



The intensity change of urban development land: Implications for the city master plan of Guangzhou, China



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ARTICLE INFO

Article history:

Received 7 December 2012

Received in revised form 25 April 2013

Accepted 6 May 2013

Keywords:

Land-use intensity

Urban development land

City master plan

Guangzhou

ABSTRACT

The Chinese economy has experienced substantial development over the last thirty years. This growth has resulted in an enormous expansion of China's urban areas and it has also led to a growing scarcity of land resources. Consequently, there is currently an urgent need to mitigate the conflict between the needs of growing urban areas and the shrinking supply of land resources. Understanding land-use intensity and its changes can provide important information to find mitigating measures for this conflict in the demand for land. Previous studies have found that increasing the utilization efficiency of land resources is one of the most effective ways to resolve this issue. This study focuses on the city of Guangzhou, which is an intensively developed megalopolis. A number of different data sources have been analyzed to find the characteristics and changes in urban land use in Guangzhou, including: Landsat data from 1979, 1990, 2000, and 2009; relative socioeconomic data from the Guangzhou statistic yearbooks; and the master plans of Guangzhou. The results indicate that the area of developed land has continued to increase. Urban development land intensity and its change were then explored using a Back Propagation neural network model of the city. Although the analysis revealed that urban development land did not have a higher intensity overall, it also showed that there was a sectional upward trend throughout the study period. Consequently, there is a potential to improve the land-use intensity of Guangzhou. A linear regression model was then adopted to explore the mechanism of land use change. The results reveal that rapid industrialization and urbanization have improved land-use intensity in Guangzhou. The per capita urban road area and per capita GDP show a strong relationship when compared with land-use intensity. Using the relative city master plans, the authors have argued that local government in Guangzhou has taken active steps to address land issues to promote the city's socioeconomic development; however, a scientific city master plan in the study area is still necessary to ensure the effective utilization of the city's limited land resources.

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Introduction

In a developing country the demand for urban land will inevitably increase over a long period of time. This demand is driven by the growth in both economic development and in the population. The two basic ways to resolve this problem are urban expansion and higher intensive land use. However, urban expansion is restricted because of land limitations while higher intensive land use is able to enhance the intensity of land use (Meng et al., 2008). The concept of land-use intensity has traditionally been used in, and has developed from, agriculture (Boserup, 1965; Jan et al., 2012; Lambin et al., 2000; Novelli et al., 2013; Weiner et al., 2011). The commonly accepted concept of land-use intensity in

agriculture can be denoted as the degree of yield amplification caused by human activities or socioeconomic inputs, including: labor, resources, water, energy, and capital (Liiri et al., 2012). In addition, it can also be caused by using more advanced technology and management methods on agricultural land (Boschi and Baur, 2007; Persson et al., 2010; Renetzeder et al., 2010; Wrška et al., 2008).

Although there is still no clear concept of urban land-use intensity, Chinese scholars have paid considerably more attention to this concept than their colleagues elsewhere. For example, they have regarded urban land use as increasing the input to land use with the aim of acquiring significantly more output, which contrasts with the traditional concept of agricultural land-use intensity (Xie et al., 2006; Zhu et al., 2009). Owing to its particularity, or to the complexity of land use in the city, Xie et al. (2006) and Zhu et al. (2009) consider that land-use intensity is closely connected with land-use structure and distribution. When output is considered,

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economic, environmental and social effect (i.e. output) should all be of concern. This paper defines urban land-use intensity as the degree of yield amplification that results from improving management strategy and optimal land-use structure within a city under current economic and technological conditions. In particular, the total land in a city does not increase or decrease. Meanwhile, economic, environmental, and social effects are all considered as the output.

Previous studies of urban land-use intensity have directly or indirectly discussed the relationship between land-use intensity and the environment. In addition, some studies have tended to quantify land-use intensity. For example, [Wr̀bka et al. \(2008\)](#) recognized that the intensification of land-use has led to a decline of natural and semi-natural areas ([Renetzeder et al., 2010](#)). Meanwhile, [Persson et al. \(2010\)](#) examined exploited land-use intensity and landscape complexity in an agricultural region, and concluded that both were more or less separate landscape level factors. [Lambin et al. \(2000\)](#) developed land-use models to examine their ability to predict land-use intensity and its change, and concluded that different land-use models (i.e. dynamic or stochastic models) showed different capabilities to depict the changing levels of land-use intensity. [Lambin et al. \(2000\)](#) also pointed out that a number of other factors (e.g. geographic and socioeconomic factors) should be considered when a land-use intensity model is being developed.

The intensity of urban land use has also been an important topic in the field of land-use studies in China. Mainstream approaches adopted in China have constructed an index system, explored appraisal models, and acquired a degree of the intensive use or the potential of urban land use by conducting a case study ([Xie et al., 2006](#); [Yang and An, 2007](#); [Yang et al., 2009](#); [Zheng and Chen, 2012](#)). For example, [Chu \(2011\)](#) studied farmland intensity utilization in the county level preliminary plans and used the city of Zhaoyuan as a case. They constructed a valuation index system of farmland intensity and comprehensively evaluated the degree of intensive farmland use. They concluded that farmland intensive utilization levels in Zhaoyuan City are relatively lower than in other comparative cities. Meanwhile, [Zhen et al. \(2010\)](#) performed a study on the zoning method of urban land intensity use throughout and their study might be used as a prospective study to understand the intensity of land-use in China.

The BP neural network's powerful capacity to calculate, its self-adaption ability, and its self-organization ability mean that a number of neural network models have been developed and have been widely applied in land-use research, such as in forecasting ([Pijanowski et al., 2002](#); [Wang et al., 2012](#)). Although the evaluation index and modeling are important techniques and measures to understand the situation of land-use intensity, "*any model prediction could only be based on what is currently known about processes of change*"; in addition, "*issues of intensification are always more policy relevant*" ([Lambin et al., 2000](#)). Meanwhile, [Erb \(2012\)](#) has made it clear that "*land-use intensity is prominently influenced by socioeconomic processes, options and capabilities*". [Cullingworth and Nadin \(2005\)](#) have suggested that planning is essentially a means for reconciling disputes in land use. Despite the importance, complexity and policy relevance of land-use intensity, few studies have explicitly sought to explore the links between land-use intensity and city planning. For example, [Meng et al. \(2008\)](#) compared the value of land-use efficiency among industrial sectors and found that promoting land-use efficiency is (and will continue to be) a crucial issue in land-use planning in China. Furthermore, a comprehensive evaluation and further study of the interaction between land-use intensity and city planning would make a meaningful contribution to this topic.

The Chinese economy has changed profoundly over the last thirty years ([Long et al., 2010](#)). This rapid change and massive growth means that China has experienced enormous demands for

land development ([Long et al., 2007, 2012](#)). On the one hand, transforming agricultural land into industrial land has resulted in the loss of large areas of fertile land to meet the needs of city construction ([Long et al., 2009](#)). On the other hand, there is an abundance of inefficient existing state-owned building land ([Wu and Qu, 2007](#)). For example, the land and resources details that were released in the 2010 annual report of the land inspectors found that 77 cities had 149,000 acres of idle land ([JHN, 2011](#)). [Wu and Qu \(2007\)](#) reported that around 4–5% of Chinese urban land is idle while 40% is used inefficiently. In addition, if inefficient land utilization is assumed to be nearly a quarter of the idle calculation value, then idle urban land would account for 15% of urban land ([Wu and Qu, 2007](#)). Consequently, the existence of idle or inefficient utilization land has stimulated agricultural land conversion.

China's accelerated urbanization and increasingly tense human–land relationship means that intensive land use has become an important means for the country to solve its contradictions; it is also one of the important elements of the development of China's economy ([Long and Liu, 2012](#)). Therefore, the Central Committee of the Communist Party of China and the Council of the People's Republic of China have both attached great importance to intensive land use. For example, the former President Hu Jintao in a working conference on central population, resources, and the environment called for land management measures and intensive land use ([CPG, PRC, 2005](#)). In addition, Premier Wen Jiabao spoke at the same working conference and called for strict land management to vigorously promote the conservation and intensive utilization of China's land ([CPG, PRC, 2004](#)). The State Council requested that overall land-use planning should strictly protect arable land, strictly control construction land, and place land conservation and intensive land utilization at the core of its policies ([GOSC, PRC, 2005](#)). The Ministry of Land and Resources of the People's Republic of China has subsequently prepared the early stages of its land-use planning policy, which calls for the study of the problem of how to promote the economy and still maintain intensive utilization of land. In particular, it plans to analyze the increased level of intensive land use in the long-term change trend in order to put forward efficient arrangement measures for the stock and incremental land ([MLR, PRC, 2005](#)). The concept of constructing an ecological civilization was given a prominent role at the Eighteenth Congress of the Communist Party of China, which was held on 8–14 November 2012. In addition, the goals of prioritizing conservation and the principle of natural restoration were clearly put forward at this meeting. The Report of the Eighteenth Congress of the Communist Party of China indicated that China will have a comparatively high standard of living by 2020. Hence, the topic of intensive land utilization was given impetus; it was also presented as a significant challenge to the country ([MLR, PRC, 2012](#)).

It has even been suggested that the planning system might be a useful means for a government to resolve conflicts over land use ([Brahmoh, 2009](#); [Cullingworth and Nadin, 2005](#)). [Peltonen and Sairinen \(2010\)](#) considered that politics and conflict lie at the heart of land-use planning. Since resources are limited, the issue of land-use and the development of land intensity should be at the core of planning. The local governments, like the municipal and provincial governments of China, have compiled city plans to interrelate the contradictions between different land uses. The plans aim to readjust the layout of urban functions over several decades. On 1 April 1990, the City Planning Law of the People's Republic of China was brought into effect. This law introduced a two-tier city planning system to China. The first tier is a master plan and the second tier is a regulatory control plan ([Tian and Shen, 2011](#)). The master plan is prepared by the planning department of the local government. To achieve economic and social development goals within a deadline, the master plan is used to comprehensively deploy and arrange

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