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Urban land administration and planning in China: Opportunities and constraints of spatial data models

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Abstract

China's economic reforms over the past decades have given rise to the development of a rudimentary urban land market. Although one cannot speak of a land "market" in the strict sense of the word, there is an urban land allocation system in which land lease rights can be acquired through the payment of a land-use fee. If the urban land market is to develop in a sustainable manner, new credible institutions need to be established that can safeguard greater legal security and transparency. For these purposes, it is necessary to establish a management system that can support the legal (tenure security), economic (leases, taxes) and broader aspects (spatial and environmental land use policies) of land administration. To make an urban land administration system socially credible and functional, land-related information should be registered and structured at a detailed spatial level, such as parcels. There is no parcel-based information system in China, but the country has developed a population registration system at a detailed spatial level that could be a starting point to develop integrated information systems, or a so-called "local spatial data infrastructure". This paper reviews China's population registration system and their spatial units and presents a proposal for an information system that can be expanded or adapted to meet the requirements of an effective land administration system.

Keywords: Urban spatial data models; Spatial planning; Land administration; Wuhan; China

Introduction

In the last century, two great events brought major changes to China in terms of land property reform. The first was when the Chinese Communist Party came to power and the People's Republic of China was established in 1949. In the wake of the Communist take-over, all land resources were nationalized, while in later years rural land was allocated to the People's Communes (see also the contribution by Ho in this special issue). The second major event was when China initiated its economic reforms and embarked on an "Open Door" policy in 1978. Although no changes in land ownership occurred, the "Open Door" policy led to a profound change in land tenure, as rural land use rights were decentralized to the individual farm households through land leases. Initially, lease was only allowed for 5 years. Yet, in later years as the economic reforms deepened in the 1990s, the lease term was extended to 30 years.

The economic reforms also entailed a steady rise in the rate of urbanization. Over a period of 34 years from 1949 to 1983, China's level of urbanization (the ratio of non-agricultural population to the total population) rose from a mere 11–22%. Yet, in the 17 years after that, urbanization reached 36% in 2000 (China Statistic Bureau, 2001). Some scholars deem China "under-urbanized" in light of its relatively high level of industrialization in comparison with

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its low urbanization rate. It is expected that the urbanization level will reach 40% in 2015 and 50% in 2030, while the urban population is expected to expand from 410 million in 2000 to 577 million in 2015 (UNCHS, 2001).

Urban reform in China is a comprehensive process involving transformations in the operation and administration of urban enterprises, rural-urban migration, land-use changes and urban planning (Gu and Shen, 2003). The spatial transformation of urban areas has been fuelled by the development of urban real estate which generates substantial amounts of direct and long-term revenues for selected interest groups, i.e. local governments and urban entrepreneurs (Ma, 2004).The urban land reform has resulted in possibilities to obtain land use rights through lease. Public land lease has been legalized and urban land can now be leased for up to 50 years to developers or users after a payment to the state. Land leaseholds can be acquired through tender, auction or negotiation. The new institution of land lease has been established to meet the demands of the emerging market economy (Zhu, 2004). During the socialist period, the geographical location of parcels was largely irrelevant as land markets were non-existent. However, with the emergence of a land rent gradient increasingly similar to that of Western cities, the assessment of the exact geographic location of real estate parcels has become critical (Ma, 2004).

Another important development over the past years, is the commodification of housing. In the past, the work unit (in Chinese: *danwei*) was responsible for all aspects of Chinese citizens' life, ranging from marriage and health care, to the provision of housing. Houses were provided to employers on the basis of marital status, age, and work experience. However, the recent housing reforms have caused the emergence of a real estate market. Work units have started to sell off their houses to employees (against subsidized prices), whereas many work units no longer provide housing, and employees have to find a house at the market by themselves. As a result, new housing is built with domestic and foreign capital, leading to a wide variety of residential spaces for citizens to choose from. It is critical to note that the housing reforms have a spatial dimension as well. Restructured commercial housing is replacing the cellular-type of socialist housing structures concentrated around work-units. Instead, the housing reform policy has broken up what may be termed a typical "socialist pattern" of land use structured around work units, particularly around urban industries (Ma, 2004).

The new land and housing markets that have resulted from the transition from a centrally planned economy to the "socialist market economy" (as so aptly coined in China), made Chinese urban planners face great challenges. For one thing, it has become vital to modify the urban planning system to accommodate rapid urban population growth (Yeh and Wu, 1999). In urban redevelopment areas, original economic activities and inhabitants are pressured into relocation, while many newcomers (migrants and the so-called "floating population"—largely rural, seasonal workers) are settling in the inner-city. This has resulted in high population densities with corresponding problems, such as infrastructure deficiencies and traffic congestion. On top of this, the urban expansion is largely occurring at the expense of valuable farmland around the cities (Lin and Ho, 2003), resulting in forced land evictions and widespread social conflict (Zweig, 2003). Urban planning departments can hardly cope with these problems due to a lack of experience with this new socio-economic environment. It is obvious that spatial planning in Chinese cities lags behind the current speed of urban construction.

Today China lacks a proactive and transparent planning with a clear, future vision that could turn the cities into aesthetically appealing, environmentally sound, economically dynamic and socially equal urban centres (Ma, 2004). The past situation of blue print planning in which the government was the sole actor in urban development is rapidly changing with a great variety of private developers and uncontrolled population movements. Physical and socio-economic analysis of cities was hardly included in previous master and structural plans, while architects and infrastructure engineers were the main professionals in urban planning. The current situation requires a fundamental institutional restructuring of the urban planning bureaux to be able to use process-planning or strategic planning concepts based on up-to-date and reliable integrated information.

Land administration departments, which in most Chinese cities fall under the same jurisdiction as the urban planning departments, have been established to handle the land lease contracts. The urban planning and land administrations bureaux are gradually developing information systems to manage land related information on land tenure, value and use. The spatial information based on the current earth-observation techniques are, with the launching of high-resolution satellites, increasingly relevant for urban data collection. At the same time, however, it is still inadequate to support the land administration and planning at detailed spatial levels (Huang and Clark, 2002; Leaf, 1995).

Land administration has been extensively studied under market economy conditions (Bogaerts et al., 2002; Steudler, 2004) (Williamson, 2001). However, land administration is still a relatively novel concept in transitional China (Qu et al., 1995), particularly from the perspective of information systems. Some of the drawbacks are that spatial and attribute data for planning and land administration exist but are inaccessible (scattered and isolated in the different departments and bureaux); are incompatible with each other; or exist only partly in digital format, while a common *spatial model* with a corresponding coding system is lacking.

This paper reviews spatial data based information systems for urban land registration in order to stimulate urban institutional change and improve land management in Chinese cities. We will do so through the case-study of Wuhan City in Hubei Province. The paper is organized as follows: after a short introduction to Wuhan city, we will describe the basic parameters for the information system required for effective and efficient spatial planning and land administration. Wuhan City is a good example of the fast changes and recent trends in China's marketization of land and real estate. In addition, the urban boom of Wuhan also provides a clear illustration of the problems for spatial planning with which Chinese urban planners are confronted today. In the following section, China's spatial data models, prior to and after the policy reforms of 1987, will be presented. Through a comparison of the two models, the impact of market forces on spatial data systems will be assessed. In the final section, we will discuss some policy implications of these models for urban spatial planning and land administration.

Wuhan city: an urban hub along the Yangtze river

Wuhan, the capital of Hubei Province, is located in central China and on the middle reaches of the Yangtze River, the third largest river in the world. As the Yangtze River and the Beijing–Guangzhou railway line intersect here, Wuhan is a critical node in water, railway and other traffic in China (Fig. 1).

In 1980, Wuhan was formally opened up for foreign visitors, and 4 years later, it was selected by the central government as one of the first cities to experiment with economic reforms. Since 1990 Wuhan is allowed to implement land use right transfers as part of the land reform policy. The selection of Wuhan was based on Deng Xiaoping's policy of the "Three Alongs" that included the development of economic hubs along: (i) the border, (ii) the coast, and (iii) the Yangtze River. The economic reforms stimulated new developments, and infrastructure projects, which soon became focal points of domestic and foreign direct investments (Han and Wu, 2004). Real estate has been a booming sector ever since. In 1997 residential sites of 5 ha or larger amounted to 120, with a total area under construction of 1817 ha (WBRS, 1998).

During the last 50 years, Wuhan underwent tremendous urban growth from 3000 ha of built-up area in 1949—27,515 ha in 2000. In 1993, 25.8% of the built-up area of Wuhan consisted of residential areas and 25.9% of industrial land (Cheng, 2003). Gross population densities have been decreasing from 181 persons/ha in 1993 to 162 persons/ha in 2000, showing that the built-up areas actually expand faster (4% per annum) in comparison to the population increase (2.1% per annum). In fact, it is assumed that a combination of fast non-residential development and lower densities (larger floor space per person) in residential areas explain Wuhan's reduced population densities over the past years.

Fig. 2 shows the comparisons between urban growth and the urban master plans of 1954 and 1988. The spatial match between urban growth and master plan is 17% for the period 1986–2000 and 24% for the period 1955–1965. The difference suggests that master planning under a market economy (1988–2000) exerted less control over urban expansion.

Information requirements and data availability

Land and housing reforms have brought about major changes in urban development, which in turn, resulted in changing land use patterns. As Ding notes, before 1987, "the land allocation system produced enormous land-use deficiencies, which was manifested in low and flat land density curves, the disconnection of land use and transportation, and the presence of warehouses in central locations" (Ding, 2003). Due to the reform process, a massive restructuring of Chinese cities has taken place and industries located in inner cities have closed down or are being relocated to the urban fringe. A typical example that shows the land use changes, before and after the land reform, can be identified from Fig. 3, where the aerial photograph of 1965 and the IKONOS image of 2000 are illustrated for the Baoqing sub-district (also in Fig. 7) of Wuhan. From the photos we can clearly see how present-day Wuhan has evolved into a major urban hub, with a complicated infrastructure and spatial lay-out. The processes of urban change require the registration of land use

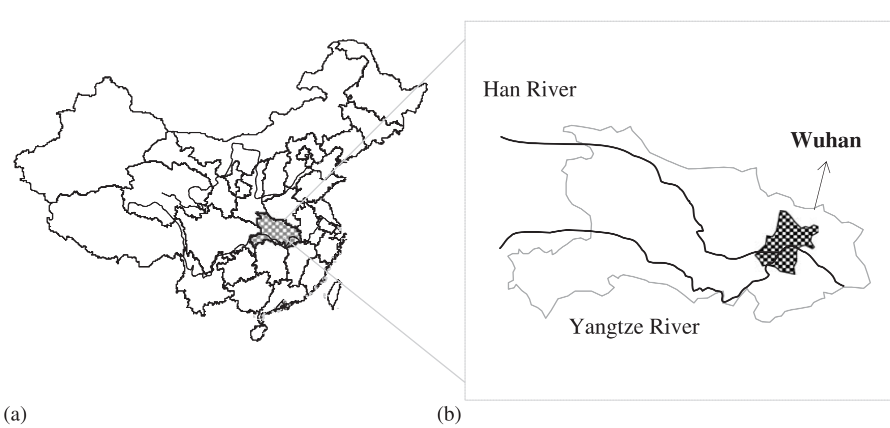


Fig. 1. Location of Wuhan city: (a) Hubei in China; (b) Wuhan in Hubei.

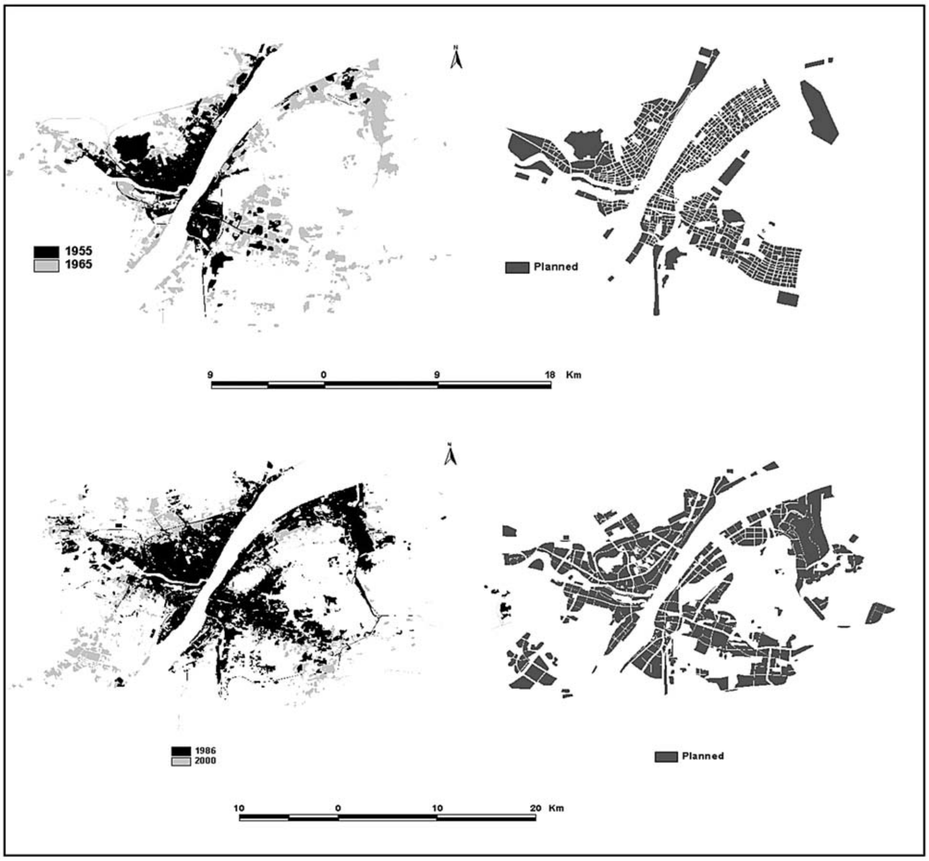


Fig. 2. Comparison between urban growth and master plan. (1) Urban growth 1955–1965 and master plan of 1954 with the planned built-up areas for 1965; (2) urban growth 1986–2000 and master plan of 1988 with the planned built-up areas for 2000.

rights, valuation of land and land use control, and improved spatial planning.

Environmental, social and economic aspects of urban development are in a process of flux, while being closely interrelated. It is up to urban planning to co-ordinate the often conflicting claims on land for optimal decision-making. Spatial planning requires a substantive amount of environmental, socio-economic and demographic data from a wide variety of sources. To be able to analyse, model and evaluate urban development, these data need to be integrated in such a manner that data can be used at different spatial, and temporal scales. Inadequate access to (spatial) data can result in limited understanding of the driving forces and the actors that shape urban development. The quantity and quality of information makes all the difference between poor and good management (Turkstra et al., 2003).

Required spatial data include topographical maps, various thematic maps, as well as maps denoting administrative boundaries. Standard map scales for urban areas are 1:25,000; 1:10,000 and the largest scale commonly developed by municipal survey institutes in China is at a 1:2000 scale. At this scale, standard topographical features, buildings (or groups of small constructions) are delineated. Topographical maps also contain contour lines that can be used to develop elevation models. Large-scale topographical maps are also the basis to delineate parcel boundaries and create cadastral maps.

In China, land use classification has gone through a number of modifications to adapt to the recent changes in economic activities. Taking the past master plans of Wuhan City (WBUPLA, 1995) as an example, we see that urban land use in 1954 was classified into areas for industries, warehouses, residences, hospitals, and schools, and green zones. In 1982 the classification was modified to include universities, while in 1988 the category "commerce and trade" was added. In 1996 the classification was extended again to include low-density residential, mixed commercial and residential areas, as well as zones for banking and trade, offices, education and research, culture, external transportation, railways, and infrastructure. These modifications indicate a shift in urban development from industry-oriented to service-oriented, as more detailed sub-classes related to the tertiary section are included in the new scheme. These changes require a substantially higher resolution and more detailed information on urban land uses.

A city is the integration of space with human activities, which involve infinite interactions between physical objects and individuals. These interactions result in the requirements of multitudinous networks to cater for the functioning of urban management systems, such as transport,

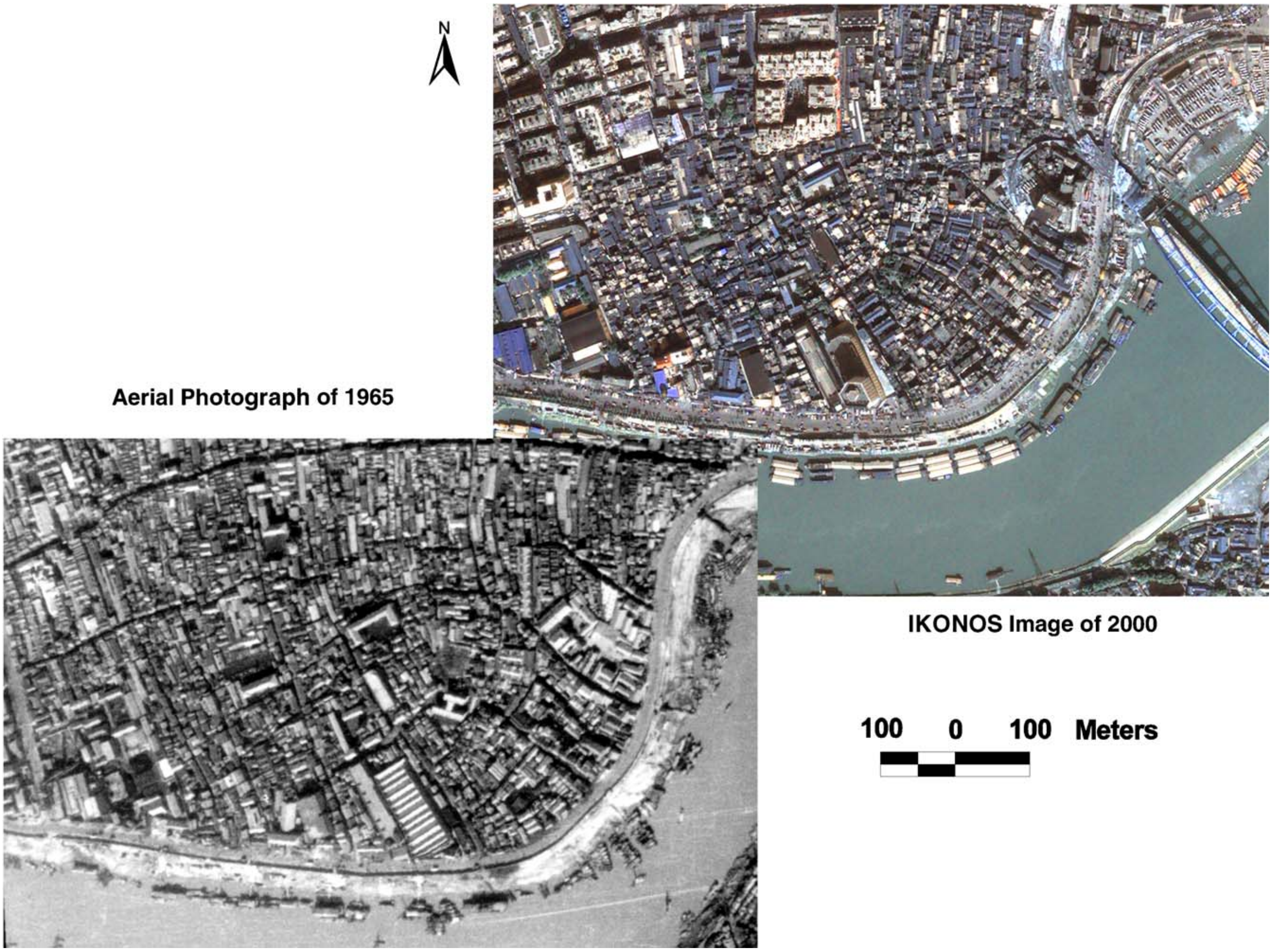


Fig. 3. Examples of IKONOS image and aerial photograph of Wuhan.

water, and electricity. Urban development, accompanied by the growth of population, frequently leads to overloaded infrastructure systems such as an insufficient supply of water and congested transportation. The main information requirement for infrastructure includes: location of the existing networks, the capacity and quality of the networks, e.g., water supply, sewerage and drainage channels, and electricity and telecommunication systems. For example, improvement of the living environment consists not only of housing conditions but also of the accessibility to social facilities such as schools, health care, cultural and recreation facilities and welfare centres. The service level, radius, and spatial distribution of infrastructure facilities are basic data for spatial planning.

Most local statistical data are spatially referenced and related to the different areas of a municipality. These areas such as neighbourhoods, districts, and postcode zones can vary among organizations. Census areas, such as in China, can be rather different from municipally defined neighbourhoods or postcode zones. The smallest spatial unit is a parcel. Yet, the integration of parcels into neighbourhoods can be difficult due to incompatible coding systems for defining spatial boundaries.

Attribute data should include land tenure and land value data, building characteristics, and demographic data. This implies that information on land ownership, lease terms and the value of land should be registered at the parcel level. While the government in China remains the owner of urban land, urban land use rights can be generally freely transferred (Ho, 2001). China is in the process of developing reference land values, but these values are gross estimates rather than market values. They thus need further refinement to avoid that land leases are too far removed from actual market prices. Promoting a land and real estate market requires security, transparency, and reliable data sets and procedures supported by effective and efficient institutions. Although one always needs to consider current local socio-economic conditions, we think it is inevitable that China develops a land registration and cadastral system.

For an effective urban management system, it is critical to view human activities (e.g. employment, living, recreation and communication between these basic activities) in relation to the city's features and changes. Adequate information for this includes the number of inhabitants and households, age structure, educational background,

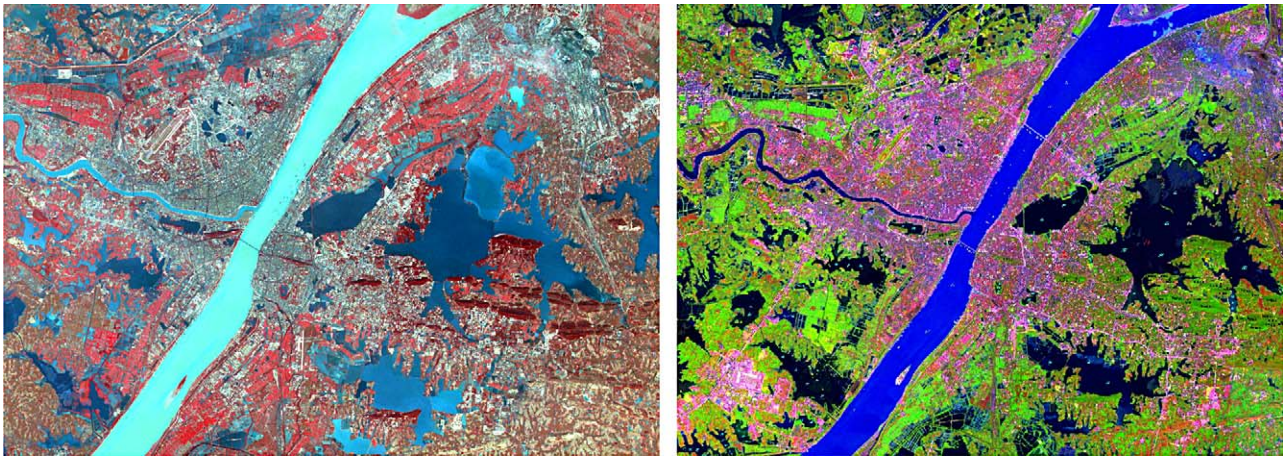


Fig. 4. Examples of SPOT and IRS images of Wuhan (a, in 1986; b, in 1997).

income, types of household, temporal or permanent registration, employment structure, and work travel modes and frequency. These basic demographic data sets, in combination with other spatial and attribute data, are needed to derive important indicators such as population density and living floor area per capita.

Attribute data are linked to administrative or physical units such as buildings, parcels, and neighbourhoods. Classical examples are census and cadastral data. A comprehensive analysis of the physical, social and environmental parameters for urban planning purposes is dependent on the efficient integration of physical and socio-economic variables. Only then one is able to calculate critical urban indicators such as net population density, living space per capita and land use efficiency. These indicators form the basis to model, predict and evaluate urban development in the service of decision-making for spatial planning. The information mentioned above is based on different spatial units. An appropriate spatial data model needs to be designed (and accepted and implemented) to spatially aggregate and disaggregate the different data sources (Figs. 3 and 4).[1]

Due to the advances in remote sensing and GPS (Global Positioning Systems), visible data (such as land cover and to a certain extent land use) are easier to obtain than demographic and socio-economic data. Numerous studies and applications have proven that remote sensing and GPS are effective tools for obtaining and updating spatial data at a low cost and in a short period. Conversely, the collection of socio-economic data is time consuming and labour costing. However sustainable development and a participatory human-centred planning approach requires the analysis and evaluation of the social, economic and environmental effects of planning scenarios which makes the topic ''local spatial data infrastructure for spatial planning and land administration'' particularly urgent when land and housing markets are dynamic, as in the Chinese context.

Shifts in spatial data models

It is no overstatement to say that urban development in China is an extremely complicated process that involves interrelated spatial and temporal trends, complex socio-economic patterns, and multiple decision makers. The understanding of urban processes is partly a data-driven process (Cheng and Masser, 2004). However, no single data collection method can yield sufficient information to meet all requirements of understanding the process, and there is also a need to integrate data from different sources.

The division of a city into smaller units is important for many planning activities. In a well-designed information system it should be possible to combine the ''*general purpose geographic units*'' such as administrative districts and census zones and thematic maps with spatially contiguous clusters of, e.g. similar land uses. Successful GIS analysis depends on the possibility to integrate secondary data sets from a variety of agencies, using these spatial units with the possibility to combine these with specific, primary data sets (Turkstra et al., 2003).

[1]With the fast progress of modern remote sensing, some physical data such as urban land cover (Masser, 2001), road infrastructure (Hinz and Baumgartner, 2003) and other important environmental data, are becoming less expensive and more available at various scales. With sensors such as the SPOT panchromatic system (10 m resolution) and the Indian IRS (5.8 m resolution) (see Fig. 4), mapping was already possible at the 1:50,000–1:25,000 scales (Masser, 2001). The IKONOS (Fig. 3) satellite provides 1 m resolution images, which makes mapping at the 1:10,000 scale feasible and other high-resolution sensors such as Quick Bird and SPOT 5 which are operational increases the availability at lower costs of such data sources. Based on SPOT images (1986 and 2000) and aerial photographs (1955 and 1965) (e.g. Figs. 3 and 4), the spatial and temporal patterns of Wuhan urban growth from 1955 to 2000 were mapped and can be visualized in animation by local planners (Cheng, 2003; Cheng and Masser, 2003). Further, the determinants to the patterns can be modelled to help the understanding of urban development process and the impacts of land administration (Cheng, 2003; Cheng and Masser, 2003, 2004).

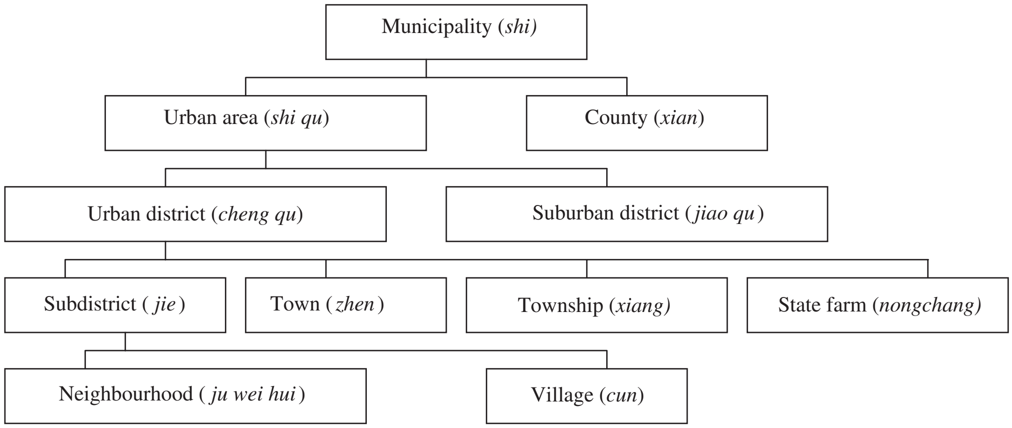


Fig. 5. Administrative structure of Wuhan Municipality.

From an institutional point of view, the need for data integration stems from the need for data sharing among institutions (Huang, 2003). Data integration tasks involve five types of operation, i.e. data standardising, interfacing and interoperability, spatial and temporal referencing, aggregating and disaggregating, as well as data warehousing. When focusing on land administration and spatial planning, spatial statistical units[2] and spatial data models are the key parts for data integration. At the same time, however, it should be noted that in the Chinese context inter-institutional coordination and data sharing is difficult. Even if data are available, inter-departmental strife and conflicting interests frequently inhibits effective information exchange.

At the heart of any GIS system is its data model, a computer-based structure that models real-world objects, such as facilities, resources, assets, conditions and events. The importance of establishing, and maintaining a basic spatial unit for analytical purposes has been well recognized in Western countries. A simple data model should be a balance between specific individual departmental interests, and the corporate view of the potential users of the system. Many systems start by being "producer-driven", like the national bureau of statistics and cadastre, that are indeed the guardians of *gold-mines of data.* An effective spatial data model should allow:

- *Vertical relationships*: from large-scale detailed level (e.g. parcel) to more general level (neighbourhoods, districts). In China a reasonably well-functioning model is the population census data with a coding system that allows the aggregation from household level along the administrative structure (neighbourhoods, sub-districts, districts, municipalities, provinces, and nation).
- *Horizontal relationships between data sets*: at the local level each specific data producer (e.g. land administration, land use, natural hazards, infrastructure, and population) should not only use its own data but also allow the exchange of data to other users. This requires data compatibility and thus standards or agreements on a similar co-ordinate system (topographical base maps) and a coding system (e.g. a unique identifier) to be able to merge databases and link attribute data to maps.

In the following section, we will describe the spatial data infrastructure before and after the land and housing market reforms in Chinese cities, using Wuhan City by way of illustration. By comparing the two periods, we are able to identify the current problems in spatial planning policies and propose strategies for a new spatial data infrastructure.

Spatial data models before the 1980s land reform

Between 1949 and the start of the post-socialist land reforms in the mid-1980s, spatial data models were dominated by population registration and spatial planning, as land administration was not needed in the absence of a land market. The administrative units in Chinese cities are stratified as, respectively, the municipality, district, sub-district and neighbourhood (or residential committee). Their administrative relationships are represented in Fig. 5.

Note that the urban area (*shi qu*) is not a real administrative unit, but is used for the divide between the urban and rural population. The urban district is divided into two levels: the sub-district and neighbourhood, which are administratively organized by, respectively, the street committee (*jie wei hui*) and residential committee (*ju wei hui*). The town is a settlement consisting of a state-defined

[2]For example, in the USA the hierarchy of statistical units is: census blocks, block groups, tracts, city boundaries, and county boundaries. Various socio-economic data such as employment, tax and population are spatially organized into a standard data format, based on these units. The TIGER format is supported by GIS software packages and is freely available (Census TIGER Data published on ArcData online at http://www.esri.com/). In the Netherlands similar units are used such as the neighbourhoods/districts and municipal boundaries for statistical data while also the postcode system are of increasing importance especially for geo-marketing.

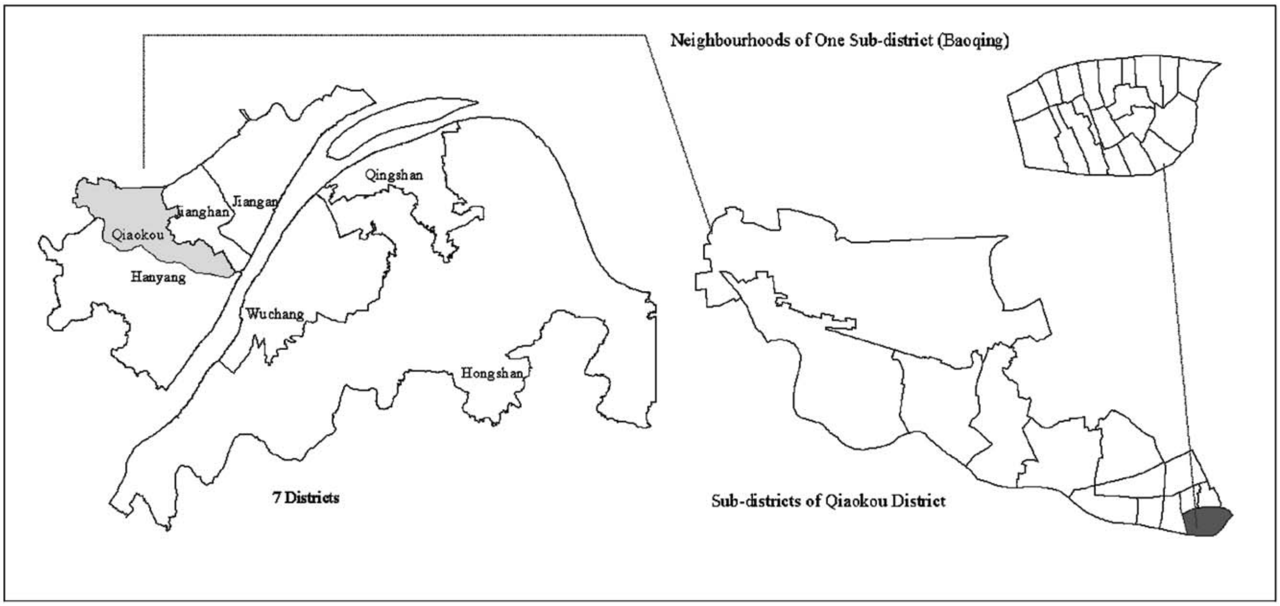


Fig. 6. Spatial administration units of Wuhan City.

minimum in terms of non-agricultural population, employment and industrial output values. A township is a smaller settlement with fewer urban components than a town. When a township develops up to a certain level, it can be approved and upgraded to a town. The criteria for doing so are subject to changes in relation to urbanization. A state farm (or *nongchang*) is an atypical unit that originated from the large-scale agricultural production in the period of the Great Leap Forward (1958–1960).

Based on the situation in 1993, Fig. 6 shows the location of the seven urban districts and the sub-districts of one urban district (Qiaokou) in Wuhan and the neighbourhoods in one sub-district (Baoqing). In 1993, Wuhan had approximately 80 street committees and 1500 resident committees accounting for about 3 million urban residents, while another 4 million people were living in the villages and townships of the three counties around the city. The administrative units also acted as the spatial statistical units, before the land reforms were initiated (Cheng and Turkstra, 1997). This spatial structure (Figs. 5 and 6) offers a hierarchical data framework for the registration of social and economic information.

The registration of socio-economic data is divided into two types: a census survey to be conducted every 10 years (e.g. 1954, 1963, 1982, and 1990) and an annual statistical report based on a 1% sample. The neighbourhood is the basic unit for the registration of the population census, while data is collected at the household and household member (individual) level. The local bureau of statistics develops the population census database. The data are aggregated and submitted to the sub-district level. By contrast, the population yearbook, which is published once a year, is only done at the district level.

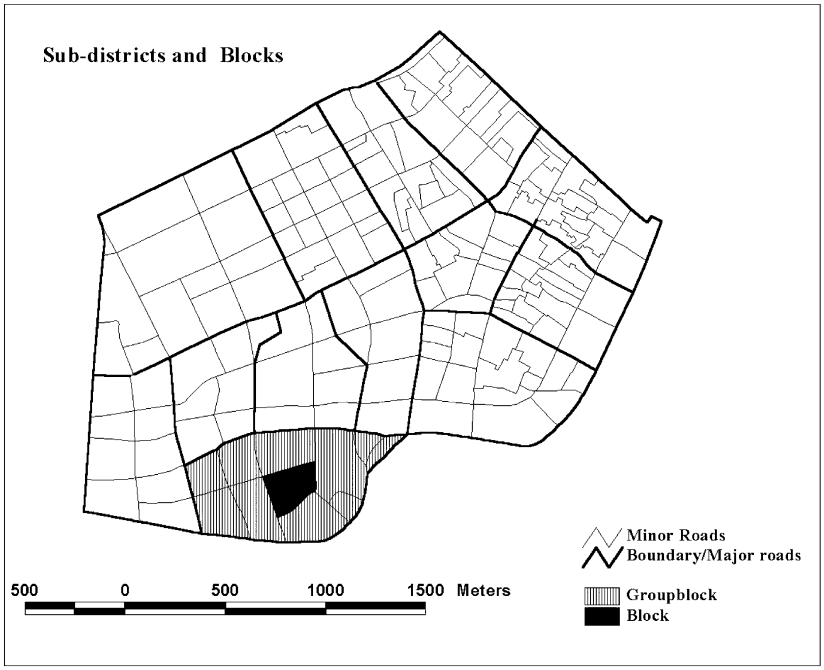
As a result, the district, sub-district, and neighbourhood are the major spatial units for data integration. A 1:m (one to many) relationship[3] between these three units provides a simple spatial framework for data aggregation and disaggregation. For example, census data can be aggregated from neighbourhood to the sub-district, and then further to the district level. As shown in Fig. 6, the district Qiaokou comprises of 13 sub-districts and one township. Their size varies with the distance to the city centre: the maximum is 1723 ha (a township) and the smallest is 25 ha (a neighbourhood). The Baoqing sub-district includes 20 neighbourhoods with varying size, due to the spatial heterogeneity of social and economic activities. These neighbourhood units are still not detailed enough in spatial resolution to support spatial planning from the perspective of integration with land administration data. It is for these reasons that we want to introduce a new spatial unit labelled the "block".

In Fig. 7, the block is only a spatial entity enclosed by roads, not an administrative unit for data registration in Chinese cities, but it could play an important role to support spatial planning with sufficiently high resolution. The block size depends on the level of roads. For example, in Qiaokou district, four main roads surround 13 sub-districts. Main or secondary roads encompass each sub-district; therefore, a sub-district can be spatially regarded as a large block (or group block). Inside each sub-district, secondary and tertiary roads define many blocks.

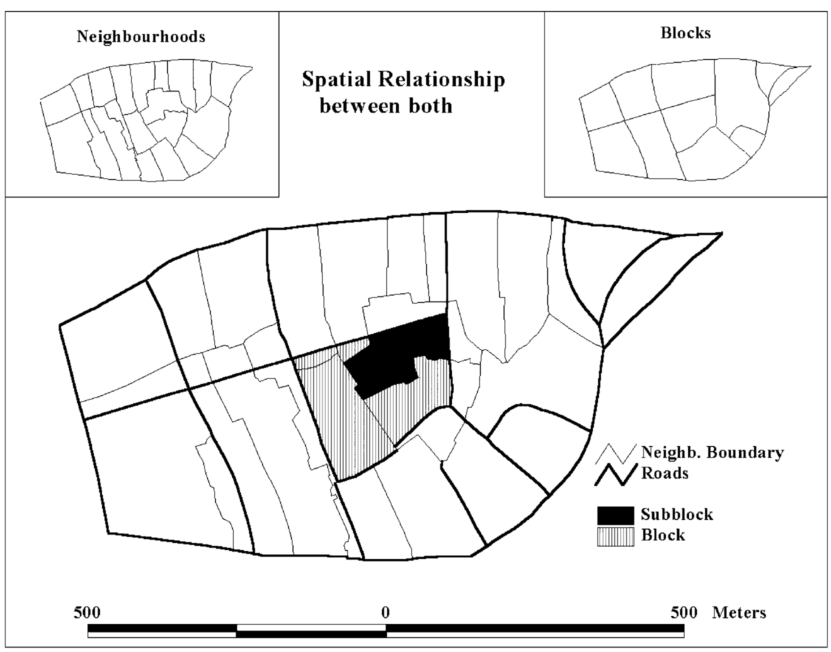
However, based on the existing neighbourhood unit, socio-economic data cannot be aggregated/dis-aggregated to the block level, as a multiple-to-multiple relationship exists between the neighbourhood and the block[4]. For this

[3]One district contains various sub-districts, while one sub-district in turn includes various neighbourhoods.

[4]The boundaries of a block can overlap with the boundaries of a neighbourhood, in other words a block can "belong" with several neighbourhoods while also a neighbourhood can be covered by several blocks.



(a)



(b)

Fig. 7. Illustration of the relationship between sub-district (or group block), neighbourhood, block and sub-block. (a) Sub-districts and blocks; (b) Block, neighbourhood and sub-block.

reason, we need an artificial middle sub-unit: the sub-block, which is at the intersection between the neighbourhood and the block (see Fig. 7). Through simple spatial disaggregation and aggregation operations in GIS, we are able to integrate social and economic information from neighbourhood to block unit. Then, an entity-relationship model can exist as shown in Fig. 8 with an emphasis on the block unit for spatial planning.

Spatial models after land reform

The introduction of land and housing markets makes it necessary to develop a registration system similar to cadastral systems in Western countries in which parcel-based systems have data on ownership, physical and property value data. Parcels in China might be large areas of land (industrial complexes, universities) on which many

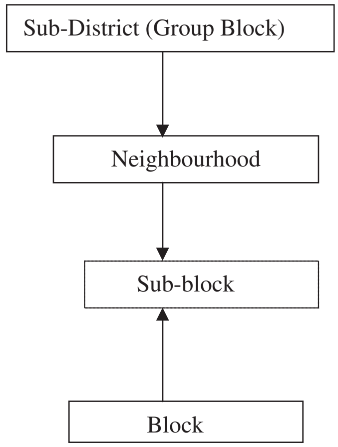


Fig. 8. An entity-relationship model for spatial planning.

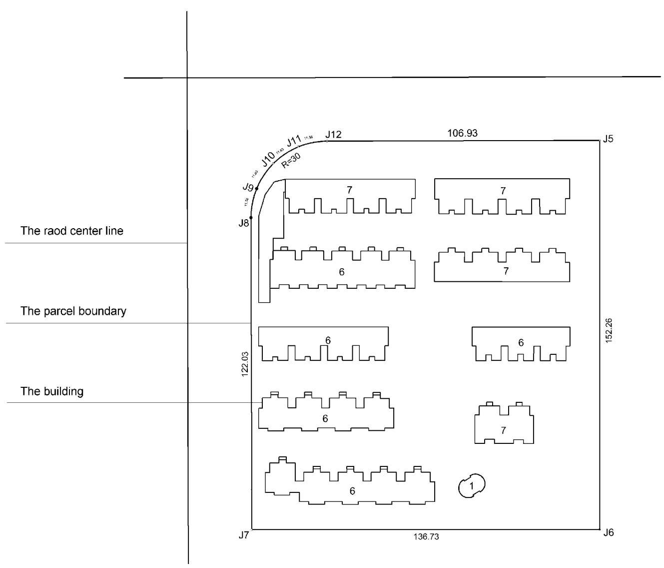


Fig. 9. Illustration of parcel and building boundary on a cadastral map of Wuhan.

buildings can be constructed and allocated under the previous non-market system and as such different registered as the parcels leased to private actors under the new market system.

Fig. 9 illustrates a cadastral map developed by the information centre of the Urban Planning and Land Administration Bureau of Wuhan and shows the building and parcel boundaries, and road centre line. Parcels are spatially defined within a block. Therefore, the block unit is not only important for spatial planning but, with a sufficiently high resolution, also for land administration. Cities with an urban structure with 1 ha grids, such as Barcelona, Washington, New York and many cities in Latin America, use blocks not only for street numbering but also for land administration. A clear entity-relationship model is now possible with one-to-multiple relationships between group (or sub-district) to block, block to parcel, and parcel to building as shown in Fig. 10. However, this model lacks a linkage with spatial planning. By combining the models illustrated in Figs. 8 and 10, we have developed an integrated model as shown in Fig. 11, which allows a link between the existing manner of Chinese socio-economic data registration and the requirement for land administration at the parcel and building level.

Changes in the household registration system

The emergence of the urban land market has important institutional consequences, in particular for the restructuring of the household registration system, its integration with data models for land administration and spatial planning, and the requirements for population census surveys. The household registration system (or *hukou*) institutionalizes the rural–urban divide in China. In the past, rural–urban migration was strictly controlled. Those with a rural *hukou* were fully excluded from the urban job market, social welfare system and education. Over the years, government control on migration has somewhat relaxed, yet, it is still important.[5] Due to the relaxation of migratory control, a large ''floating population'' began to migrate from the rural areas to the urban areas (Gu and Shen, 2003). As a result, a direct relation between household registration and people's interests (for education, housing, and health care) has somewhat been reduced. At the same time, however, a rising number of people has a residence inconsistent with their household registration, or even no household registration at all.

The latest (fifth) population census was conducted in November 2000. To ensure an efficient and effective operation, local census offices were created at different administrative levels, each responsible for organizing certain tasks for the survey. Compared with previous surveys (i.e.1954, 1963, 1982, and 1990), the method of census taking underwent many changes to meet the requirements of the changed economic environment. For instance, new items have been added to include place of birth, employment, source of income, and various variables on the housing conditions. During the previous population censuses, items about housing were not included. Another difference between the census of 2000 and previous censuses is that for the first time *all* the people—both ''permanent'' and ''temporary''—were enlisted in the place where they were staying at the time of the Census. In addition, the 2000 census was also the first to define migrants based on smaller spatial units, such as the sub-district or township levels (Chan, 2003).

Historically unprecedented was also the fact that the census made use of maps at a detailed spatial level specifically designed for the survey. The maps had been sketched by non-professionals, mostly the census supervisors and interviewers. In the maps, the spatial units

[5]For more information on the household registration system, see also Cheng and Selden (1994).

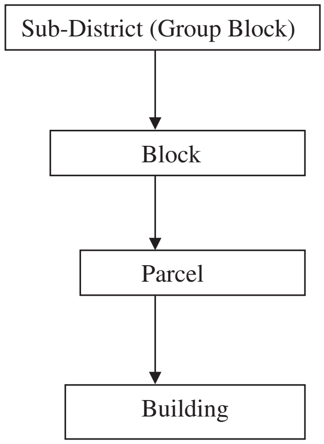


Fig. 10. An entity-relationship model for land administration.

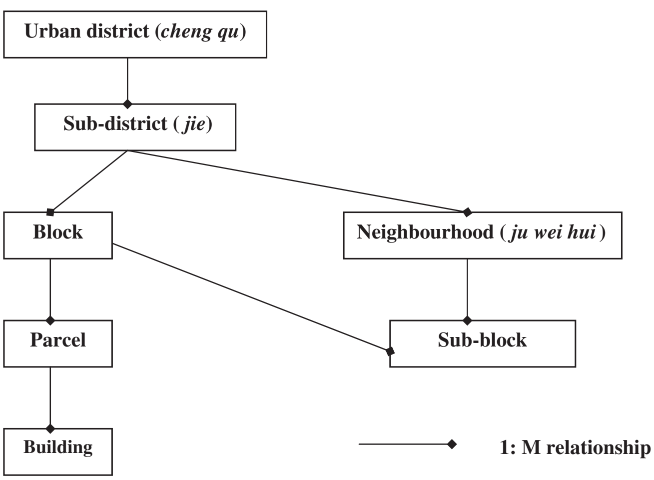


Fig. 11. An integrated model for spatial planning and land administration.

coded for the spatial database are municipality (2 digits), districts or counties (2 digits), sub-districts (or towns, townships) (3 digits), the so-called ''Enumeration Area'' (hereafter: EA) (3 digits) and smaller EAs (2 digits). The EA is spatially equal to a neighbourhood, which is administrated by the residential committee. However, it has no administrative meaning and is therefore not tantamount to the residential committee. Nearly 5 million EAs were created and detailed EA sketch maps covering the entire nation were produced. The description above seems quite straightforward; yet, Chinese reality has proven more unruly.

Before the land property reforms of the mid-1980s, China's administrative structure was relatively stable and consistent with spatial units. However, after the land reforms had been initiated, Chinese people have become increasingly active in various economic activities. This is particularly so for China's peasants, many of whom have either permanently or temporarily left their villages. The so-called floating population or rural migrant population has risen sharply over the past years (Mallee, 2003). A negative side effect of rural migration, is that migrants' residential places are increasingly inconsistent with that registered by the household registration, or they have no household registration at all. As we have seen earlier, the registration of population is linked to the ''*hukou*'' system and the identity card. Based on the Wuhan census data Yang (2003) has argued that the *hukou* system is ill-adapted to the needs of the current socio-economic environment, and urgently needs to be reformed. For one thing, at present the identity cards are generally valid for a period from 10 up to 20 years. Yang (2003) maintains that this term is far too long in light of the pace of changes in the living and working conditions of urban residents. In fact, the validity of identity cards should be reduced to a shorter period of at most 5 years. In addition, the population census data should be digitized and made available through an urban information system.

A second problem that has severely inhibited the census taking are the shifts in administrative boundaries due to urban (re)construction. For instance, Wuhan municipality comprised of five urban districts and four suburban districts in 1952. After a series of expansions, mergers and redivision of units in respectively 1955, 1956, 1957, 1958, 1959, 1964, 1976, 1983, and 1986 (ECWLR, 1996), the city currently contains seven urban districts, two suburban districts and two counties. Urban growth results in new urban neighbourhoods, sub-districts, and new development zones. On top of that, urban redevelopment has also led to the demolition of many neighbourhoods in the inner city for real estate development. As a result, long-term comparisons of administrative units is difficult because boundaries are no longer where they used to be. Over the period of reforms, the neighbourhood has increasingly lost its administrative significance. In the past the residential committee functioned as an extension of the communist state, responsible for various tasks such as birth control, the extension of party policies, and so forth. Despite this, the neighbourhood as a spatial unit is still crucial for the collection and integration of socio-economic data with land administration data as also shown in Fig. 11. Experiences from the fifth census survey, however, point to the need how to reshape the neighbourhood in relation to the traditional residential committee; how to define the neighbourhood spatially; and how to relate it to new spatial units, such as parcels. In this sense, future research could make a useful contribution by making a thorough evaluation of examples from countries such as the UK, USA and The Netherlands.

Concluding remarks: towards improved urban spatial management

The reforms in the land and housing market in Chinese cities have attracted substantial domestic and foreign financial resources for urban expansion and redevelopment. This in turn has given rise to a virtual "boom" in construction projects and concurrent changes in the spatial lay-out of cities. In order to respond to these new urban challenges, Chinese municipal governments and academic institutes have launched initiatives for a "Digital City" to enhance the exchange and standardization of spatial data, as well as the conversion of physical objects (e.g. buildings) into three-dimensional models (Wan et al., 2004). These data models, visualization and animation techniques have proven quite effective and helpful for urban design and land registration at a micro-level but are still limited for spatial planning at the meso- and macro-levels. Particularly so, because the latter levels require a comprehensive analysis of the complex interactions between physical, functional, social, economic, and environmental aspects of future-oriented plans. For these reasons, the digital city strategy for data infrastructure development will only be of limited use for the required integration of socio-economic data with land administration data.

Through our case study of one of China's fast developing urban centres, Wuhan City, we have attempted to highlight some of the current institutional constraints and opportunities in Chinese urban spatial planning today. It is vital that when local governments formulate land and housing policies, they simultaneously consider the policies to improve the spatial data infrastructure so that the newly emerging problems in the land and housing markets can be adequately analysed and evaluated. This touches on the need for cadastral development and the establishment of effective and efficient information management systems. The data sets that are currently developed by municipal land administration bureaux basically have to be developed from scratch, and unfortunately generally adopt a stand-alone approach. The creation of municipal information centres and the rapid diffusion of information technology are facilitating possibilities to achieve efficient gains; yet, these can only be achieved when the costs for database establishment and management can be shared with other concerned parties.

At the institutional side, different stakeholders engaged in land development and maintain data sets for their own purposes, which are valuable sources for spatial planning. Data sharing is necessary so that data sets from different agencies can be incorporated. However, access to data in China, even for municipal planning bureaux, is difficult; this is mainly because the emphasis on hierarchical structures (local bureaux are directly accountable to provincial bureaux) makes data exchange between different organizations at the local level a highly complicated issue. This is further aggravated by the incompatibility of data structures, and the lack of awareness among senior staff about the importance of information exchange for strategic decision-making, middle-level management and efficient land administration.

In today's China, the neighbourhood is the basic unit for population registration or the *hukou* system. The neighbourhood is administrated by, respectively the street committee (*jie wei hui*) and the residential committee (*ju wei hui*). Data for the population census are collected at the household and household member (individual) level. For these reasons, the *hukou* system forms a good basis on which an integrated cadastral and spatial planning information system could be built. However, as we have shown the neighbourhood units lack sufficient resolution to adequately support spatial planning and integrate this with land administration. Therefore, we proposed the introduction of a new spatial unit termed the "block". A common data model that integrates spatial and cadastral information, can facilitate the exchange of data, improve internal efficiency of land administration, planning and census organizations. Such models are closely related to current initiatives on spatial data infrastructures (see also www.gsdi.org).

At present, the changes in Chinese cities are by far exceeding the pace of data development required to support spatial planning and land administration. Urban planning practices have to cope with new requirements, which involve a multitude of new stakeholders, socio-economic principles, and increased transparency and public participation. These changes require the implementation of complimentary policies, common standards and effective mechanisms for the development and availability of interoperable digital geographic data and technologies to support decision-making at different scales for multi-purposes (Turkstra et al., 2003). While in many developing countries the availability of technology and human capacity is a critical issue, this is far less the case in China. However the institutional and organizational aspects are critical. Improved coordination and communication between different departments should avoid the mushrooming of stand-alone information systems. Meta-level data services to overcome the lack of information about information sources might be good strategy to increase the demand and use of these data sets, but also requires working relations at the operational level. These are some of the many challenges that Chinese urban planners face on their way to improved urban spatial management.

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