Urban Units as an Analysis Tool for Mega-Urban Development. The Case of Guangzhou, China

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Abstract

In China urbanization developed quite late in international comparison due to the household registration system which made migration into cities difficult until the state opened politically and economically in 1978. Since then the study area Guangzhou, located in the Pearl River Delta, belongs to one of the most dynamic and rapid growing regions in China. Migration, industrialization and urbanization led and are still leading to an uncontrollable and incalculable development of the city causing not at least serious consequences for the environment. Regarding the water resources, problems of water supply and purity of drinking water as well as adequate sanitation facilities, sewage disposal and treatment of wastewater are apparent and endanger parts of Guangzhou's population: access to good water quality often depends on the social status and living standard. In particular, domestic wastewater is discharged untreated into water bodies forming the main source of pollution in river water in the Pearl River Delta nowadays. Surface and groundwater quality are increasingly deteriorating which also affects human health given that groundwater is still used directly as drinking water.

The highly complex structure of Guangzhou leads to the analysis tool of 'urban units', predominantly morphological homogeneous urban areas, in which in-depth analysis becomes feasible. By reason of close relationship between the different kinds of dynamic patterns within the 'urban units' in terms of interdependencies of ecological, economical, spatial and social attributes and characteristics, different aspects of vulnerability in the urban system – and especially related to water – become identifiable.

Giving a résumé the article's goals are to highlight the results of an ongoing research project financed by the German Research Foundation related to land use changes, water supply and sanitation and peoples' and natures' vulnerability in Guangzhou.

Keywords: Guangzhou, Mega-Urban Development, Urban and Peri-Urban Water Resources, Organic Pollutants.

1 Introduction

Chinese cities, especially in the regions of Beijing, Yangtze River Delta (Shanghai) and Pearl River Delta have seen enormous development and radical changes under the influence of globalization and the corresponding ecological, socio-economic and political changes (Yan et al. 2002). Over the last thirty years they have developed with the worldwide highest dynamic: The highest growth rate and the biggest number of megacities – depending on definition cities with more than five, eight or ten million inhabitants – is expected (Deutsche Gesellschaft für Asienkunde 2007). These fast urbanization processes result from different factors, for instance

reorganization of the institutional and administrative system (like e.g. incorporation of Panyu city into the administration of Guangzhou 2000) as well as from new modes of production, employment and investment.

In the frame of these processes the mega-urban area Pearl River Delta increases in economic power and number of inhabitants substantially within a couple of years; cities like Guangzhou, Shenzhen or Dongguan grew in shortest time from small cities to megacities with more than five million people and to mega-urban agglomerations with modern high-tech industries that are highly interlinked with the world market (Wu et al. 2007; Wehrhahn et al. 2008). Having not only one single historic city center, the Pearl River Delta is not a megacity-complex with a mono-central urban structure, but a clustered region of several growing (mega)cities moving closer due to formal city planning and informal, and thus incalculable, population growth.

Guangzhou, the capital of Guangdong Province, is located at the confluence of the Bei Jiang (North River), Xi Jiang (West River) and Dong Jiang (East River) which converge to form the Zhu Jiang (Pearl River) (Fig. 1).

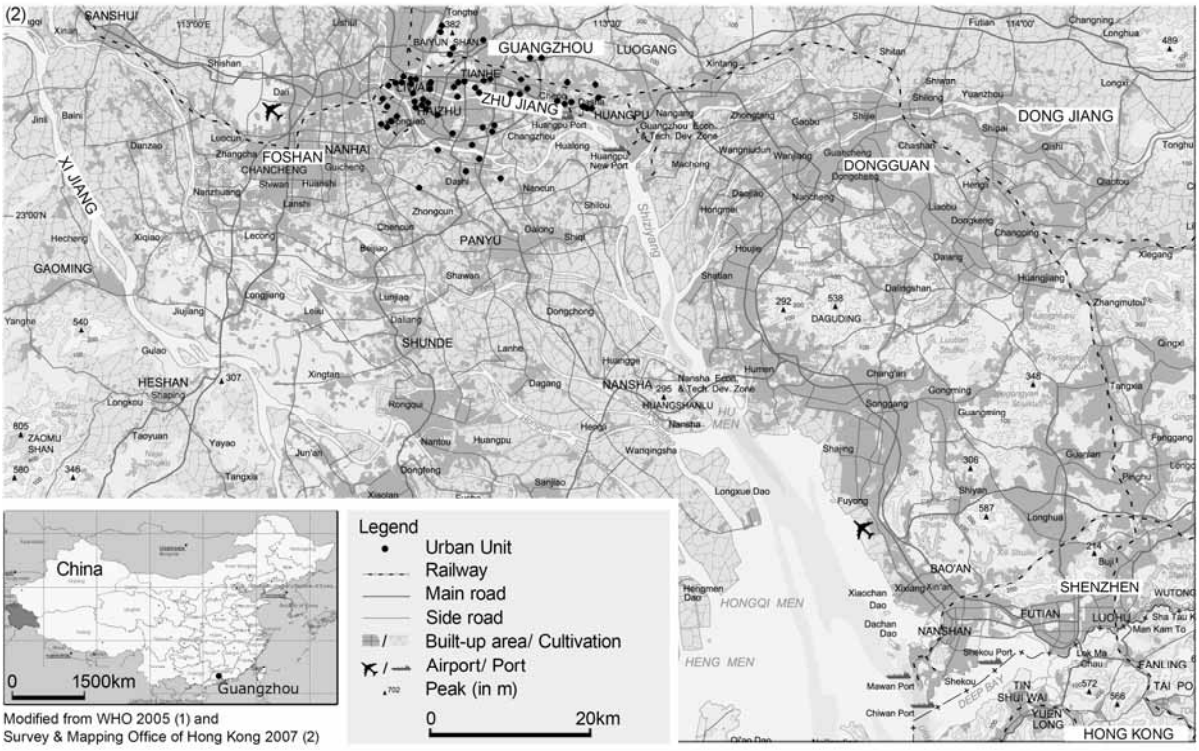

Fig. 1: Guangzhou's geographical position in the Pearl River Delta (including location of urban units)

As the central megacity in the Pearl River Delta, Guangzhou concentrates all political, economic, educational, scientific, technological, cultural and social functions. According to the Guangzhou city council the city already covers a total area of 7.434km² and had a registered population of 7.6 million plus approximately 3.9 million migrants at the end of 2005.

The basic development strategy of Guangzhou area is exploration in the south, optimization in the north, extension in the east, adjustment in the middle and co-ordination in the west (Jin 2007). These dynamic growth processes do not only transform urban economies and population structures but also the urban morphology and Guangzhou's cityscape with more and more people living either in becoming urban villages with a high building density or in high rise buildings instead of traditional Chinese town houses (Wu and He 2005) as well as the

urban land use pattern and its surrounding areas. The city's GDP has virtually doubled since 1995, reached about 411.58 billion Yuan in 2004, only second to Shanghai and Beijing and reaches annual growth rates in the 13% range (Jin 2007; Hugentobler et al. 2002).

2 Land Use Change in Guangzhou

The processes of urbanization lead to fundamental changes in the urban structures with a high quantitative growth and strong concentrations of population, infrastructure and economic and power. As mentioned above the continuous influx of population from the inner provinces and the incorporation of previously independent cities and villages into the city are two of the driving forces in the development of urbanization structures in Guangzhou. Due to this there is a rising land use change which is still continuing, also because of the growing number of foreign investment. The land use becomes increasingly involved in real estate development (Wu 2001). In the course of land use change the urban area with a high building density has considerably increased in the period 1990 to 2005 (see also the article of Lu et al. in this proceeding). Thereby former settlement areas with a low building density became more and more densified, either by building of new houses or by constructing informal annexes or superstructures on already existing buildings (compare article by Wiethoff et al.). Also still traditional and rural villages became to the urban core and large urban settlements are on the rise in the so-called rural periphery (Fig. 2).

Fig. 2: Demolition of traditional residential and small trade buildings for construction of modern high-rises

'Urban villages' (also named as 'villages in the city', 'villages amid the city' and 'villages encircled by the city') for example are usually one of the urban entities that are particularly affected by urban transformation processes in Guangzhou. Those are settlements with a previously rural population engaged in agriculture that have become enclosed by new built settlement and business areas and thus became part of the urban area during the rapid expansion of the city in recent years (Yan and Wei 2004). The city of Guangzhou today has 139 urban villages with a built-up area of 86.6km², which is about 21% of the total urban area (Changqing et al. 2007). However, many urban villagers have given up farming and have instead expanded their houses to rent the new amount of space to migrants. Thus, not only the villagers' main source of income changed but also the social and spatial pattern of the village and this of the whole city. The villages nowadays are predominantly characterized by high

building densities, limited light incidence, little open and green space, buildings of inferior quality and open sewage. Approximately 2.5 million migrants live in these villages (Changqing et al. 2007). The residents are provided with affordable housing on the one hand, but with quite poor living conditions which are even though mostly still better than in the migrants' homeland on the other hand.

The immense increase of urban villages has become one of the pressing issues in many large cities with the consequence that in the course of modernization of many cities, urban villages do not fit into their new image anymore and are being erased from the cityscape incrementally. Abandonment of residents' domiciles, uncertain future for the residents, a loss of traditional settlement structures and of course a transformation of land use (e.g. from urban agriculture into settlement areas) are only some of the consequences.

Another indicative of land use change in Guangzhou is its rapid industrialization which has been fuelled primarily by dramatic expansion of rural industry that is mostly low-tech, small-scale, labour- and resource intensive. This industry is widely scattered all over the countryside and has functioned as the most important absorber of surplus rural labour released from agricultural production because of increased productivity (Lin 2001). However, those rural-urban industries produce a large amount of wastewater which is led out without any treatment, creating problems that are often beyond the capacity of the local authorities to handle (Lo and Yeung 1996).

Because of the highly dynamic processes of urbanization mega-urban areas are characterized by an increasing loss of controllability and predictability. In regard the high-speed urbanization (Ipsen 2005) mega challenges of Guangzhou are to provide fresh water in an acceptable quality for all inhabitants as well as a sustainable handling of water resources.

3 Method

Different levels of consideration constitute a high challenge in complex aggregations of mega-urban centers. The examination of the whole area or the mostly large administrative units do not provide a differentiated image, while the complexity on the smallest level – for example single buildings – is not controllable anymore. In order to reduce the complex processes related to the development of highly dynamic mega-urban areas the large urban agglomeration is subdivided into smaller units. For that reason repetitive micro structures, such as single types of buildings and their contiguous surface broaching, will be merged into groups with respectively uniform and homogenous characteristics. These units exhibit both in their building and open space structure and in their social composition and economic functions a relatively high homogeneity and can be aggregated to spatial categories or urban units with similar ecological characteristic values, economic functions and social structures (Fig. 3). With the aid of such urban units it is possible to reduce the confusing system of a megacity to its important and significant major constituents that are characteristic for the analysis of development. The different types of city building blocks may for their ecological, economical and social specific values and respective changes act as indicator structure for the overall system of a megacity. For the definition and classification of those units, structures are offered which arise from traditional and current settlement development and which are based on growing sub units below the level of the settlement complex as a whole. In Guangzhou it is possible to easily identify such area units by means of closed settlement structures due to social patterns and political planning. These units can be put together as single room categories or city building blocks with similar

ecological specific values, economic functions and social arrangements. Urban units are supposed to facilitate a better understanding of complex structures in mega-urban areas on the basis of characteristic reference areas. These units are a feasible tool to analyze the complex system of the mega-urban region by reducing the complexity to important characteristics or meaningful elements.

Fig. 3: Conceptual approach. Schematic typology and demarcation of urban pattern

4 In-Depth Analysis of Land Use Change in Urban Units

In the first phase of the project, between 2007 and 2008, nearly 70 urban units have been roughly analyzed. Of these, four units each representing a typical structure, have been chosen for an in-depth analysis. Results from the peri-urban village Shibi and the 'village in the city' Xincun are given below:

Shibi is a village in the rural periphery of Guangzhou. The village is located ca 23 km south of the new business center of Guangzhou center in Pan Yu District and is divided into four communities. The population figure of all four villages of Shibi was about 19,000 in 2007; about half of the population was migrants.

The land use subdivision is typical for a traditional village: areas for agriculture, fish farming and husbandry are in close combination with large-scale residential areas. Due to domination of agricultural land, which mostly belongs to and is tilled by the local residents, the least amount of migrants live in the north western part of Shibi, namely the second village.

First influences of urban and spatial dynamics and structural changes are evident. Resulting from the ongoing influences of urbanization several changes can be identified in Shibi. Until the early 1990s, Shibi remained a traditional rural community. Transformation started, when several factories nearby were established by investors

e.g. from Hong Kong, as a result of new national economic policies, industrialization and urbanization. As a consequence, rural workers from other provinces moved to Shibi searching for a job. Due to the increasing number of inhabitants, there is a growing demand for living space and changing demands concerning the functionality of the existent space, both resulting in various interacting processes. Regarding the structure and the hinterland of Shibi, future extension will tent towards the neighbouring areas, so that pressure of urbanization will increase in these areas. The future city development plans cause high impacts for Shibi: The village had been chosen as location for the new railway station of Guangzhou linking the city with Shenzhen and Hong Kong on a new high-speed line because of absence of vacant land in the city center and of abundant land belonging to the village (Lai 2009a). The station will be equipped with 28 platforms which cover an area of approx. 200,000m² in total (Legislative Council of Hong Kong 2009). The total building area of the station will be 377,600m² (Wing 2006). Particularly due to the future railway station which is the major dynamic force for further development of Shibi, many significant changes are already taking place and are increasingly to be expected within the next years. Agricultural area is dissected by new roads and tracks and is being transformed into the built-up area of the station. Former ponds used for fish farming were filled which causes a loss of livelihood for the breeders. Frugal dwellings have been removed. In the long-term city planners assume that because of building the railway station in Shibi, it would also attract investment there, enabling the satellite district to develop itself into a new sub-center of Guangzhou next to Tian He District (Lai 2009b)

The urban village **Xincun** is located in the central part of Hai Zhu District, south of Tian He District that is designed to become Guangzhou's new commercial and administrative center. Focus is given to move the city's CBD away from the inner city and two development axes are planned to promote economic growth and to enhance the city image (Xu and Yeh 2003). Despite today being encircled by the city, Xincun still keeps some characteristics of its rural origin. The criss-crossing alleys of the old village and the predominately small-scale structures are clearly identifiable in the map, distinctly different from the surrounding grid patterned with wider streets and new residential high-rises. But, like in other urban villages the village committee decided to give up the remained area of agriculture between 2007 and 2008 so as to allocate building land for a school and a residential home for the elderly.

Xincun is part of a complex urban agglomeration with a high dynamic. Related to the fact that global change and China's opening to the world economy have deep impact on socio-economic, political, ecological and cultural processes and on living conditions in general, the urban village has been experiencing rapid development and tremendous changes in terms of (economic) restructuring, spatial reconfiguration, water resource management and social reorientation and repositioning (Wehrhahn et al. 2008). The demand for housing grew with the increase of migration; villagers took note of the opportunity to make money by taking advantage of the tight supply situation. In the beginning of the 1990s they started to built new four to five storey-houses for rental on their agricultural land. Because of this the spatial and social structure of Xincun is evidently changing from a traditional village to a village that is more and more influenced by the effects of urbanization.

5 Impact on Water Resources

Although water resources are relatively abundant in Guangzhou, the megacity faces a lot of a lot of environmental problems as well as other urban agglomerations in China do. The whole drainage basin of Guangzhou is to some extent polluted (Mu et al. 2005) and the situation is aggravated by the cities' high-speed economy with thousands of factories and small scale enterprises (some of them with old and ineffective methods of production), the huge population growth and the land use change which also includes a decrease of the size of urban water bodies, all leading to a serious threat of water resources.

In-depth analyzes have shown explicit consequences of urbanization on the water resources of Guangzhou:

- direct conduction of wastewater via open trenches into the receiving water medium (pollution of surface and groundwater),
- untreated domestic wastewater as the main cause of water pollution,
- downsizing of streambeds by sedimentation,
- filling of urban creeks for urban reconstruction,
- strong interference of groundwater quality by means of coliform bacteria and Ammonium (deficient capacities of sanitary plants and adequate wastewater disposal),
- a main part of the urban groundwater recharge comes from wastewater,
- high surface sealing affects the natural recharge of groundwater,
- detected pollutants are primarily coliform bacteria and Ammonium,
- also tap water shows contaminations with coliform bacteria over limit value and an
- increasing water demand because of rising living standards and a growing population.

Related to the water resources, Shibi shows several signs of ecological vulnerability concerning water quantity and water quality: namely deficient access to safe drinking water and sanitation, poor drainage with open sewers as well as several dumps adjacent to agricultural land and fish ponds. A lack of access to safe potable water and adequate sanitation seems to be Shibi's greatest humanitarian and social challenge in terms of changing environmental issues. Samples of flowing (brook, river) and stagnant (feeder) surface water showed an extreme water contamination with total coliform bacteria of up to $1.3*10^5$ MPN/100ml. The impacts of the ongoing urbanization process on the one hand and the structure of the village on the other hand can be observed looking at the water supply, regarding use of tap water and groundwater. Not every household in Shibi is connected to the water distribution systems yet. Access to the public infrastructure has to be paid privately, creating obstacles for low-income households. In Shibi as much as in other parts of Guangzhou tap water cannot be consumed due to inferior quality (e.g. contamination by total coliforms of max. $4.6*10^2$ MPN/100ml) and non-acceptable taste. Instead of tap water many residents – even people living afar in other parts of Shibi – use groundwater from private and public wells in their daily diet. Also groundwater is seriously polluted by coliform bacteria (max. $4.9*10^4$ MPN/100ml) which thus might pose a health risk to the user. Water contamination in Shibi is mainly

related to untreated domestic sewage discharges and agricultural activities such as animal husbandry in the watershed. Shibi's domestic sewage is conducted untreated in a receiving water course via a ditch that is also used for agricultural irrigation.

A modernization and enlargement of Shibi is expected in the next years as stated above, and related to the resource water, the number of people (inhabitants and passengers) who must be provided with safe drinking water and also sanitation services already raises. Also the daily water demand in Shibi is increasing due to the rising living standard (e.g. use of washing machines) and a growing population owing to moving in of migrants. The problems concerning water supply and quality will continue: With increasing future traffic, continuous non-point pollution by e.g. residues of combustion and lubricants will rise and therefore pose a risk to ground and surface water.

In contrast to Shibi, it is estimated that today all inhabitants of Xincun do have access to tap water by central water supply conducts. Additionally, several public water vending machines that are located at central places across the village could serve as an alternative water supply.

As much as in Shibi, water demand is increasing because of rising living standard and a growing population. Rising water demand consequently leads to a rising volume of sewage. It is obvious that the brook section in Xincun is heavily polluted with human excreta as well as solid waste from small trade in the adjacent areas. In fact, samples of surface water, brooks as well as ponds and feeder, showed an extreme water contamination with total coliform bacteria of $1.1*10^7$ MPN/100ml, maximum load of ammonium of 55mg/l and only little pollution with nitrate of up to 1.62mg/l. As surface water and groundwater form a complex system and are influencing each other, also the tested groundwater showed a heavy contamination with total coliform bacteria $3.3*10^4$ MPN/100ml maximum and a slight pollution with ammonium of 8.34mg/l. The detection of ammonium indicates impureness by domestic and/or industrial effluent.

Another aspect of water analysis relates to land use structures within the settlement area of Xincun concerns open spaces. In the oldest as well as in the newer parts of the village, the surface is highly sealed. Because of sealing of the surface less or no infiltration will be possible in the future which evokes that natural groundwater recharge might be further diminished in the area of Xincun.

6 Conclusion

The urban structure of the megacity Guangzhou in the south Chinese Pearl Delta River reflects the consequences of decentralized Chinese economic policy and settlement policy. The morphological pattern mix consisting of settlement and work units of different developmental periods are typical – expression of political and economical history of the region since the late 1980ies. The coexistence of classical industrial-residential centers such as the Danwei of the communist era, multi-storey residential blocks, one-two-storied rural courtyard house structures, modern business districts and high-rise complexes, urban agriculture and small trade firms are coining the cityscape. The interaction of functional and structural diverse urban units, which constitute the urban landscape, the relevance for the complex mega-urban system and its influence on the dynamics of development and on the flow of resources are of crucial importance for the deeper understanding of the functioning of megacities.

The conceptual approach of urban units is a matter of an integrated line of research for the ascertainment of dynamics in fast growing urban areas, which takes on the additive urban landscape and defines on this basis different types of urban units. Altogether the concept of urban units is applicable in Guangzhou since the above described morphological city structure consisting of settlement and working areas of different phases of the urbanization process enables a good definition and delimitation of urban units unless they cannot be seen as closed systems.

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