



## Evaluating green development level of nine cities within the Pearl River Delta, China



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### ABSTRACT

Due to the uncertainties resulted from environmental changes, the importance of green development has been paid increasingly attention in the world. However, our knowledge of the green development level of nine cities in the Pearl River Delta (PRD), China, was still limited. Therefore, this study, based on the analysis on the connotation of green development, employed multi-level evaluation method and entropy method to develop the urban green development evaluation index system from five aspects, including enhancement of living environment, treatment and utilization of pollutant, improvement of ecological efficiency, optimization of economic growth and development of innovative potential. This evaluation index system was further applied to evaluate the green development level of nine cities within PRD. Results showed that significant difference in green development level occurred among cities within PRD. Green development level in Shenzhen, Zhuhai, Guangzhou was relatively higher than that in other cities, with the advantages in improvement of ecological efficiency and optimization of economic growth. Green development level in Zhongshan, Dongguan, Huizhou, Foshan averaged in PRD, while Jiangmen and Zhaoqing had a delayed green development level because of their irrational economic structures and extensive growth patterns though these two cities possessed good ecological environment endowments. In the future, it is necessary for PRD to formulate specific and targeted policies and measures to further upgrade energy structure, transform industrial structure, improve public transportation, enhance forestry carbon sink, and eventually construct low-carbon circular industrial system and development pattern.

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### 1. Introduction

With the global economic development and the profound change in environmental conditions, various problems such as global warming, regional pollution, contradiction between supply and demand of resource and energy, gradually intensified. Many countries have made great efforts to create a sustainable future through formulating green development strategies, policies and actions. For examples, United States stimulated green development

by investing in clean energy, and European Union (EU) developed green economy by building “green industry”. South Korea proposed “green growth” economic revitalization strategy, while Japan promoted the growth of green economy by building “low-carbon society” (Skea and Nishioka, 2008). Other developing countries like Cambodia and South Africa have also developed green economic strategy plan (UNEP, 2012a). By far, with the increasing pressures of environmental protection, the forces of green development are sweeping across the world.

With the implementation of green development strategies, researches on the evaluation index system of green development have been increasingly explored. Hall and Kerr (1991) proposed the concept of “green index”, and divided the green index evaluation system into three classes, which involve in 256 specific indexes belonging to two categories of green state and green policy in the first class. Cobb et al. (1995) created a Genuine Progress Indicator

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(GPI) with sustainability, which includes indicator of three accounts: society, economy and environment. Lawn (2003, 2005) suggested that based on the index of sustainable economic welfare and GPI, other alternative indexes should be proposed to achieve broader acceptance.

Due to the dual needs of economic development transformation and ecological civilization construction, green development in China has received unprecedented attention as well. In fact, China has already done a lot of practices such as reducing emission and promoting clean energy (Jiang et al., 2016; Zeng et al., 2017), and the overall green development in China is currently at the stage of the energy utilization and economic output tending to be more effective. However, the green development still exists obvious differences among regions because of the unbalanced development of economies (Meng et al., 2016). Thus, the green development in China still has a long way to go and large spaces to be improved.

Till now in China there were already studies on green development on the national or regional scale. For example, China Green Development Index Reports have been published for consecutive years, but little information was available for cities within the PRD, China. With first-mover advantage of transformation and upgrading, the PRD city cluster was making efforts on building the national green development demonstration area, and thus an in-depth evaluation research on green development was needed to effectively promote each city's green transformation, and provide a reference and demonstration for other cities to explore green developing pathway.

## 2. Connotation of urban green development

### 2.1. Global explanation of green development and urban green development

The concept of green development can be traced back to Spacecraft Economic Theory proposed by the American scholar Boulding in 1960s, as well as a series of discourses related to steady-state economy (Daly, 1977), green economy (Pearce et al., 1989) and ecological economy (SDSRG, 2010). With the deeper understanding of the relationship between economic activities, and resources and environment, especially after the international financial crisis in 2008, a new context of Green Economy (Green New Deal, Green Growth, Green Transformation, and Green Development) was proposed, in order to solve practical needs by integrating development problems with sustainable problems.

At present, there were several influential definitions of green development in the world. OECD (2011) considered green development as a solution to pursue economic growth and development, and meanwhile to prevent environmental degradation, loss of biodiversity and unsustainable use of natural resources. UNESCAP and UNEP focused on greenhouse gas (GHGs) emission in the economic development process, and resource and environment protection (UNESCAP, 2009, 2010; UNEP, 2012b). World Bank emphasized green development as an environmental-friendly and social-inclusive way of economic growth, aiming at efficient use of natural resources and minimizing pollution emission as well as reducing impacts on environment (World Bank, 2012). Jänicke (2012) defined green development from the perspective of eco-industry, that fostering low-carbon economy and green economy by policies such as adjusting factor prices and differential taxation, instead of using high energy consumptions and high pollution, to realize a modern industrial growth pattern with sustainable and circular development.

Urban green development is the extension and concretization of green development on a city scale, and currently relevant

discussions have existed. OECD suggested that green cities should have the following characteristics, including less environmental negative externality, smaller negative impacts on natural resources and ecosystem services, green economic growth brought by the “greening” process of traditional urban economy or urban green expansion (Hammer et al., 2011). Zhang et al. (2016) believed that the connotation of green city in China should include two features, which are prosperous green economy and green living environment, in the urban developing form and pattern. Generally speaking, urban green development has two aspects: one is “economic greening”, which means urban economic system should be green and vibrant; second is “environmental greening”, which means urban living environment should be green, livable and healthy.

### 2.2. Boundary of urban green development connotation

The urban green development evaluation is the evolution of the concept of sustainable development in the context of China's new normal development, and in recent years, it is the research topic with Chinese characteristics getting increasingly attention. This study aims to further deepen and instantiate the definition and connotation of urban green development. On the basis of the study by Zhang et al. (2016), and some relevant empirical evidences from other institutions and countries, such as Green Growth Measuring Framework from OECD (2011), Green Economy Measuring Indicator System (UNEP, 2012a), Norwegian experience on natural resource accounting (Alfsen et al., 1987), the green growth index systems of Netherlands (Statistics Netherlands, 2011), Mexico (INEGI, 2011), and Czech Republic (Czech Statistical Office, 2011), the connotation of urban green development was concluded by two dimensions: one is the “greening” of economic activities; and the other one is a healthy supply of green capital within cities.

With the economy rapidly growing in China including PRD area, the contradiction between economy and environment have become increasingly acute. To better adapt to China's development status, the two dimensions can be, specifically speaking, explained from five aspects: treatment and utilization of pollutant, improvement of ecological efficiency, optimization of economic growth, enhancement of living environment and development of innovative potential. These five categories cover current focusing problems of imbalanced economic structure, intensive resource consumption, and excessive environmental pollutants in China including PRD area (SERM, 2017), and thus can fairly evaluate the green development level for cities.

## 3. Construction of green development evaluation system

According to the principles of systematization, feasibility, scientificity and guiding, the urban green development evaluation index system (Table S1), which consists of five criteria and twenty-three indexes, was constructed.

In the aspect of the enhancement of living environment, good air quality and water quality are the basis of human survival, while adequate open green space is an important and necessary infrastructure in cities. Therefore, five indexes, which include per capita urban public green area, percentage of greenery coverage in built-up area, the number of days with good air quality, percentage of surface water up to and above Class III, percentage of surface water below water section Class V, are selected to measure the enhancement degree of urban living environment.

In the aspect of the treatment and utilization of pollutant, it is mainly characterized by the situation of urban infrastructure construction and the recycling degree of resource utilization. The construction of infrastructure is the important part of urban

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