Tokyo, Osaka and Nagoya megalopolises in Japan [8] [9] and the Bangkok megalopolis in Thailand [7]. Large quantities of studies have been done regarding the urban development in China, however, they were largely focused on "conurbation" or "agglomeration" or other factors like urban growth pattern and sprawl of *metropolitan* areas [10] [11] [12]; studies and documentations on the formation of modern *megalopolis* areas at the national level of China are very few. This study is one of the first attempts to quantify and characterize the major megalopolis areas in China due to its recent large scale urbanisation, infrastructure construction and landscape transformation.

China is the world's most populous country and the fourth largest in area. Its economy, already huge, is growing at the fastest rate of any major nation [13]. Since the launch of economic reforms in the late 1970s and urban reforms and open-door policies in the mid-1980s, China has been undergoing a transition from a largely rural society to a predominantly urban one. Over the past two decades, urban areas in China have experienced explosive growth in both human population and physical size [14] [15], showing no signs of slowing down and likely continuing unabated into the next decades. China's population has grown from about 980 million people in 1980 to almost 1.3 billion today [16] [17]. In 1980s, fewer than 20% of China's people lived in urban area, today it is 36% and by 2030 it is expected to be 54% [18] (Fig. 1) or 80% by 2045 [19]. Urbanisation at such a scale has greatly accelerated environmental pressure on the ecosystems, thus placing an enormous burden on organizations responsible for the planning and management of urban areas in China. Urban areas are not only the settlements of more than one-third of China's population, but also the hubs of China's manufacturing and service industries [20]. Since 1980s, the unprecedented economic boom coupled with population growth and the flow of people from rural areas to large cities in the process of intensive urbanisation has made three megalopolis areas in China come into being (Fig. 2). Megalopolisation in China has resulted from large scale urbanisation and construction of infrastructure and land use transformation. The increase of urban area comes at the price of the loss of arable lands [15] [21]. Large scale urbanisation and megalopolisation showed significant impact on climate [22] [23] [24], urban environment change [25] [26], net primary productivity (NPP) [27] and biogeochemical cycles at both local and regional scales [28] [29] [30] and will continue to shape China's social and natural systems in the coming

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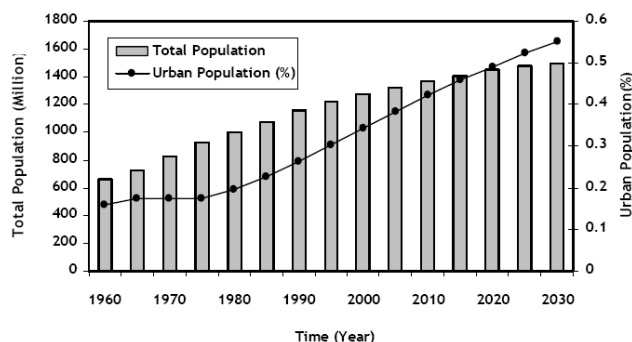Vol:3, No:6, 2009

decades.

Fig. 1 A comparison of China's total population growing trends and urban population (%) growing trends and their projections. The increasing rate of urban population has been greater than that of the nation's total population since 1980s [15] [18].

Fig. 2 The three major rivers and the political boundary at county level in China, showing the three developed megalopolis areas in China, The study area, are located at the densely populated coastal areas where the rivers join the sea.

Space-borne remote sensing and geographic information systems (GIS) have combined to produce a virtual explosion of growth in ecological investigations and applications that are explicitly spatial and temporal [31]. Of all remotely sensed data, those acquired by Landsat sensors have played the most pivotal role in spatial and temporal scaling [31] [32]. Modern terrestrial ecology relies greatly on remote sensing for characterizing land use and land cover types/changes. Given the more than 30-year record of Landsat data, mapping land cover change is becoming commonplace [31] [33]. Numerous studies have used image data at 30-m spatial resolution to map and monitor land cover at landscape to regional scales [31] [33] [34] [35] [36] [37]. In China, scientists from the Chinese Academy of Sciences have recently developed a National Land Cover Dataset (NLCD) through visual interpretation and digitisation of Thematic Mapper (TM) images after their first large scale analysis of TM images for China in the early 1990s [36] [38] [39]. Most of the source TM images were acquired in three time periods, e.g.

1990, 1995/1996 and 1999/2000. In this study, the megalopolisation in China is reported - as a result from overwhelming effect of urbanisation characterized by the increases of urban and built-up areas estimated from the high resolution remote sensing of Landsat TM (Thematic Mapper) and Enhanced Thematic Mapper Plus (ETM+) imagery.

II. DATA AND METHODS

Remote sensing and GIS technologies are widely used in the studies of earth and environmental sciences in China (Chen et al., 2003; Xiao et al., 2003; Zhou et al., 2004, Liu et al., 2005). The Chinese Academy of Sciences is the nation's key research institution in applying remote sensing in land use/land cover change studies in China. In the late 1990s the Chinese Academy of Sciences organized eight of its research institutions and about 100 scientists to conduct its second national scale land cover and land use classification project, using more than 500 TM images primarily that cover most part of the country [14] [18] [38]. Datasets developed by the Chinese Academy of Sciences are used. The datasets were developed from Landsat TM/ETM+ scenes with a spatial resolution of 30 X 30m [40] [41]. The database includes time series data for three time periods: i) late 1980s, including Landsat TM scenes for 1987–1990; ii) mid 1990s, including Landsat TM scenes for 1995/1996; and iii) late 1990s, including Landsat ETM+ scenes for 1999/2000. For each time period, more than 500 scenes were used to cover the entire nation (514 TM scenes in late 1980s, 520 TM scenes in 1995/1996 and 512 ETM+ scenes in 1999/2000). The images were geo-referenced and ortho-rectified, using field-collected ground control points and high-resolution digital elevation models, and have an average geo-position error of 1.5 pixels, i.e. 45 m [14] [18] [38]. Visual interpretation and digitisation of TM/ETM+ images at a scale of 1:100,000 was conducted to generate thematic maps of land use and land cover.

A hierarchical classification system of 25 land-cover classes was applied to the data. The 25 classes of land cover were grouped further into 8 aggregated classes of land cover: paddy, dry land, forest, other woodlands, grasslands, water bodies, unused land and built-up areas including urban area and other industrial and transport infrastructure built-up area. Interpretation of TM/ETM+ images and validation of land cover classification were based on extensive field surveys. For example, more than about 8000 field photos were taken using cameras equipped with global positioning system receivers, across a transects of about 75,000 km in China. The validation results showed that the overall accuracy of the land cover classification approached 98.7% for the 1995/1996 National Land Cover Dataset (NLCD-1995). Liu et al [15] reported the Changes in land cover at national scale during 1990-2000 for China (Table1).

In the analysis presented here, the spatial distribution of the urban and built-up areas were extracted from NLCD-1990 and

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TABLE 1
CHANGES IN LAND USE IN CHINA DURING 1990-2000 DERIVED FROM LANDSAT TM DATA (UNIT: 1000 HA) [15]

Land Use Type	1990	2000	% of total land area for 2000	2000-1990	% Change
Paddy	35508.9	35650.2	3.8	141.3	0.40
Dryland	102643.4	105494.0	11.1	2850.6	2.78
Forest	138314.4	137595.5	14.5	-718.9	-0.52
Woodland	227827.8	226738.3	23.9	-1,089.5	-0.48
Grassland	306356.3	302919.5	31.9	-3,436.8	-1.12
Water body	32762.0	32922.0	3.5	160.0	0.48
Unused land	200501.9	200121.7	21.1	-380.2	-0.19
Built-up area	44670.6	46430.1	4.9	1759.5	3.94
(Urban)	(3322.2)	(4145.4)	(0.4)	(823.2)	(24.8)

the NLCD-2000 products. To quantify the increase of urban and built-up areas in China during 1990s, the vector Map of Land Cover in China (1:100,000) was converted into a 1-km gridded database that still captures all of the high-resolution land cover information by calculating percent fractional cover within 1-km grid cell [42] to account for the fraction of sub-pixel area for the fragmented ground features. The 1-km gridded cell data were further aggregated to 10 km dataset (using ESRI/ArcInfo's AGGREGATE command with the AGGREGATION-Type set to MEAN) to map the expansion of urban and built-up area across China from 1990 to 2000.

III. RESULTS

It is estimated that there was 44.67 million ha built-up land (including 3.32 million ha urban lands) distributed over 1,704 10-km grid cells in China in 1990 (Fig. 3(a), Table 1). In 2000, there was 46.43 million ha built-up area (including 4.15 million ha of urban area) in China, distributed over 5, 417 10-km grid cells (Fig. 3(b), Table 1). In this 10-year period in China, the built-up area grew by 1.76 million ha, of which 0.82 million ha was expansion of urban areas, an increase of 24.78% compared with 1990 at the national scale. The increase of the number of 10-km gridcell containing built-up land from 1,704 in 1990 to 5,417 in 2000 fits well with investigations by the State Statistical Bureau of China (SSB). That numbers of cities in China were reported increased from about 200 in 1980s to some 650 in 2000, and the number of towns skyscraped from 5,000 in 1980s to almost 20,000 in 2000 [18] [43] [44] [45]. This study suggests approximately 90% of those 1,704 10-km grid cells in 1990 have $\leq$ 15% built-up land fraction within the pixels (Fig. 4(a)). The cumulative frequency of pixels in 1990 map shows good correlation with the natural logarithm of built-up land fraction within the 10-km gridcell ($R^2 = 0.8811$) (Fig. 5(a)). The investigation for 2000 gives similar percentage, though the number of the 10-km grid cells containing built-up lands tripled (Fig. 4(b)). The cumulative frequency of pixels in the map of 2000 also shows good correlation with the natural logarithm of built-up land fraction within the gridcell ($R^2 = 0.8845$) (Fig. 5(b)). This perhaps suggests that when a number of grid cells with a built-up land fraction within them, say f_1, turn into higher-density urban area, the same number of grid cells, previously with lower urban density, grow into cells with an f_1 urban land fraction, or, when those least-urbanized grid cells with a built-up land fraction of f_2 ($f_1 > f_2$) turn to be further urbanized, the same numbers of non-urban cells ($f = 0$) change

to urban land with a same built-up land fraction of f_2. These situations could occur when cities sprawl, highways extend, or suburbanisation takes place.
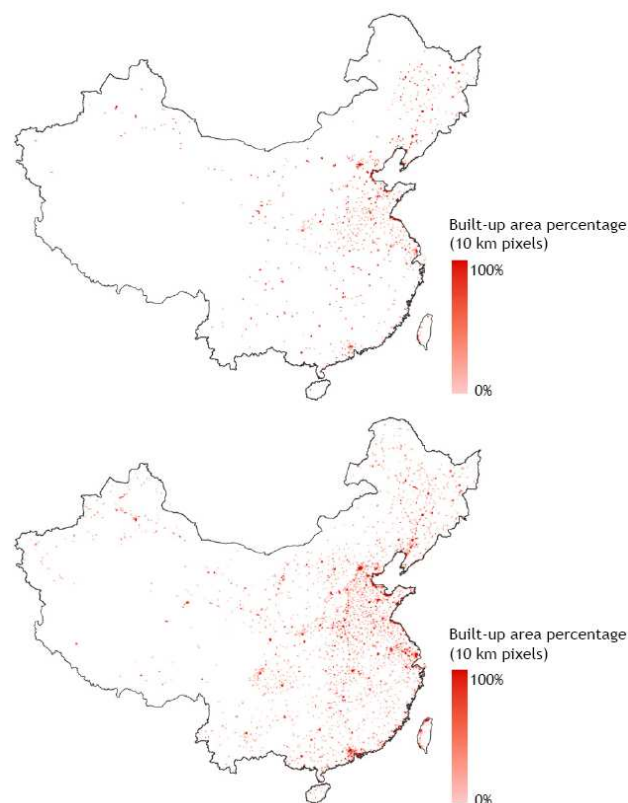

Fig. 3 A comparison of the spatial distribution of urban and built-up areas at 10-km resolution, showing the expansion of urban and built-up area in China from 1990-2000. (a) percent urban and built-up areas within a 10-km gridcell in 1990; (b) percent urban and built-up areas within a 10-km gridcell in 2000.

The rate of urbanisation differed among regions across China. The Yellow River Delta-Bohai Sea Ring (YRD) area, the Changjiang River Delta (CRD) area and the Pearl River Delta (PRD) area saw the most intensive urbanisation and infrastructure construction in the 1990s, sprawling from the three most important cities in the nation: Beijing (in YRD), the capital city of China, Shanghai (in CRD), the biggest city in China; and Guangzhou (in PRD), the one among the cities first practicing China's open-up policy, and perhaps the most rapidly developing city in the 1990s. There is an obvious crescent of urbanisation during the 1990s that runs from Guangzhou

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through Shanghai to Beijing. The explosive expansion of the major cities in these three regions and the communicating infrastructure construction among these cities within each region have made three megalopolises come into being: the Guangzhou-Shenzhen-Hong Kong-Macau megalopolis, the Shanghai-Suzhou-Nanjing-Hangzhou megalopolis, and the Beijing-Tianjing-Tangshan-Qinhuangdao megalopolis, which are located in the PRD, CRD, YRD, respectively (Fig. 1, Fig. 3).

YRD megalopolis had an initial urban /built-up area of 262,200 ha in 1990, much higher than 185,500 ha for CRD and 59,900 ha for PRD. In 2000, the megalopolis area of YRD is still the biggest one among the three (Table 2, Fig. 7). The size of the megalopolises decrease from the North to the South (YRD-CRD-PRD), however, the growing rate of urban/built-up area among the three megalopolis regions decreases from the South to North (PRD-CRD-YRD) (Table 2, Fig. 7).
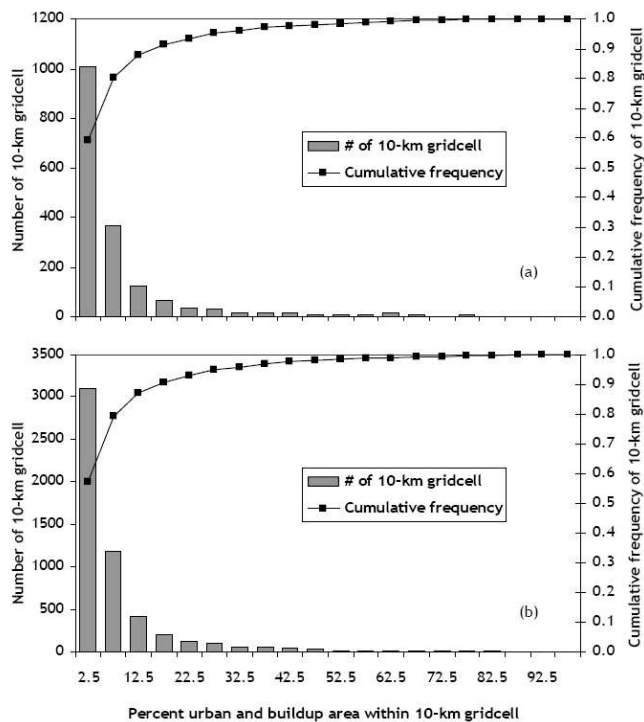

Fig. 4 Frequency distribution and cumulative frequency histograms of percent urban and built-up areas with a 10-km gridcell, which including only those grid cells that have a ≥ 0.01% urban and built-up land fraction within a 10-km cell. In the above graphs, the percent built-up area fraction within 10-km gridcell is in 5% bins from 0.01% to 100%, and the labels in the x-axis are the mid-point of the 5% bins. (a) 1990; (b) 2000.

Fig. 5 The correlation of percent urban/built-up area within 10-km gridcell and the cumulative frequency. (a) 1990; (b) 2000.

Since the urban and built-up lands are small patches in land cover maps at the national level, it is hard to tell how big changes have undergone from maps given by Fig. 3. Therefore the three megalopolis sections were cookie-cut from the national database for further spatial statistical analysis in the context of social-economic development and population growth and migration. First the three major megalopolis areas were mapped for the two time periods, 1990 and 2000, in greater detail so that a closer look at the urbanisation process in these three regions could be made (Fig. 6). It is clearly shown that in 1990 the urban/built-up lands in YRD, CRD and PRD are isolated, sparse and the color of most grid cells on the maps are light red, indicating lower built-up land fraction within the gridcell (Fig. 6 (a1), (b1), (c1)). In 2000, however, the cells are connected, densely distributed and the color of most grid cells on the maps turns to dark red, indicating higher urban/built-up land fraction within the gridcell (Fig. 6 (a2), (b2), (c2)). The
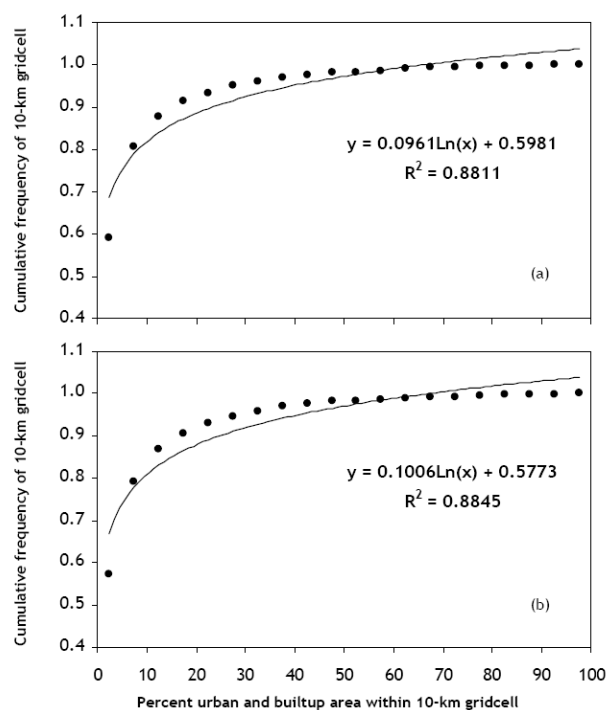
The YRD megalopolis area includes a city chain of Beijing-Tianjing-Tangshan-Qinhuangdao; the CRD megalopolis area includes a urban complex area of Shanghai-Suzhou-Nanjing-Hangzhou; the PRD megalopolis including a city chain of Guangzhou-Shenzhen-Hong Kong-Macau. The increase of the built-up lands was calculated for each time period (Table 2). It was worth noting that the increase rates of urban and built-up lands from 1990 to 2000, for YRD, CRD and PRD megalopolises, are much higher than the country's average level (Table 1, Table 2). The PRD megalopolis in Guangdong Province, which also includes Hong Kong and Macau Special Administration Regions (SAR), has the highest urban land increase rate, 83.0%, which is about 10% higher than the average of the three megalopolis areas. The increase rates for the other two megalopolises, YRD and CRD, are 63.8% and 69.9% respectively.

Megalopolisation, or urbanisation, is the result of human activities. The human beings have cut forests, plowed up grasslands, drained wetlands, built cities and constructed transportation infrastructures in pursuit of shelter and convenience of communication. Before 1970s, the rural people

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in China were restricted to stay at their local place by the *Hukou* system [18] [46]. However, since the implementation of the open-door policy in 1980s, China saw substantial inter-provincial migration in the past two decades [47]. The provinces and major cities the three megalopolis areas based were on the top of the migration share table (Table 3). Guangdong, where the PRD megalopolis area located, took up more than half of all the country's migrants that flew out of other provinces. The rest two biggest shares, 11.9% and 9.1% of the country's migrants flew into Shanghai and Beijing, the two biggest cities in China. These three megalopolis areas absorbed more than 70% percent of all the migrants in total.
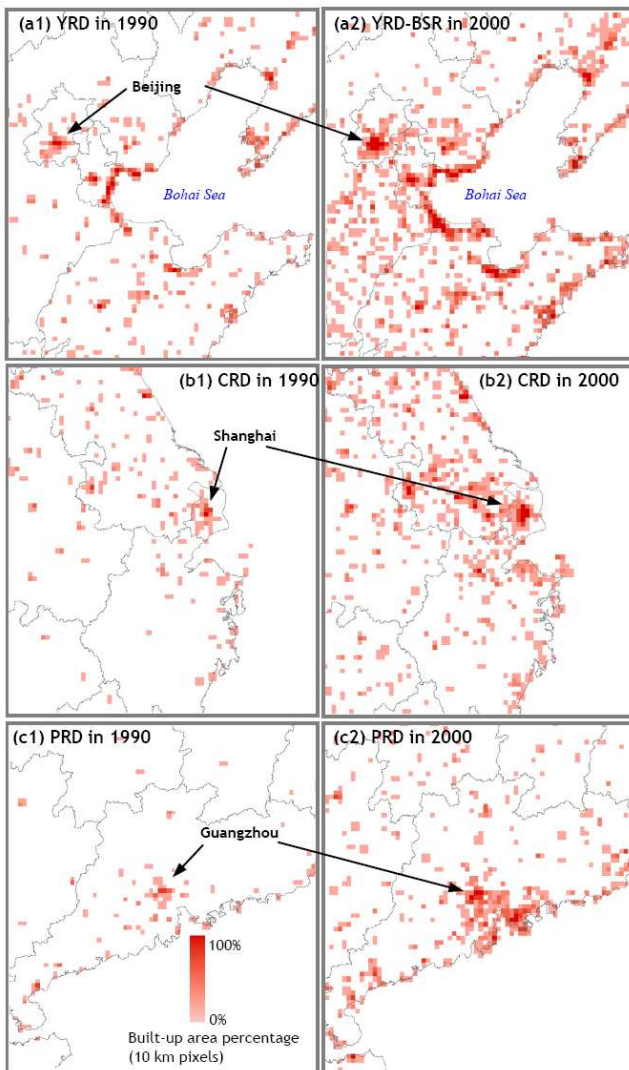

Fig. 6 The development of the three megalopolis areas in China in 1990-2000. (a1)-(a2): YRD-BSR megalopolis area; (b1)-(b2): CRD megalopolis area; (c1)-(c2): PRD megalopolis area.

The migration can be divided into four major components: rural to urban, urban to urban, rural to rural and urban to rural, which were respectively 49.0%, 33.7%, 13.4% and 3.9% of all the country's inter-provincial migration in the period 1985-1990 (Fig. 8(a)). However, in 1990-1995 the shares of its four

components were 36.0%, 35.5%, 23.8% and 4.8% respectively (Fig. 8(b)). Compared Fig. 8(a) to Fig. 8(b), it is observable that the share of rural to urban declined sharply from 49% to 36% from 13% to 24% from the late 1980s to the early 1990s, it was but still the biggest type of migration. The flow of rural people to urban area is a strong driving factor for urbanisation. Using the data in Table 2 and 3, the relationship between the increase
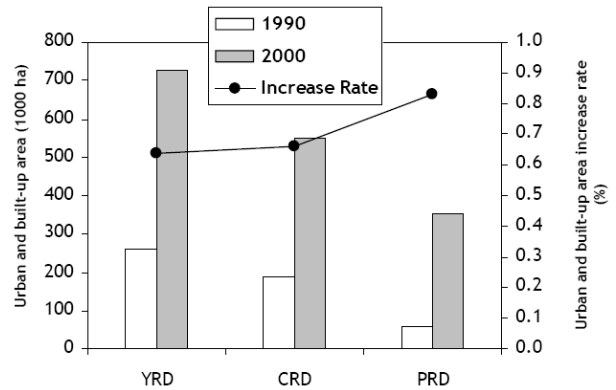

Fig. 7 The urban and built-up lands and their increase rate for YRD, CRD and PRD megalopolises from 1990-2000.

of built-up area and population expansion for the seven provinces (cities) in the three megalopolis areas were studied. The results show that there is a slight correlation effect ($R^2 = 0.5881$) between these two factors (Fig. 8). Their not-so-strong correlation perhaps results from the inconsistency of the time period when these data stand for: the migration share data were for the late 1980s to the early 1990s, while the land cover change data were for late 1980s to later 1990s.

TABLE II
NCREASE OF THE URBAN AND BUILT-UP LAND FOR THE THREE MEGALOPOLIS AREAS IN CHINA DURING 1980 -2000 (1000 HA)

Megalopolis region		Urban and builtup area (1000ha)		Change (%)
		1990	2000	
YRD	Beijing	41.3	114.2	63.8%
	Tianjin	84.2	88.6	5.0%
	Shandong	136.7	524.3	73.9%
	Subtotal	262.2	727.1	63.9%
CRD	Shanghai	26.1	86.8	69.9%
	Jiangsu	141.5	358.7	60.6%
	Zhejiang	17.9	103.9	82.8%
	Subtotal	185.5	549.4	66.2%
PRD	Guangdong	59.9	352.3	83.0%
	Subtotal	59.9	352.3	83.0%
	Average	-	-	71.1%

IV. DISCUSSION AND SUMMARY

In this study, the urban/built-up land cover data derived from multi-temporal Landsat TM/ETM+ imagery were used to detect large scale urbanisation or megalopolisation in China from 1990-2000. Three megalopolises were identified within the YRD, CRD and PRD areas. The scale and the magnitude of the megalopolises decreases from North China to South China

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TABLE III
PROVINCIAL SHARE IN INTER-PROVINCIAL MIGRATION TO URBAN AREAS [18]

Region	Share (%)*	Region	Share (%)*
Guangdong	51.8	Gansu	-0.3
Shanghai	11.9	Qinghai	-0.3
Beijing	9.1	Hebei	-0.7
Zhejiang	7.4	Hubei	-0.7
Xinjiang	5.7	Liaoning	-0.9
Jiangsu	4.3	Inner Mongolia	-1.8
Fujian	3.6	Shaanxi	-3.8
Tianjin	2.3	Jiangxi	-6.8
Shandong	1.1	Heilongjiang	-7.3
Shanxi	0.9	Hunan	-9.1
Hainan	0.6	Guizhou	-9.8
Ningxia	0.6	Guangxi	-10.7
Jilin	0.5	Henan	-14.0
Yunnan	0.2	Anhui	-14.7
Chongqing	0.0	Sichuan	-19.1
Tibet	0.0		
Total	100	Total	100

* Positive numbers imply net gains and indicate the percent share of the province in the total number of immigrants. Negative numbers imply net losses through inter-provincial migration and indicate the percentage share of the province in the total number of emigrants. For example, about 12% of all inter-provincial migrants go to Shanghai, whereas about 19% of all inter-provincial migrants stem from Sichuan Province.

indicating the initial urbanized size of the megalopolis plays an important role in the area's further megalopolisation. The increase rate of the built-up area differs among these three regions. PRD has the largest increase rate, then the CRD, and YRD has the smallest increase rate. This sequence is contrary to the order of the area of the newly-urbanized land for the three megalopolis areas.
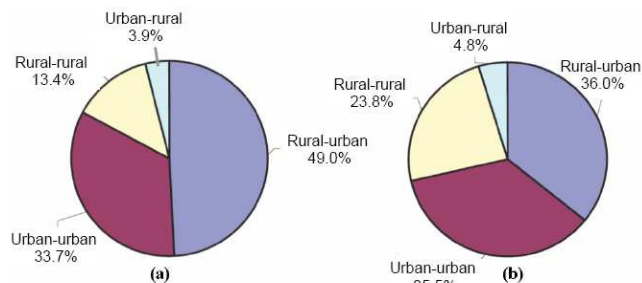

Fig. 8 Composition of different types of migrants in China (after Liu et al., 2003b) (a) 1985-1990;   (b) 1990-1995

Urbanisation and further megalopolisation are resulted from human activities. When the humans seek food, clothes and shelter from the land system, they begin shaping the land system. With the development of social economy and the building-up of transport infrastructure, the low-density settlements and urban development along transport corridors is causing megalopolis areas come into being. China only had 21,800 km of railway in 1949, but the length of railway in operation was 68,700km in 2000 [48]. At the same time, the length of highway that automobile could go through in 1949 was 80,700km, and it increased to 1.4 million km in 2000 [48]. The ease of transport and communication between cities and rural areas could be a strong context within which the urbanisation and megalopolisation set their background.
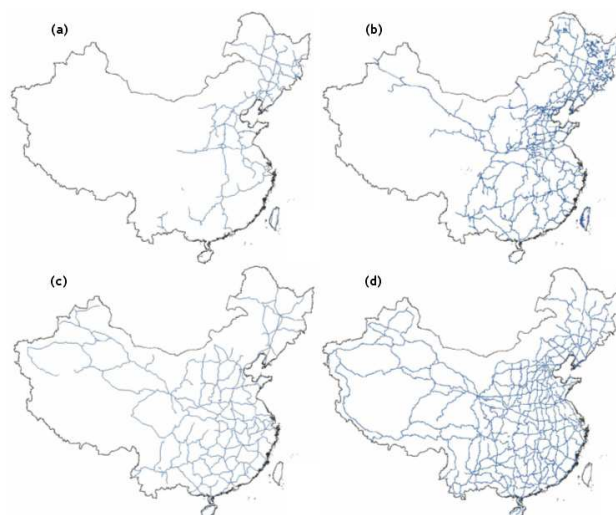

Fig. 9 The spatial distribution of railway and road in China [48]. (a) Railway in 1949; (b) Railway in 2000; (c) Highway in 1949; (d) Highway in 2000.

Convenience and efficiency in transport and communication also make it easy for the rural population to flow to big cities, which is another factor that helped in the development of the megalopolis areas in China. Since most of the highway and railway were built in East China (Fig. 9), the three megalopolis areas were first development in the coastline of East China Sea or the major river delta areas in China. At the same time, the employment structure in urban areas changed. In 1978, when China has not implemented the open-door policy, almost 100% of its rural labor force was restricted in farming, forestry, animal husbandry and fishery. Then, in 1980s and 1990s, with the Chinese central government brought forward the open-door policy, the employment structure in urban areas changed and the demand of persons working in the service, construction and industry field in most urban areas sharply increased from zero in 1978 to about 20% in 2000 (Fig. 10). These positions were mostly filled by migrants from rural area (Table 3 and Fig. 8).
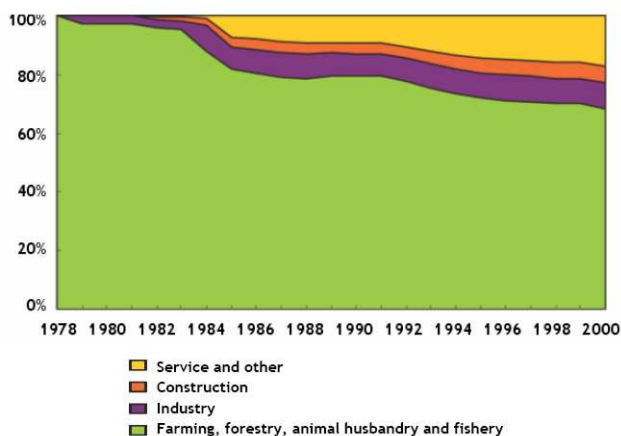

Fig. 10 Employment structure change of rural labor force in 1978-2000 in China [49]

Historical data about inter-provincial migrations indicate that on average 2.2 million people migrated across provincial

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boundaries between 1985 and 1990 annually whereas this Fig. amounts to 2.724 million per year for the period 1990 to 1999 [18].

Social-economic development, urbanisation, transport infrastructure construction and inter-provincial population flow were mutually enhanced to make megalopolisation inevitable in China since 1980s. China's expanding economy, which is the fastest growing in the world, along with continued population growth, will lead to continued urbanisation /megalopolisation and other land transformation in the next decades. Further efforts should be made to investigate the impact of urbanisation and megalopolisation on urban climate system, urban environment quality (air, water, soil, green space, etc.), green house gas emission and net primary production (NPP) in the context of global change, for the three river delta areas are not only economically important but also ecologically critical in China. For example, China has the longest and most intensified land use practice and land use change since ancient times. The three megalopolises were developed in the river delta area, which were the most traditional agricultural zones in China's history [7]. Recent land use/cover change studies have detected cropland conversions to urban land uses, increased grassland desertification and more [14] [15] [18]. The loss of agricultural land to urban land should jeopardize the food security in China [50] [51] [52 [53], because China homes 80% percent of its 1.3 billion people who work on and are fed by farms [16]. In Central and South China, many of the newly-urbanized areas come from paddy lands [14] [15]. The practice of paddy rice agriculture as a source of trace gas emission is widespread in South China, which is of significant concern to global climate change [54]. Many studies reported that large scale urbanisation had significant impacts on climate [22] [24] [25]. Therefore more researches on the dynamics of the urban areas and the urbanisation-induced land use change are needed to ensure the feasibility of effective polices and plans designed to sustain the urban and agriculture ecosystem, manage the cropland and the urban/rural interfaces, and provide services in these rapidly changing environments.

Since megalopolisation, or urbanisation, has often been viewed as a sign of the vitality of a regional economy [5], the polarized regional variations in urbanisation observed in this study are useful to guide future urban planning and environmental management in China. The study suggests that eastern China has been experiencing intensified urbanisation for decades, while the western China shows little increase in urban area during 1990-2000. The lop-sided urbanisation in East China relative to West China should draw the attention of the government and warn the policy-makers in regional planning. Fortunately, many Chinese, including its leaders, are aware of these problems and have tried to tackle them. One example is the implementation of China's Western Development Program by the Chinese central government (http://www.usembassy-china.org.cn/sandt/db-westdev.htm), which is hoped to make China's terrestrial ecosystem both economically and ecologically balanced. Therefore, to achieve both socioeconomic and environmental sustainability, timely and accurate geospatial datasets of urban land and other land use types for China, coupled with corresponding social-economic data, climate data, and ecosystem modelling, are critically needed for quantifying the spatial pattern and temporal dynamics of the urban environment and assessing their impacts on climate in China and East Asia.

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