Juke Liu · Weiping Sun
Wenzhen Hu *Editors*

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Foreword

The concept of the ecological civilization as a new form of civilization follows on from the preceding fishing and hunting civilization, agricultural civilization and industrial civilization. The city, as the birthplace and carrier of human civilization, is at the center of our economic, political, cultural and social activities. How does the concept of the ecological civilization fit into wider urban development? A group of scholars in China are exploring the path of the development of the Chinese eco city, and *The Report on the Study of the Eco City in China* is the theoretical crystallization of that exploration.

In 2015, China's rate of urbanization was over 56.1 % and about 750 million people lived in urban areas. China has been transformed from a largely agricultural society to a much more urban society. In 1978, China's rate of urbanization was only 18 %. Over these 37 years, the annual increase in the urban population has been about twelve million, approximately equal to the total population of Belgium, and the total increase of the urban population every five years is roughly equal to the total population of the United Kingdom, doubled. China's urbanization process has required huge resource utilization, a substantial increase in the secondary and tertiary industries with the attendant problems of employment, housing, transportation and social security, and it has also meant tremendous changes to the lifestyle of residents and an associated environmental impact.

The rapid process of urbanization in China has been accompanied by the emergence of "urban diseases", for example an explosion in population, shortage of housing, unemployment, traffic congestion, environmental degradation and frequent public safety incidents etc. How are these problems to be solved? In December 2015, China held the working conference of the central cities, which clearly defined the guiding ideology, general ideas and key tasks required in doing the work of a city well. The Chinese government has accelerated the transformation of the mode of economic development, so as to ensure that the economy operates in the new environment, and economic growth has been decreased by about 6.5 %, however, GDP cannot be used as the main index of evaluation. The Chinese government has also strengthened reforms of supply measures in order to lower capacity, destock, de-leverage, reduce cost, compensate for weakness, adjust economic structure, expand domestic demand and address urbanization as the greatest potential in the expansion of domestic demand and to address “urban diseases” effectively.

The Report on the Study of the Eco City in China implemented the urbanization policy of the Chinese government to solve the problems associated with China’s urban development, and began to explore the path of the Chinese eco city in 2011. Reports on the progress of research into the construction and development of eco cities in China have been published in Beijing since then, including *The Report on the Construction and Development of the Eco City in China (2012)*, *The Report (2013)*, *The Report (2014)* and *The Report (2015)*. We aim to construct a guiding ideology, theoretical systems, developmental ideas and principles, and a standard system and evaluation model of eco city development, in order to guide the construction and development of the eco city in China.

The guiding ideology of the eco city in China, informed by a scientific concept of development, aims to implement the concepts of innovation, coordination, greenness, openness, sharing, adherence to the human-centered principle, and to guide urban construction with the idea of “Following the Way the Human Body Works”. The core of “Following the Way the Human Body Works” considers the city as a kind of organism, just like the human body. The function of the human body can to be used to guide urban construction and management.

Man is the initiator of the deterioration of our environment and the spread of “urban diseases”, which are a serious threat to the health and survival of humans. In order to rebuild the ecological civilization and save mankind, we have to address both the symptoms and causes of these problems. The reconstruction of the relationship between man and the environment is the core principle, and changing people’s values is key, while a change in the mode of production and lifestyle is the focus. First, the level of civilization of mankind, and the harmony and development of humans should be improved. Secondly, we need to improve both social civilization and ecological civilization, the harmony between man and nature, man and society and develop these relationships. If this cannot be achieved, then ecological civilization, social harmony and economic development are not sustainable.

The ideas of *The Report on the Construction and Development of the Eco City in China* are green development, a circular economy, low-carbon lifestyles, and improvements to health and livability. To establish an ecological view that “the natural health of human beings is the primary goal of green development, and the ecological environment is the basic ecological security of the natural health of human beings”, while serving modern construction, improving residents’ happiness index and achieving the comprehensive development of humans is the objective, along with updating the perspectives of the people, providing consultation on decision-making, guiding engineering practice, and leading green development in order to fully integrate the concept of the eco city into the process of urbanization, and to promote the formation of green low-carbon methods of production and life through “the inlay of the three zones”—the agricultural zone, the natural zone and the human zone, and to explore the development trajectory of a new type of Chinese-style eco city.

The aims for the development of the eco city in China are "integrating five aspects in one, supporting them with two points, inlaying three zones, driving with four wheels, while centering on humans and developing in a green way". "Integrating five aspects in one" means that eco city construction in China should stick to rural urbanization, urban landscaping, clean production, green lifestyles and the ecological environment, and address the integration of urban and rural ecological construction. "Supporting with two points" means that the eco city should take the ecological industrial parks and the green ecological community as two important agents of construction, supporting production and life in the city The concept of "inlaying three zones" involves the natural ecological zone, the agricultural ecological zone and the cultural ecological zone and should be inlaid inside and outside the city. The idea of "driving with four wheels" indicates that the construction of the eco city should aggregate the power of government, businesses, non-governmental organizations and the public to form a coordinated management mechanism. "Centering on humans" indicates that the development of the city should be centered on the livable environment, rather than on the economy, while "developing in a green way" indicates that under the constraint of the ecological environmental capacity and resource carrying force, environmental protection should be regarded as an important pillar in the realization of the sustainable development of the city.

The development principle of the eco city in China is "classified construction and step-by-step implementation". "Classified construction" refers to the dividing of eco cities into six types, namely the environmentally friendly city, the resource-saving city, the circular economy city, the landscape and leisure oriented city, the green consuming city and the integrated innovation city, and then constructing cities according to the types they belong to. "Step-by-step implementation" indicates that urban construction should be implemented in three phases: the first phase being preliminary green, the second moderate green, and the third dark green.

The evaluation index system of Chinese eco cities includes three types of secondary indicators and 14 core indicators. The ecological index consists of 5 indicators: forest coverage rate (%), good air quality days (days), water consumption per capita (tons/per person), public green area per capita, and hazard-free garbage treatment rate (%). The ecological economic index includes 5 indicators: comprehensive energy consumption per unit of GDP (tons of standard coal/million), the comprehensive utilization rate of solid industrial waste (%), urban sewage treatment rate (%), GDP per capita (Yuan/per person) and information infrastructure. The ecological social index includes 4 indicators: population density (million people/per square kilometer), the public satisfaction rate with the urban ecological environment (%), the number of civilian vehicles/the length of the urban road (km), and the expenditure of urban maintenance and construction/urban GDP (%). The six types of eco city have 5 different characteristic indicators.

The evaluation management style of the Chinese eco city is "dynamic evaluation and dynamic management". All 286 cities above prefecture-level in China are included in the range of the assessment and evaluation and the cities are divided into five types of eco city: very healthy, healthy, sub-healthy, unhealthy, and very unhealthy. After having done a dynamic analysis of the changes of the indicators in every city and in each year, we found the reasons for the problems and put forward countermeasures. We also established "the ecological early warning system of the eco city in China", and put forward timely countermeasures to effectively prevent, resolve and deal with any ecological risks the city was subjected to, aiming at addressing any abnormal phenomena in an index of the city or any coordinated problems existing between indices.

There is still a long way to go down the path of development of Chinese eco cities. We will include the experience of the construction of the low-carbon city, the sponge city, the smart city, the garden city and the forest city in China and learn from overseas perspectives on the construction of eco cities. By respecting the law of urban development, transforming the mode of urban development, perfecting the urban management system, improving the abilities of urban governance, making every effort to solve problems such as "urban diseases", improving the quality of the urban environment, people's lives and the competitiveness of the city, building a modern city which is harmonious, livable and vibrant with distinctive features, and improving the standard of new urbanization, we will find a way of progressing the development of Chinese eco cities.

Jingyuan Li

Acknowledgments

China's ecological development has already become the subject of a national strategy. Cities are the birthplace of human civilization and the matrix for human economic and social development. They embody modern civilization, functioning as hubs of economic, political, cultural, and social activities. The construction of eco cities is the historical meeting point of ecology and urbanization, both representing and leading the process of up-to-date construction.

To merge the concepts of ecological civilization into the guidelines of urban development to create a beautiful China, this team of Chinese scholars is exploring a new way of Chinese eco city development. This new way of development shows China's responsibility and obligation to actively address global climate change. ***The Report on the Development of China's Cities*** is the theoretical crystallization of researchers' endeavors. Adhering to the state's five-point development concepts of "innovation, coordination, eco-friendly development, openness and shared development", we both respect and comply with the laws of modern urbanization. Motivated by the concepts of green development, a circulation economy, low-carbon lifestyles and the city's habitability/livability for people, the research aims to better serve the goal of modernization while helping humans to improve their happiness index and achieve comprehensive personal development. We try to improve the general public's ecological awareness, provide consultation on decision making and give guidance to inform the engineering practices of eco city construction, as well advocating and leading green development. By integrating eco city concepts into the process of urbanization, we present some basic ideas on the construction of an eco-city: "Integrating the ecological environment, green lifestyles and environmentally friendly production with the development of cities and towns; Supporting the development of eco cities with ecological gardens and green communities; Linking cities with agricultural zones, natural zones and cultural zones; Joining the hands of government, business, NGOs and the general public in order to build eco cities; Focusing on people-oriented green development."

We uphold the concepts and the standards of the green development of eco cities. Taking general demands and featured purposes into consideration and using "big data" technology, we have built a dynamic evaluation model in order to comprehensively examine 286 cities, ranking them in accordance with the government's input in city development and its output effects, as well as with the progress of smart city construction. The report follows the principle of "categorized evaluation, categorized guidance, categorized construction and phased implementation", and points out the key targets and challenges for the annual construction work in the green development of each city accordingly. Along with the evaluation, the report presents countermeasures against urban diseases such as haze/smog, traffic congestion and environmental degradation.

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Part I
Exploring the Theory and Practice of Ecological City Construction in China

Chapter 1
The Principle of "Following the Way the Human Body Works" in the Construction of an Eco City

Juke Liu and Tao Liu

Abstract "Of all creatures, man is the most highly endowed." A human body is perfectly structured, quick-witted, responsive, coordinated, and flexible. Enlightened by such a configuration, structure, functions and working systems, we have arrived at innovative management principles such as "Following the Way the Human Body Works", "One Centralis", "Tertiary Structure and Two Stage Reflex", "Five Processes", "The Function of Information", "Self-regulation of Organs", and so on. The application of such principles in the construction of an eco city is helpful in bringing the city into full play in the promotion of eco-civilization, and especially in improving values, means of production, lifestyles, green development, and the promotion of harmony between man and nature and between man and society.

Keywords Following the way the human body works · Eco city · Green development

1.1 Introduction

Eco-civilization refers to an advanced form of human civilization. This form of civilization is more advanced than both the hunter-gatherer model and the industrial model. The construction of an eco-civilization was proposed in the Eighteenth National Congress of the Communist Party of China. In this sense, an ecological

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city is in demand at this time as people are working to realize the great Chinese Dream. As such, eco-civilization is part of the government's strategy for advancement and as such there is a real will to promote it.

The construction of eco cities is where eco-civilization and urbanization go hand in hand. Eco-civilization is the natural choice if man and nature are to exist in harmony and urbanization is the inevitable course of modernization. Therefore, eco cities are the only road China can take in its process of urbanization. In a people-oriented society, "people's natural health is the top priority of green development, and an ecological environment is the fundamental guarantee of such health" [1]. Above all, the fundamental guarantee of such health is to build green, intelligent, low-carbon, livable cities.

By "Following the way the human body works" [2], we intend to design and plan the construction of an urban eco-civilization through following the knowledge of how a human body shapes and structures itself and how it functions, operates and commands itself. This principle is expected to help improve the relationship between man and his urban surroundings, and between cities, the natural environment, values, modes of production and lifestyles. It is also hoped that the economy can be developed alongside the development of eco-civilization, and that this will promote the construction of eco-civilization through the construction of eco cities, and will enhance civilization in an all-round way by keeping to the principle of putting people first. By so doing, it is anticipated that there will be an improvement in man's overall development, in sustainable social and economic development and there will be a realization of the harmonious development of man, nature, and society.

1.2 Research Methodology

An anthro-sociological method is adopted to construct and manage the eco city, following the concept of how a human body configures itself, how it functions, moves, works and manages itself. By analogy, somatic science is applied to the management of social and urban organisms, making clear the relationships between humans and society and between humans and their environment. This methodology is aimed at improving urban management as well as human health and living standards.

1.3 Results and Findings

The research findings point to management principles such as "Following the way the human body works", "One Centralis", "Tertiary Structure and Two Stage Reflex", "Five Processes", "The Function of Information" and "Self-regulation of Organs" etc.

1.4 Conclusions and Discussion

1.4.1 The Management Principle of “Following the Way the Human Body Works” in the Construction of an Eco city

1.4.1.1 The Motivation of the Management Principle of “Following the Way the Human Body Works”

Why should we follow the way the human body works? Because human beings have evolved into a superior form of life following three million plus years of evolution. The configuration of the human body is deemed by aestheticians to be one of the most harmonious and balanced things in existence. The physiological functions of the human body are considered by physiologists to be the most scientific and perfect, and a human’s mental ability is regarded by philosophers as the keenest, richest and deepest. Human languages are unique and are referred to as the second signal system by Pavlov (the functional system of the cerebral cortex’s response to the first signal system). The second signal system is human specific. In addition humans are able to generalize the physical world through language as well as to conceptualize it and make inferences. In this way, humans can improve their cognition so as to have a better understanding of nature and the surrounding world, constantly discovering and mastering natural laws.

The human body is an entity where the soul and body are interactive and interdependent. Since the 1970s and 1980s, researchers in both the humanities and social sciences have enthusiastically taken the “human body” as the object of their research. They have studied it from many different angles including the physiological, social, religious and ideological. The aim is to have a better understanding of human beings themselves through research into human bodies and how they work. For instance, Edward B. Taylor, the well-known British anthropologist and “the father of anthropology”, authored a book entitled *Anthropology: An Introduction to the Study of Man and Civilization*, which studies both human bodies and the civilizations these “bodies” have created. Taylor’s book covered such topics as physical and cultural anthropology, the central directing system, the perception of information system (including the five sensory organs: skin, muscles, viscera, etc.), the energy supply system, the motor system, the immune and excretory systems, the endocrine modulation system and the reproductive system etc.

“The City as an Organism” in *Eco Cities: Building Cities in Balance with Nature* by Richard Register, an American eco city designer, cites Miller’s analogy of an organism and holds that the cities we live in are also organisms, the sizes of which lie between human communities and the biosphere [3]. Through physical configuration and matching of functions, cells, organs, individual beings, communities, organizations, societies and transnational organizations are regarded as living organisms consisting of different respective subsystems. Naturally, Taylor uses cities, biospheres and even complex buildings—as long as the buildings can "reproduce"—to illustrate the relationship between cities and organisms.

Henri Fayol, one of the distinguished French management thinkers, put forward the concept of "social organisms" at the beginning of the twentieth century. This holds that a social organism is one that is distinct from material organizations. Every member of a social organism can be viewed as an individual cell, and only the combination of the majority of members can give rise to changes and development of the social organism, hence organs coming into being (management organizations). Without an organism, there would be no management and without management social organisms (organizations) would not come into shape in an effective way and be able to maintain themselves [4].

The Book of Changes, the best known of ancient China's six great classics and referred to as the origin of the Way, is an attempt to discover the relationship between humans, the universe and changes through history. *The Great Appendix* (Sect. 1.2) has it that "Anciently, when PaoHsi had come to the rule of all under heaven, looking up, he contemplated the brilliant forms exhibited in the sky, and looking down he surveyed the patterns shown on the earth. He contemplated the ornamental appearances of birds and beasts and the (different) suitabilities of the soil. Near at hand, in his own person, he found things for consideration and the same at a distance in things in general. On this he devised the eight trigrams, to show fully the attributes of the spirit-like and intelligent (operations working secretly), and to classify the qualities of the myriad of things. The phrase "Near at hand, in his own person, he found things for consideration" [5], means to follow the way the human body works. The ancient Chinese philosophical theory that man is an integral part of nature is expressed in the relationship between man and nature. Laotzu, a philosopher in the spring and autumn periods, believed that the right way to understand humans and the relationship between man and nature was that "Man follows earth, earth follows heaven, heaven follows the Way, the Way follows nature." [6]. *Lingshu* (or *Miraculous Pivot*) in *Huang Di Nei Jing* (or *The Inner Canon of Huangdi*) has it that "man is responsive to heaven, earth, the sun and the moon" [7].

Chairman Mao Zedong put it in this way in *Studies of Physical Education*: "The human body is where knowledge rests and morality lies."

Modern evolutionary theory confirms that the universe has been evolving for at least 20 billion years. The earth first came into being around 4.5 billion years ago [8], and life on the planet began about 3.8 billion years ago, while humans appeared and began to evolve around the Cenozoic period, or 3–4 million years ago. For example, the human brain is an organ of awareness and thinking which has developed over a very long time. When human beings first appeared the brain had over 100 billion neurons, forming a powerful central command over advanced neurological activities. The cranial capacity of humans grew from the 700 ml of early *pithecanthropus* (about 3–15 million years ago) to 1450 ml in later *homo sapiens* (about 50,000–15,000 years ago) [9], a volume approximate to the cranial capacity of modern man.

Human society (including the management of cities) was born with the appearance of humans themselves and developed as humans themselves developed. Management came into being when primitive people worked and lived together. According to *The Concise Edition of General History of China* by Fan Wenlan, “primitive communes did exist in immemorial times of China”. In *General History of China* by Zhou Gucheng it states that, “The development of the Chinese nation, just like that of many other nations, experienced millions of years of primitive communes without classes” [10]. *The Concise Edition of the World History* edited by Liu Minghan and HaiEnzhong put it in the following way: “There is no recourse available to the knowledge as to how primitive people organized themselves. Speculation points to the conclusion that there were 30–50 *pithecanthropus* in a commune, and 70, 80 or 100 of them in the early evolutionary stage of *homo sapiens*. Those people worked and ate together. It is possible that the experienced and aged were responsible for management. In this case, a group of humans constituted a primitive commune.” This means that there were “groups” of humans in the early stage of the development of *pithecanthropus*. It further indicates that there existed management-like “command” and “administration” in primitive communes. A long period of historical development has passed from classless primitive management to modern management science. The publication in 1911 of the famous *The Principles of Scientific Management* by Taylor, “the father of scientific management”, marked the birth of management science.

The principles of management refer to the fundamental laws that have to be observed in management. They highly synthesize, abstract and generalize practical management. For example, the various management regulations and methods that mirror the objective requirements and general laws of management. Therefore, they provide universal guidance in all areas of management (including that of cities).

The birth of management science took place only a century ago. However, human bodies have been evolving for more than three million years, and this includes the human brain, which even the most powerful computer is not comparable to. In this sense, the construction of eco cities should “follow the way the human body works”.

It is true that the structure of the human body is not equivalent to a social structure. However, the fundamental principles of Marxism maintain that human beings bear dual attributes: natural and social. In this sense, it is scientific and natural to construct eco cities following the way the human body works.

1.4.1.2 The Structure, Functions and Operative Features of the Principles of “Following the Way the Human Body Works”

The idea of “following the way the human body works” offers a model of eco city organization. It can be applied to the functions of organizational structure and to the operating mechanism of the operative features.

The structural features: after more than three million years of evolution, human bodies are highly complex in structure—there are systems to meet all of the body's demands such as those of energy supply and of the excretory and motor systems etc.

The functional features: human bodies are capable of sensitivity, movement, growth and development, metabolism, and autosynthesis. As a scientifically complex construction, a human body is very well adapted to such functions as advanced cognition, language and writing, coordinating and directing the motor functions of the central nervous system, energy supply, metabolism and immunoregulation etc.

Functional operative mechanism: the motor system is one of the basic features of the movement of organisms. A human body moves on the command of the central nervous system, using bones as levers, joints as hinges, and skeletal muscles as a driving force. A person cannot properly exist without movement and one cannot do without the motor system, either in one's daily routine, while working or playing sports. Similarly, a city cannot develop without dynamism.

In short, it is entirely natural to follow the way a human body works in constructing a city, and in its division of functions, its operative mechanism and its management style as well.

1.4.1.3 The Practical Significance of the Principle of "Following the Way the Human Body Works"

The overall significance: a human body is a whole system where a slight move in one part may affect the whole via a command from the central nervous system.

Both a city and an organization are entire, with various social functions and structural hierarchies. Its operation has to, under the unified command of the "pivot", go by law in socio-political, economic, legal, cultural, educational, military, health, scientific, technological and labor security affairs. Only in this way is it possible to promote comprehensive, balanced and sustainable economic and social development.

Internal stability and its consistent harmony with the external environment of the human body sheds light on the construction of the harmonious society of a city. As the constant vital processes such as metabolism, growth and development, adaptability and movement etc., affect the internal stability of the body, and external changes (either natural or social) exert an influence on the internal environment, it is necessary for the human body to make constant adjustments to various physiological functions (e.g. circulation, respiration, digestion and excretion etc.), so as to maintain internal balance and homeostasis. Adaptability and adjustment to the external environment are necessary for both for internal homeostasis and for the harmony between humans and society and between humans and the environment as well.

The ancient Chinese idea of "valuing harmony" usually goes along with that of "worshipping the mean". Harmony stands for the best order and state—an ideal pursuit. The primary approach to harmony is to follow the "golden mean."

"The virtue embodied in the doctrine of the Mean is of the highest order, but it has long been rare among people" [11]. In saying that, Confucius took "the golden mean" as his approach to maintaining harmony.

The operation of a city must be in line with both intelligent and green development, so as to ensure the harmonious development of man's work, life and the ecological environment.

1.4.2 The Principle of "One Centralis"

1.4.2.1 The Motivation for "One Centralis"

"Centralis" refers to the dominant part of a system, or a central hub. As far as the human body is concerned, it refers to the central nervous system, and for a society it refers to the central institutions.

Human beings are advanced vertebrates. The human brain is a highly advanced and powerful part of our central nervous system, directing and coordinating all advanced thinking and physical movements. As a result, humans were able to evolve from apes to man and become the dominant species on the Earth.

A vertebrate's central nervous system consists of the brain and the spine. The central nervous system is connected to the body and other inner organs by 12 pairs of cranial nerves and 31 pairs of spinal nerves. The system receives perceptive impulses and sends out motor impulses, managing and coordinating all activities of the nervous system—a system that is sensitive, rapid, decisive, coordinative and quick acting.

The centralis refers to a nation, an agency or organization and their sub-agencies. A nation, or a city, can only have one supreme centralis.

1.4.2.2 The Structure, Functions and Operative Features of "One Centralis"

The reason why the central nervous system is endowed with a unified and powerful coordinating function is that it has a special structure. The human brain is the most advanced part of the central nervous system. It evolved over a long period of time into an organ of awareness and thinking. The brain consists of left and right cerebral hemispheres, which are connected at the bottom with numerous (around 0.3 billion) associated fibers, referred to as corpus collosums. The brain's hemispheres are composed of both grey and white matter. Grey matter mainly covers the surface of the hemispheres—an area called the cerebral cortex. The involvement of the brain is mostly demonstrated in the development of the cerebral cortex.

The human cerebral cortex is characterized by: (a) being partitioned and layered; (b) functional cells (or neurons) in all layers of the cortex are connected like a vertical column, which is the basic unit for the cerebral cortex to process information.

As the cerebral cortex is partitioned and layered, some of its areas are endowed with given functions, referred to as functional localization. These areas include the motor area, sensory area and visual area etc. According to Brodmann, the human cerebral cortex is divided into 52 distinctive functional areas, and this is the way the cortex is described across the world (see Fig. 1.1).

In summary, the functions of the central nervous system include integration of perception, information conduction, analysis and judgment, direction, coordination and somatic movement, as well as advanced functions like language and learning, cognition, waking and sleeping, etc. The central nervous system never stops receiving and integrating incoming information from the sensory organs distributed in every part of the body, and is constantly deciding what reactions (or reflexes) the organisms should make. In this way, the organism is highly unified.

It should be noted that although the central nervous system is very powerful in coordinating responses, this function is directly or indirectly adjusted depending on the needs of the organisms. That is, not all activities are subject to the command and coordination of the central nervous system. For example, the adjustment to the visceral organs is mostly done indirectly and the beating of the heart is adjusted indirectly through autonomic nerves.

The principle of "one centralis" suggests that the reform of a city's management system should be in line with the following principle: a city or an organization should have only one unified leading center. The structure of the center dictates that it works in a hierarchical way, depending on different sections. The change of functions should start from the function positioning and organizing structure. The work flow of the center should be rigidly in line with the five flows making a reflex arc, one of which is dispensable.

1.4.2.3 The Practical Significance of "One Centralis"

The principle of "one centralis" is important in the unified leadership of an eco city, in overall coordination and in hierarchical administration.

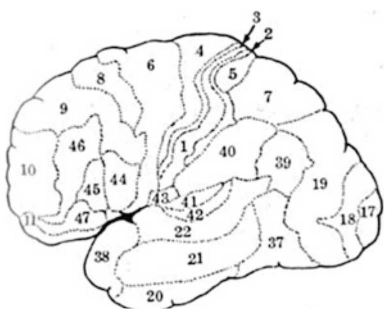

Fig. 1.1 The human cerebral cortex is divided into 52 distinctive functional areas, and this is the way the cortex is described across the world

Unity rests in the unified human body, the body's unified directing system, the harmony of kinesiology, the harmony between humans and society and between humans and nature. For a city, its structure, function positioning and coordination, etc. comprise an independent unit, subject to one unified leadership center. Only in this way can a city develop in an orderly, harmonious, stable and healthy way and its residents enjoy a good and prosperous life.

Overall coordination: a human body can coordinate a harmonious unity between homeostasis and the external world through internal adjustment and adaptability to the environment. For a city or an organization, it is beneficial to follow the way the human body works.

The management of a city should, under a unified center of leadership, determine the layers and position the functions, making the subjects responsible clear.

1.4.3 The Principle of "Tertiary Structure and Two Stage Reflex"

This principle means that a human body is a tertiary structure, and the conduction of information goes through a two-stage reflex.

Somatic science testifies to the bureaucratic stratification suggested by Max Weber, who believed that the management of an organization is in effect a stratified pyramid. Most organizations have tertiary managing stratifications: policy makers, executives and operators.

1.4.3.1 The Motivation of the Principle of "Tertiary Structure and Two Stage Reflex"

A human body is a tertiary structure with upper, middle and lower components. The nervous structure is the same, having a brain, spinal cord and nervous tracts that connect every part of the body, and the tissue cells—the cell nucleus, cytoplasm and cell membrane. "Humans follow the earth", i.e., the earth is also a tertiary structure. The transmission of information goes through a two-stage reflex in a human body. To be precise, the central nervous system reflects all information from every organ through the spinal cord and brain.

The term "reflex" comes from physics. It was first applied to biology by René Descartes (1596–1650) in the seventeenth century. He noticed that all the activities of organisms were regularly responsive to all external stimuli, just like the reflection of a mirror to an incoming light. Therefore, the term "reflex" is used to represent the interaction between the stimuli to the sensory organs and the organism's reactions.

In physiology, the term "reflex" refers to the regular response of organisms to internal and external stimuli, when the central nervous system is present. The most

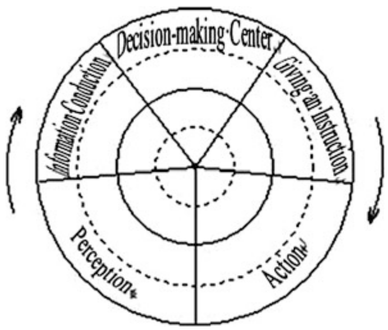

Fig. 1.2 The most fundamental activity of the central nervous system is the reflex

fundamental activity of the central nervous system is the reflex. Any reflex has its given pathway called a reflex arc, which is the structural basis for reflection (see Fig. 1.2).

There are two kinds of reflex in a human body: the inborn reflex and the reflex acquired through learning and training. The idea of a “conditioned reflex” was first put forward by Ivan Pavlov, the great Russian neurophysiologist at the beginning of the twentieth century. It was later referred to as the “classical conditioned reflex”. The formation mechanism of this conditioned reflex laid the foundation for further studies of learning and memory and was very instructive to the work on “the management principle of the reflex arc” in this research.

The human central nervous system is locational and stratified. Each reflex has its own pathway—or reflex arc. A simple reflex is completed by the spinal cord, while a complex one should also involve the cerebral cortex.

The experiment of the knee-jerk reflex confirms that the reflex center of simple reflexes (monosynaptic reflexes) lies in the spinal cortex. Such reflexes are very rapid, the impulse travelling at about 0.6 ms. The spinal cord is also the lower reflex center of some visceral organs involved in defecation and urination.

1.4.3.2 The Structure, Functions and Operating Features of “Tertiary Structure and Two Stage Reflex”

The human central nervous system is hierarchical and stratified, facilitating a quick response to both “internal” and “external” information and subsequent decision making. Hence, it can be seen as the optimal model.

Since the issue of organization was first presented and studied systematically by masters of classical organizational theory such as Taylor, Fayol and Weber at the turn of the twentieth century, many other theories have emerged such as Classical Organizational Theory, Behavioral Science Theory, Contingency Theory, Environment Determining Theory, Organizational Economics, Learning Organization, and Restructuring Theory etc. These theories produce an insight into organizational structure and offer differing perspectives on it. They play a leading role in the development of this discipline.

The principle of "Tertiary Structure and Two Stage Reflex" created a scientific base for the organizational structure of Chinese eco cities with regard to construction and management. In terms of structure, there must be as few intermediate agencies as possible. Simple reflexes are processed by the central nervous system at a lower level and complex ones at a higher level. In this case, there are fewer hierarchies and a lower cost, but better efficiency. Additionally, directions are flexible, accurate, and economical. A new concept termed "systems thinking and learning organization" [12] was advanced by Peter M. Senge, and this concept demands "flat" organizations (with as little intermediate management as possible). This idea and the principle of "Tertiary Structure and Two Stage Reflex" bring out the best in each other. Michael Hammer and James Champy from MIT put forward the idea of organizational restructuring in 1993, which attaches importance to work flow as a center and claims to redesign the structures and procedures of businesses [13].

The span of control and management hierarchies is among the key issues in organizational structuring. How many hierarchies and how much span are scientific and rational for an organization? It depends on the size and the need for efficiency of the organization in question. There is some correlation between the span and the hierarchies. Given a certain size, the hierarchies and the span are in inverse proportion. That is, the wider span, the fewer hierarchies and vice versa. Given a certain span, the hierarchies are in proportion to that span. That is, the wider span, the more hierarchies there are. Generally speaking, the more hierarchies there are, the slower the communication of information and the higher the probability of information distortion. The wider the span is, the more difficulties in coordination there are and the greater the possibility for overstaffing and management inefficiency. Therefore, Max Weber, a leading German organization theorist, believed that bureaucracy based on rational-legal authority is the optimal form of organization and the most efficient form for human kind is "the optimal form of bureaucracy."

As to the span of internal management, Henri Fayol's Organizational Growth holds that an organization develops by geometric progression, with a leader of 15 and a common ratio of 4. That is, at the base of an organization, every 15 members are subject to a person in charge and above that rank every 4 such persons are led by a superior. In contrast, the 7S Molecular Diagram of Management claims that the optimal span is seven. Wider than that, it would be difficult to control and narrower than that it would be possible to leave out important projects. Some Chinese researchers, based on statistical analysis, suggested a 2/8 rule of leadership span: in an ordinary organization, a principal leader should be supported by two deputies and eight subordinates and a deputy should be accompanied by two assistants and eight subordinates.

In philosophy, "stratification" describes categories of differing hierarchies in a system. Every system has stratified parts. For instance, matter can be divided into molecules, atoms, nuclei, "fundamental particles", and so on. Similarly, advanced lives have systems, organs, tissues, cells and biomacromolecules, etc. Stratifications subordinate to and live on structure. As an “anatomy” of the whole, stratifications embody the structural order, distinctiveness and diversity of the structure as a whole. Such distinctiveness and diversity are in unified and regular connection.

This study holds that the proper span of control and hierarchies, as well as the ratio between the two, are scientific. The principle of “Tertiary Structure and Two Stage Reflex” provides a proper span and hierarchy on a scientific basis. Using this principle, there are fewer hierarchies and therefore lower costs and greater efficiency. It is the best way to bring management functions into full play, such as organizing, information transmission and reflexes. It is especially beneficial to the construction of eco cities and information management.

This principle suggests that decision making at the top is indispensable and that workers at the base are also necessary. Only intermediate hierarchies and agencies can be cut down or reduced.

In light of the functions this principle displays and its efficiency in coordinating a body, it is scientific, rapid, accurate, economical and safe [14], bearing a distinctive structure and management of information.

1.4.3.3 The Practical Significance of the Principle of “Tertiary Structure and Two Stage Reflex”

The reform and innovation of municipal management organizations according to the principles of “Following the way the human body works” and “Tertiary Structure and Two Stage Reflex” have lots of advantages such as fewer hierarchies, lower costs and greater efficiency as well as being scientific, economical, rapid, accurate and safe etc. They guarantee a reasonable organizational hierarchy and information flow, along with scientific and competent decision making.

In line with the principle, the construction and management of eco cities can better coordinate functional departments and different hierarchies, which in turn guarantees the unity and authority of the party and municipal disciplines and policies.

Concentration and separation of power. Observation of the central nervous system shows that numerous regular and simple reflexes take place in “local” areas, while more complex ones have to turn to more advanced parts. This structure offers an insight into the concentration and separation of power, making sure that a greater separation of power goes to the base on the condition that concentration of power and unity remain intact.

Tertiary Structure, Two Stage Reflex, and lateral communication. The principle highlights longitudinal hierarchies, and both longitudinal and lateral communication of information. It also applies to communication among municipal functional departments, and the longitudinal hierarchies between cities, and also to both lateral and longitudinal information communication. In contrast, Fayol Bridge emphasizes the importance of information communication between parallel organizations.

The fundamental purpose of the Chinese Communist Party is to put people first, keeping close ties with them and serving them whole-heartedly. Face-to-face communication, such as keeping in contact with people, conducting investigations, getting access to the base, comprehensive analysis, information feedback and the guiding of work etc., facilitates access to the conditions of people, the implementation of both Party and national guidelines and policies and also the lasting contact between the Party and the masses.

1.4.4 The Principle of “Five Processes”

This principle drew upon the fundamental law governing the working of the human central nervous system and it is applied to the management of procedures.

1.4.4.1 The Motivation of the Principle of “Five Processes”

The basic process of nervous actions is the reflex. This refers to the regular response of organisms to “internal” and “external” stimuli, when the central nervous system is present. In the process, information flows regularly through the reflex arc—the basic structure of reflex. The reflex arc is a pathway through which any reflex takes place. It consists of five parts: receptor, afferent nerves, reflex center, efferent nerves and effectors. When a stimulus acts upon the receptor—a structure specialized in receiving stimuli (such as eyes, ears, nose, tongue, skin, muscles and viscera etc.)—it transforms the stimulus into an action potential (a nervous impulse), which goes through afferent nervous fibers to the pivot, where the incoming information is analyzed and integrated, and then the pivot sends out directions through efferent nerves. Finally, the efferent nervous fibers command the effectors (such as the motor system or the visceral system) resulting in changes to the organs involved. Any reflex takes place only when these five parts work together. Damage to any of the five will cause the failure of the reflex. The afferent and efferent nerves are the pathways that connect the reflex center, receptors and effectors (see Fig. 1.3).

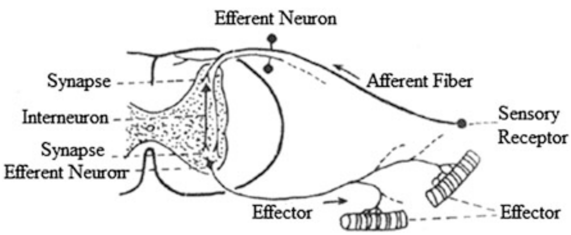

Fig. 1.3 The afferent and efferent nerves are the pathways that connect the reflex center, receptors and effectors

The term human reflex covers both inborn reflexes as well as conditioned reflexes that are acquired through learning and training. There is also an operant conditioned reflex (or instrumental conditioned reflex), corresponding to the conditioned reflex. Most human knowledge and experience come from later learning, memory and training. That is, human beings are able to build up multi-conditioned reflexes in order to adapt to changes in the environment and thereby meet their survival needs and development. This is significant both in management science and sociology. In order to promote the progress of human civilization and socioeconomic development, a state or a society, based on its needs in different times can build up a series of institutional orders of socio-economics, politics, culture, society and ecology, etc. through laws, regulations and policies. Every member can build up new values, and political, cultural, social and ecological outlooks enabling it to adapt itself to new needs and social changes by receiving guidance, training and education. By doing so, it is possible to improve working life and lifestyles and to promote the overall development of the individual as well as harmonious and sustainable social and economic development.

1.4.4.2 The Structure, Functions and Operating Features of the "Five Processes"

The basic process of the central nervous system is the reflex and the structural pathway of the reflex is the reflex arc. The functions of the arc go through five pathways: information reception—afferent information—decision making in the pivot—sending out direction—command of actions.

The major functions of the processes are perception, introduction of information (uploading), integration of information (decision making), giving direction and motor command functions etc. Such conditioned reflexes can be created by later learning and training.

These five processes are characterized as being scientific, procedural, normative, accurate and intelligent.

1.4.4.3 The Practical Significance of the "Five Processes"

The paths in management provide a procedural and intelligent standard for procedure management, hence their importance in the construction and management of Smart Cities.

Conditioned reflexes are attributed to human learning, memory, work, daily life, sport, and so forth. The given procedures have to be observed rigidly for automatic actions to take place. For example, new words in a foreign language are memorized by rote learning, skills of experienced workers are acquired through continuous practice and sporting performance is strengthened by non-stop training. All these factors reflect on the extent of human wisdom.

The mechanism of city management should first establish its municipal administration according to the principle of “tertiary structure and two stage reflex”, based on its functions in economic and social development. Each of the functions (including planning, organization, leadership, control, and policy making) has to be fulfilled through rigidly following the five paths. The decision making center, due to its decisive role, should be stricter with itself in abiding by the procedures and should lead the construction of a green city in the correct way. The procedure of five processes is applicable to macroscopic, mesoscopic, and microscopic management. Longitudinally, there should be fewer hierarchies for greater efficiency and the management of each hierarchy should be in line with the processes, acting in accordance with the law. Laterally, there must be exchanges of information across counterpart departments and agencies between cities. For example, the first step in city planning is to conduct investigations and get full knowledge of the relevant facts. Then the information concerned is gathered and reported to superiors. Next, the leading center must make a choice from the proposals available and then make a decision. Thereafter, the plans are made known to the lower levels. The final step is to carry out the plans. As far as the rational allocation of social resources is concerned, the procedure of the five processes should also be followed in order to plan and make full use of all the resources in a way that is energy saving, efficient, environmentally friendly and recyclable.

A management system of a modern city usually covers population flow, material flow, energy flow and information flow. The first three flows are the major ones in terms of the management system. How well they run depends on whether the information flow goes smoothly, and decides the fate of the management. Therefore, it is the prerequisite for the construction of a smart city.

Michael Hammer and James A. Champy were the first to put forward the idea of “Business Process Reengineering” (BPR) in 1993, to reflect on the basic issues of the process of business and to carry out a thorough redesign of it [13].

Peter F.Drucker advanced the “principle of priority” (management by objectives) in his book *The Effective Executive* [15].

“Steps” adopted in ancient China’s I-go game.

Both programming and applications in modern computer technology highlight the importance of “process”, “priority”, “steps” and “programs”, etc. In traditional management science, the process covers four steps: planning, organization, leadership and control. W. Edwards Deming, an American engineer, suggested another four steps: Plan, Do, Check and Action, referred to as the PDCA Cycle. There is also a suggestion of three further steps: decision making, execution and examination.

The principle of the reflex arc indicates that there are five processes in management and this standard is applicable to every field of management and the hierarchy of cities, countryside, society, businesses and schools. It runs in circles and spirals without end.

1.4.5 "Following the Way the Human Body Works" as an Information Management Principle

How a healthy human body perceives, conducts, stores and analyses information and then makes decisions and takes action is exemplary to the construction of a smart city.

1.4.5.1 The Motivation of "Following the Way the Human Body Works" as an Information Management Principle

The human "pivot", composed of the brain and spinal cord, is unrivalled in its complex structure, powerful functions and quick response time. In short, it is highly scientific. The nervous network that spreads to every part of the body continuously receives and transmits information of any kind of slight changes inside and outside of the body, and never stops conducting the adjustments the pivot makes through the network, ensuring internal balance and homeostasis as well as the body's adaptability to changes in the external environment.

The transmission and regulation of information by the nervous network aids the human body to work completely harmoniously as a whole system. As a result, every organ performs its functions very well under the unified coordination of the superior pivot and plays a role in maintaining vital movements. On the one hand, the human body fits extremely well into the changing environment, and on the other, it improves the environment that mankind lives off through its own "wisdom and power".

The term reflex refers to the process whereby information flows regularly through the reflex arc. Information, whether it is coming in or going out, travels along nervous fibers. The human nervous system has many complicated and powerful functions, due not only to the 10^{11} neurons in the central nervous system, but also to the fact that all the neurons are interconnected, forming multi-layer neural circuits and a vast network, which provides a structural basis for the conduction and processing of all information.

Neurons (or nerve cells) are the basic constituents of the nervous system. Synapses are the points where neurons are closely linked for the transmission of information. There are over 100 billion neurons in the central nervous system and each neuron on average has about 10^3 synapses. Such a structure is the basis for the nervous system to perform its complicated functions. There are three ways for information to be transmitted between neurons: chemical and electronic synaptic transmission, and non-synaptic chemical transmission. As there are numerous neurons in the central nervous system, they are connected in different ways: between two and many ends, and by feedback circuits (see Fig. 1.4).

The human cerebral cortex is localized, stratified, and columnar in structure and is the place where information is processed.

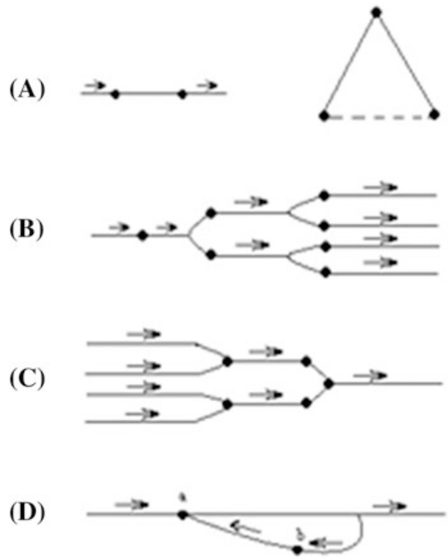

Fig. 1.4 Numerous neurons in the central nervous system, they are connected in different ways: between two and many ends, and by feedback circuits

1.4.5.2 The Information Structure, Functions and Operating Features of the Principle "Following the Way the Human Body Works"

The structural basis for perception of information, conduction, storage and analysis is the nerve center system composed of neurons, nervous fibers and the pivot.

Information is perceived, conducted, analyzed, processed and adjusted through the nervous network so that the body keeps an internal equilibrium and an exo-adaptation and performs every complicated task required in daily life.

Information transmission through nervous fibers is insulated, one- or two-way, non-attenuated, coalescence-proof and synapse-fatigued.

Information management involved in the construction of a smart city should follow the way the human body structures information, functions and operates.

1.4.5.3 The Practical Significance of the Principle of "Following the Way the Human Body Works"

It is important for the construction of a smart city to follow how the human body perceives, conducts, stores and analyses information, and subsequently makes decisions and takes actions. The principle at issue indicates the importance of information. Information is an indispensable factor in management. Therefore, we believe that "information" should be an important function of management. Since Henri Fayol, a French master of management, first proposed the idea of five functions of management (including planning, organization, command, coordination and control) in 1915, many other western scholars in this field have made improvements based on his idea. As a result, the ideas of three, four, five, six, and even seven functions emerged, none of which covers the "information" function.

Much can be learned from how the central nervous system of the human body perceives, conducts, stores and analyses information and this learning can be applied to the construction of a smart city, especially in terms of information gathering, construction of communicative facilities, big data and cloud computing as well as in scientific decision making. There are three notable areas in terms of this learning: the construction of the city management center, the development of information technology and the infrastructure of information. A complete information management center of a city can be built in line with the principles of "one centralis", "tertiary structure and two stage reflex" and "five processes" (the center—the network—neurons—information gathering places—the effectors of the operation of a city) and the innovation and development of information technology. Advantage should be taken of the features of information transmission such as being non-attenuated, insulated and one-or two-way, etc. [14] in order to ensure that transmission is safe, timely and accurate. A decision making mechanism should be built based on big data and cloud computing and the construction of the infrastructure for information should be improved.

"City neurons" are composed of people, material, energy and information etc.

1.4.6 The Principle of "Self-regulation of Organs"

The mechanism of self-regulation is applicable to the construction of the regulatory mechanism of an eco city.

1.4.6.1 The Motivation of the Principle of Self-regulation of Organs

The principle of self-regulation of organs is based on the mechanism of following the way the human body works. A human body never stops its internal self-regulation and adaptation to the outside environment in order to keep its dynamic balance and harmony with that environment.

It is necessary for the body to make constant adjustments to all physiological functions (such as blood circulation, respiration, digestion, excretion, etc.) so as to secure an internal equilibrium (balance) and homeostasis, as the changes in both natural and social environments exert their influences on the body, and as non-stop vital movements impact on the stability of the internal environment such as metabolism, growth, development, adaptation and vitality etc.

A human body usually regulates itself in three ways: nervous regulation, humor regulation and self-regulation.

Nervous Regulation

Nervous regulation is the major form and channel of regulation in an organism. Many physiological functions are regulated through the nervous system, hence the name. The basic component of the nervous system is the reflex, the most important regulatory mechanism of an organism. Each reflex runs through its own pathway called a reflex arc. The reflex center refers to the group of nervous cells that regulate a given physiological function in the central nervous system. The reflex of the human central nervous system travels through the spinal cord and the brain.

The nervous system regulates the movement of the body and viscera. This regulation varies with the complexity of the movements involved. From the reflex response to simple body movements, to the efforts to maintain normal actions and the arbitrary movements of complex actions. Simple reflexes go through the spinal cord while more complex ones go through both the spinal cord and the brain. The regulation of visceral movements takes place when automatic and central nerves work together. By automatic, we mean body movements that are in sharp contrast with those obviously controlled by conscious thought. Such nerves are relatively independent and free from the regulation of consciousness. For instance, the beating of the heart is automatically rhythmic and free from conscious control. Most of the regulation by the central nerves takes place indirectly.

Humor Regulation

This refers to the fact that when some histocytes secrete special chemical substances, such substances, through humor circulation reach and act upon the target organ, regulating the physiological movements of the target organ or tissue. Such regulation is relatively primitive and widespread in physiological functions. It enhances the metabolism of substances and energy in the organism, promotes growth and development, and affects both the growth and functions of the nervous system.

Self-regulation

Some regulations depend on neither nerves nor humor. Instead, some cells (individuals), tissues or organs, by their own character, adapt themselves to changes in the internal environment, hence the name.

The self-regulation mechanism of cells, tissues and organs was the very important scientific motivation for the authors of this study to discover and propose the principle of “self-regulation of organizations”.

1.4.6.2 The Structure, Functions and Operating Features of the Principle of "Self-regulation of Organizations"

Cells are the basic structural and functional units of human bodies and other organisms. All the physiological functions and bio-chemical reactions take place at the cellular level and such activities embody the basic life processes and mechanisms of organisms.

Nervous regulation, humor regulation and self-regulation have their own characteristics: nervous regulation is rapid, effective, and accurate; humor regulation is slow, long lasting, dispersive and constant, covering a wider acting surface, and plays an important role in the regulation and maintenance of homeostasis of vital processes such as metabolism, growth, development and reproduction; and self-regulation is weak and insensitive, affecting fewer areas with the effect being confined to certain organs or cells. Anyway, it remains important for the regulation of movements of the organs or cells concerned.

The regulation of human physiological functions varies, with some taking place in a single way, while others take place in two or more ways. For example, some of the "nervous-humor regulations" are performed by the central nervous system directly, and some indirectly. Different regulations operate simultaneously and in their own styles. They are closely related and work together, maintaining homeostasis of the internal environment and guaranteeing the continued operation of the organism's physiological movements.

The adaptability of the human body refers to the adaptive responses it makes to the external environment depending on its own regulation and improvement.

1.4.6.3 The Practical Significance of the Principle of "Self-regulation of Organs"

The self-regulatory mechanism of physiological functions offers an insight into improving the regulatory mechanism of a city, thereby creating a stable and harmonious social environment and building a clean municipal government.

Self-regulation of a city as an organization means that the organization makes adaptive reactions and changes its movements when there are changes to the internal environment, in order to maintain its internal equilibrium.

The basic means for a city as an organization covers internal regulation and exo-adaptation. The fundamental ways are through self-discipline and heteronomy.

The establishment of a self-regulation mechanism should also be in line with the framework that covers governmental regulation (including judiciary regulation), social regulation (including societies and various academic bodies) and self-regulation of the organization, along with the self-regulation of government, societies and various other organizations. Such a framework is expected to regulate and solve a variety of serious issues and problems that arise at all levels of city organization during the construction of an eco city so as to maintain urban stability, promote social harmony and guarantee sustainable social and economic development.

The central nervous system regulates directly and indirectly depending on the needs of the organism and so does the management of a city. Ronald H. Coase put forward the idea of transaction costs in his *The Nature of the Firm* in 1937. This is an important concept in economics and organizational theory. A transaction cost is a cost incurred when making an economic exchange. Any economic exchange incurs a cost, which varies with differing means of exchange. Exchanges between organizations generally take place in two ways: through the market or through the hierarchy. Which of the ways is chosen depends on a comparison between the transaction cost and the management cost. If the former is greater than the latter, some external activities will be replaced by internal ones which take place across the hierarchies, and vice versa. In short, the market is better for simpler transactions while hierarchies are better for more complex ones. This provides a theoretical motivation for municipal and market regulations.

Government regulations are rapid, powerful and accurate, while social regulations are slow, complex and long lasting. In addition, self-regulations by various organizations (including individual citizens) are also important and/or indispensable.

It is a natural need to establish learning and self-regulating organizations in order to construct a harmonious city and a clean government.

Humans and society, and humans and nature are highly interconnected. Each body is a "mini society" and each citizen is a "mini environment". Somatic science is analogous to the construction of an eco city. The principle of "following the way the human body works" is applicable to the construction of an eco city, and is supported by principles such as "one centralis", "tertiary structure and two stage reflex", "five processes", "information function" and "self-regulation of organs". It is the only road to take to build Chinese style eco cities and to make sure a harmonious development between man and environment and between man and society happens.

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Chapter 2
Construction of Eco Cities in China in an Information Age

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Abstract In China, eco cities are constructed against a background of informationization. As a result, mutual integration and promotion between informationization and ecologicalization are new features in the construction of modern eco cities. The present report devotes some comments to and analyses the positive influences from informationization upon the construction of modern eco cities in China. It also presents some of the problems and challenges resulting from such a process, and offers solutions and suggestions that may help alleviate them. All the work done in this report is based on the changes that have occurred in our era, and on the relatively new concept of ecological conservation and on the evaluation system of eco cities.

Keywords Eco cities · Ecological conservation · Informationization · Smart cities

2.1 Introduction

With ever faster social and economic informationization, mankind is advancing into a completely new age—the information age. This is due to the increasing popularity of computers, mobile phones and the internet. This is also an age when ecological crises and "city diseases" occur so frequently (and in such serious ways) that countries all over the world are making efforts to build eco cities. The phrase "eco cities in an information age" refers to those modern cities, built against a background of informationization, based on the concept of ecological conservation, whose construction is done so that information resources and technologies are applied soundly such that the city plans are optimal and attractive, the extent of the

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circular economy is increased, the green consumption of citizens is promoted and their living conditions improved. It also means that the management and livability of cities should be upgraded in such a manner that a harmonious relationship between man and nature, man and society, and between individuals can be established on the basis of highly advanced productivity. All in all, mutual integration and the promotion of informationization and ecologicalization are the new features in the construction of modern eco cities. As the largest developing country in the world, China has to choose between industrialization, informationization and ecologicalization in its process of urbanization. The country is also confronted with a shortage of resources and energy as well as a deterioration in its environment. So, building eco cities turns out to be an unavoidable choice if we are to achieve sustainable urban development. This report attempts to analyze the current situation of eco cities in China in an information age and to find the direction, policy and route for the construction of eco cities against a background of informationization.

2.2 Research Methodology

Literature survey method, Observation method, Quantitative research method, Information research method, Experiential Summary Method.

2.3 Results and Findings

2.3.1 Reshaping of Eco Cities in China by Informationization

When eco cities are constructed in China, information technology is adopted so that it exerts a wide and profound influence upon the concept of what cities are, the planning of cities, the infrastructure found within cities, the way of life and productivity of cities and the management and service systems of cities.

2.3.1.1 Information Technology Has Changed People's Ideas About Building Eco Cities and Upgrading Their Planning and Design

Careful application of information technology has assimilated informationization into people's ideas about building eco cities. At present in China, before every possible draft of city design, computer simulations of proposed changes using spatial technology are commonly run enabling computers to process various data such as the plane figure, or the distribution of residents and industries. This results in a virtual digital sand table, so that by processing the data each developing trend and outcome of the city is displayed virtually in front of the designer. During human-computer interaction, defects in many of the plans and designs are clearly identified. Data applied in virtual digital sand tables are entirely true statistics and if any change to the design is necessary it is achievable by adjusting the relevant data. Such changes are quick and easy with visible results and thus losses from unscientific planning or unreasonable design are greatly reduced. One of the typical cases is the design project of "the Square Island" in the new eco city in Wuhan New District. In this project, in addition to terrain simulation, earthwork fill dig, land selection, traffic network, wind conditions, sunlight analysis and the like, are all scientifically simulated by computer [1].

Eco cities of the information age are relevant to all residents, so it is necessary to put into practice the idea that all residents should be involved in the construction of the city. Information technology has made it possible for the general public to participate in the planning and design of eco cities. In the old days in China, the government was mainly responsible for planning and designing cities and any channels for public participation were rather limited. Though there are methods such as "open government policies" from government departments, proposals from NPC representatives and CPPCC members, oral inquiries from citizens and questionnaires filled out by the public, public participation is still at a low level and is also rather inefficient. Since entering the information age, the Chinese government usually has messages and questionnaires about city construction delivered through official websites or by We Chat and micro blogs etc, in order to canvas public opinion. This is both an easy and reliable method, so electronic surveys are widely applied to every aspect of city construction. The Questionnaire on the Municipal Infrastructures of Hefei, issued by Hefei Planning and Design Institute of Anhui Province in 2014 took the shape of an online survey [2], from which plenty of proposals and suggestions were obtained.

2.3.1.2 Informationization Reshapes the Infrastructure of a City, Making It Easy, Convenient and Human Oriented

Infrastructures in Chinese cities are steadily being informationized and the level of informationization is increasing. This means that most citizens are able to enjoy the conveniences brought about by informationization. On the 21st of November, 2015, the three super platforms for users—Tencent news to clients, We Chat and the mobile phone app. QQ—all participated in "Beijing Urban Services". They offer a service to over 20 million users. Tencent also signed cooperation agreements with the Municipal Transportation Bureau, the Local Taxation Bureau, the Weather Bureau and the Network Security Team of the Public Security Bureau of Beijing, launching the notable joint enterprise called "internet plus". This reflects the situation that the strategy of "internet and intelligent cities" is now in full swing [3].

In China, the information network covers almost all parts of almost all cities. Digital cable radio and television, terrestrial digital broadcast and television, satellite digital broadcast and television are growing rapidly and are being transformed from simulated types into digital ones. By the end of 2014, China had 231 million cable TV users and 187 million digital cable TV users. The comprehensive population coverage of radio and TV was 98.0 and 98.6 % respectively. The number of mobile broadband users was 582.54 million, an increase of 180.93 million over the previous year. The number of internet visitors is 649 million, an increase of 31.17 million over the previous year. The number of mobile internet visitors is 557 million, an increase of 56.72 million over the previous year. The internet penetration rate has reached 47.9 % [4]. On April 4, 2013, China's Ministry of Housing and Urban-Rural Development and China's Ministry of Industry and Information Technology jointly issued a notice requiring that optical fiber reaches every home in all newly built dwellings in China. Wi-Fi service has been added to railway stations, bus stations, seaports and airports in most Chinese cities. A free Wi-Fi service is also offered in many hotels, restaurants and supermarkets. An increasingly human oriented service is being offered to passengers on the public transit system in Beijing and by December 2014, about 12,000 buses in Beijing had finished their network upgrade, changing Wi-Fi network cards into 4G networks. The bandwidth can be as great as 50 million kilobytes per second, simultaneously providing a free services for at least 40 passengers on one bus [5]. These information infrastructures are able to offer a service whenever and wherever possible in such aspects as electronic government affairs, educational training, healthcare, pensions and crisis disposal etc.

Information technology has turned such things as the remote control of public lighting facilities and water supply facilities in cities into a reality. Some present day Chinese cities have been provided with intelligent distribution boxes of street lamps. In addition to the functions of traditional distribution boxes, these intelligent ones have automatic alarm systems in the case of malfunction. They can also automatically control or adjust the time of their switching on or off of street lamps according to their intelligent perception of sunlight. Intelligent taps used in municipal greening can water lawns and trees by remote control as well. The operating principles of intelligent distribution boxes and intelligent taps are similar. The devices are attached to computers or mobile phones by cable internet or by wireless Wi-Fi. Users can send remote instructions to the lamps or the taps from their mobile phones or desktop computers as long as they have downloaded the specific software relevant to the intelligent distribution boxes or intelligent taps. Intelligent distribution boxes are even equipped with camera sensors, which when connected can monitor the surroundings of the street lamps round the clock. From the intelligent distribution boxes, these monitoring cameras can send vast amounts of real-time data back to the central controlling system, echoing the intelligent terminal systems of other distant cities. Thus a visible "skynet" is created, making intelligent cities that are "sensible, knowledgeable and controllable".

Information technology has also brought about intelligent traffic infrastructure. Information platforms like intelligent urban traffic control systems, intelligent bus dispatching systems and intelligent logistics command systems are widely applied throughout China, which means a new level of intelligent transportation. For example, the intelligent traffic light has changed the traditional switching patterns of fixed times for red and green lights at crossroads. It can make intelligent judgements about switching time according to the data on vehicles and pedestrians automatically obtained from its camera system, thus avoiding or reducing traffic jams caused by the uneven flow of vehicles at two intersected roads. In many cities, arresting fences are installed to bar the way to non-motor vehicles. When the traffic light changes, the arresting fences on both sides of the road facing the red light close automatically. This stops pedestrians and non-motor vehicles from running red lights, thereby avoiding some of the traffic accidents resulting from such behavior.

Different types of huge indoor LED screens can now be seen around cities. These screens are connected to computers and their great advantage is their dynamic display, showing similar messages to tens of people or even hundreds of people. For example, at the airport those who are waiting at the exit can obtain messages relating to the service number of each flight, the departure time, the expected arrival time and the present status (arrived, on time, delayed etc.) of different flights. Screens at crossroads are generally larger and some of them are over 100 m^2 and are clearly visible from 1 km away. At ordinary times these screens are mainly used to advertise ideas and policies about the construction of eco cities, while at times of emergencies they can be used for disaster warning, crowd dispersal and traffic guidance, thus speeding up the dissemination of information.

As stated by Wang Yuesi from the Institute of Atmospheric Physics at the Chinese Academy of Sciences, the biggest source of pollution in Beijing is the automobile, which contributes about 25 % of the annual average total air pollution [6]. In order to exert strengthened controls over automobiles with excessive emissions so as to reduce air pollution, fixed remote sensing monitoring equipment has been installed along the main roads in both downtown areas and suburban districts of Beijing in order to measure vehicle exhaust emissions. According to the plan, it is expected that 150 new sets of fixed remote sensing monitoring equipment and 20 new remote sensing monitoring cars will be facilitated in Beijing by 2017. When remote sensing monitoring equipment is put into use, illegal vehicles with excessive emissions will have no place to hide. This means a shapeless for of deterrence will force such vehicles off the road.

Firefighting facilities in cities have also become “intelligent”. Nowadays, indoor public places in most Chinese cities are equipped with automatic sprinkler extinguishing systems that are available around the clock. Once there is a fire and the temperature in the room rises, the temperature sensitive component within the sprayer (a glass ball) cracks and water is sprinkled automatically to extinguish the fire, while the alarm valve which is joined to the water supply system of the sprayer will be switched on automatically and the fire alarm will be sent to the fire command center by electro-optical signals. According to the acoustic-optical signals given by the alarm lights, the control office of the fire command center will then locate the fire and send out firefighters in the shortest time possible. When there is no fire, the whole firefighting system is in its armed state. The programmable automatic inspection technology can automatically inspect the whole firewater supply system at regular intervals. When there is trouble with the facilities, there are automatic acoustic-optical alarm signals sent to the control center for maintenance.

2.3.1.3 Information Technology Provides Strong Technical Support for Developing Green Production and a Circular Economy in Cities

Production instruments are the key factor in measuring the development level of productivity. Information technology has led to a revolutionary transformation of production instruments. The “internet plus” development pattern has already extended into traditional production in China. Meanwhile, traditional industries have adopted internet technology into their production, management, upgrading and reconstruction. Once more, Chinese businesses are thriving and full of vigor and vitality through informationized research and design, digitized production facilities, intelligentized working processes and networked operation control. One such example is the Yili Industry Group Co., Ltd. of Inner Mongolia, which applies information technology to its dairy production. Each cow has its digitized ear mark, raw milk purchasing lorries are traced by GPS systems and the raw milk gets its bar code at random after entering the plant. During the production process, information about different batches of products are listed on trace tables and the key steps are recorded in the electronic message system. Quality control information is collected into an integrated system and the ERP network system covers the whole country. All in all, information about the product is identifiable and traceable anywhere, at any time, on computers [7].

It is safe to say that the building of vegetable factories in China signifies a revolutionary transformation in Chinese city agriculture in the information age. Electronic computer network control is applied to the whole course of vegetable factories, where plenty of intelligent terminal systems such as cameras and sensors are installed, exerting continuous supervision upon production. Technicians can perform remote examinations and have control over the factories by mobile phone or computer even if they are thousands of miles away. In greenhouses, at least three to five levels of plants can grow, one level above another, thereby drastically increasing the efficiency of space utilization. These type of vegetable factories mainly apply organic ecotype soilless cultivation technology in which the growth medium is not soil, but comprises wastes such as coal cinder, crop straw and the like, thus making the best use of natural resources. The nutrient solution used to nourish the plants can be recycled again and again after disinfection. Under these ideal man-made conditions, the plants have stronger disease resistance and can grow more rapidly. Basically there is no need to spray pesticides over them and their yield can be several times or even over ten times larger than those grown in outdoor conditions. Today, successful plant factories include the “United Farmers and Products” of Pinggu District in Beijing, the “Sanyang Plant Factory” of Wuxi City in Jiangsu Province and “Miracles on the Green Land” of Changxing County in Zhejiang Province etc.

Beginning with intelligent manufacturing, it is an unstoppable trend of the information age that industrialization and informationization are becoming closely integrated, that the key manufacturing procedures of implementation and control are intelligentized and that key posts of men along assembly lines are superseded by robots. In 2013, nearly 37,000 robots were sold in China, which was a fifth of global sales. With total sales surpassing those of Japan, China became the first and largest market for robots [8]. Plenty of industries such as the automobile industry, the electronics manufacturing industry and the food and drug industry all show great interest in industrial robots. On November 5, 2014, a report from the International Federation of Robotics said that the demand for robots in China would still grow dramatically with an annual increase of over 25 %, and that by 2017 market sales of robots could be expected to rise to 100,000 and the population of industrial robots could expand to over 400,000 [9]. These numbers show that industrial production in China is becoming increasingly intelligent, from which a series of revolutionary results will come.

A new trend is beginning to appear in Chinese businesses, which reveals a shift from mass production to personalized production. Based on big data, personalized production is supposed to meet the different needs of different clients by making use of information technology. It is not long since the manufacturing pattern of personalized production appeared, and personalized products were confined to the areas of food, gifts, art wares, clothes and so on. However, with further developments in technology, it is certain that personalized production will extend into such domains as intelligent housing, intelligent vehicles, intelligent marketing and intelligent leisure and recreation etc.

2.3.1.4 Informationization Reshapes People's Way of Working, Learning and Living

Since infrastructures and service and management systems in cities are rapidly being informationized, revolutionary changes are taking place in people's way of working, learning, living and even leisure and recreation in Chinese cities.

Though the level of informationization enjoyed by different citizens may itself be different, and the efficiency of acquiring information may also be different, all ordinary citizens can still obtain most of the information they need from the network. Electronic payment systems of different types enable people to pay various fees without leaving their homes, and electronic shopping websites allow people to select their favorite goods while sitting in front of a computer. Informationization has made it possible to make online payments and this area is developing dramatically. At the end of 2014, TaoBao displayed "TaoBao Bill Ten Years". Statistics show that over the ten years since the foundation of Alipay in 2004, a total of 42.3 billion purchases have been implemented in this network. That is an average of twenty purchases per person of the 300 million real-name users of Alipay [10]. People can buy all kinds of goods online including almost all types of objects from everyday life. Survey results indicate that 28.4 % of users are accustomed to using the network to obtain information about social consumer goods and to share shopping information on social networks [11].

“Home” has been turned into an “intelligent cabin” thanks to informationization. Devices like automatic gas alarm systems, automatic fire alarm systems and intelligent speech recognition entrance guard systems have become indispensable components in intelligent buildings. Intelligent sweeping robots, intelligent rice cookers and intelligent cooking robots have gradually come into common use in households in China. Electrical domestic appliances of different types are all entitled “intelligent”. One example is the new product “CHiQ TV” introduced by the Changhong Company in January 2014. A series of systematic solutions like “multi-screen collaboration, video aggregation, cloud account and smart services” are proposed for technological innovations in this product, thus achieving the goal of “mobile TV, playback for live telecast, programs by genre and easier use”. In addition, people can watch TV freely without the remote control [12].

Revolutionary changes are taking place in people’s learning style. With e-books, people don’t need to travel between their home and the library to borrow or return books. E-books can be saved on mobile phones and can be read at any moment without restrictions of time and place so long as you download the necessary mobile phone software and pay a small fee (some e-books don’t cost anything at all). Reading software like “scholar reader” not only allows the individual to read the book, but also allows them to “listen to the book”. During the early days of the computer network, “traditional typing” was a job which could only be done by those who could type 70 Chinese characters per minute, but speech input software like Xunfei Sound has now changed this. Xunfei Sound input software can identify three types of speech, namely Chinese mandarin, Cantonese and English respectively. With a little practice, the speech recorder can input at the speed of 160 Chinese characters per minute and recognition accuracy can be as high as 95 %. In terms of file storage, the days are gone when 3.5-in. floppy disks were used to store files. U disks with an internal memory ranging from 1G to 64G have become necessary file saving tools for people nowadays. A mobile hard disk drive with a memory as large as 2T is now quite cheap and can store huge amounts of information. Furthermore, the internationally accepted USB interfaces are capable of joining these data storage devices to mobile phones, computers or intelligent equipment on vehicles. As a result, data can be read at any time, meeting the needs of various people.

Since virtual businesses and virtual cities have been set up, an entirely new working pattern—the home office, has come into being, which has become an accepted norm of everyday life for some white-collar workers and freelancers. For the individuals on one hand, the home office means there are no time restrictions, no need to catch buses or subway trains, nor is there the necessity to care about complicated interpersonal relationships. Considerable amounts of time and money spent in commuting are thus saved. Home office workers can get the same wages and bonuses as full-time workers do as long as they have completed the tasks given by the company, but they can save time for housework, for recreation, for physical exercise and to take care of their families. They can also have spare time to enjoy life, do more useful things and to improve their working efficiency and quality of life. In terms of public welfare on the other hand, pressure on public transportation is reduced because of the reduced number of trips to work relieving traffic congestion and reducing vehicle emissions. Thus energy conservation, emission reduction and green transportation are in turn promoted.

Lifestyles have become more varied. Take tourism for example. In the information age, not only is tourism a means of recreation and entertainment, but it is also booming into a new industry. Professionals like hotel connoisseurs and travel writers have quietly emerged and more and more people are engaged in the career of travelling for the sake of developing tourism products. Boundaries between work and recreation are becoming less and less distinct. One can work while relaxing and enjoy relaxation while working. Networks are everywhere, so for some freelancers, especially those engaged in occupations relevant to networks, it is of no greater importance when or where they do their work, so long as they do it. They can work in the morning and travel in the afternoon or they can travel in daytime and work at night. Alternatively, they can work while traveling since traveling itself is work. For those who want to increase their knowledge by travelling, but who are too busy to spare the time, informationization helps to make their dreams come true. At present, some Chinese museums have started their online tour services. Examples are the "Chinese Virtual Museum", "three-dimensioned 360-degree virtual full view tour of the Palace Museum in Beijing" and so on. Using these services, people can visit the world famous museums as if they were there personally.

2.3.1.5 Informationization Has Brought About Smart City Management, Increasing the Efficiency and Standards of Urban Administration

Management is the most complex aspect in the construction of eco cities since all sorts of things can be involved. The traditional pattern for city management is normally criticized by the public owing to its poor efficiency—attending to one thing but losing sight of another etc. Information technology has brought about new patterns and methods for city management. As a result, administrative efficiency has been successively increased and people are expected to become more and more satisfied with it.

It is becoming increasingly common in all cities that government affairs are handled through the computer network. By July 1, 2015 programs or platforms have been established in every provincial government in China to provide online governmental services to the public. By making use of the government portal websites, 24 provincial governments integrated online service items of different departments and offered governmental services online. 11 provincial governments, on the basis of their physical governmental service centers established their online service centers for examination and authorization of government affairs in order to offer help to people and businesses. Additionally, 8 provincial governments set up their online service platforms of multi-level interaction with unified access and harmonized standards to offer governmental services in one single step [13].

By November 2015 China's first district-level data management organization—the Nanhai District Data Management Bureau of Foshan City, Guangdong Province, established two platforms: the platform of data resource catalogue and the platform of data resource service, where 65 departments including industry and commerce, quality supervision and labor and social insurance etc. can register, browse, share and exchange data. This is an excellent example of how the situation whereby different government departments acted as "discrete information islands" has been changed.

Information technology is used so widely that it is feasible for it to be used in every area of city management. Take traffic for instance. In recent years, the Ministry of Science of China has started some sample projects of intelligent transportation systems, seven branches of which have already been built in Chongqing and some other cities. These include traffic control centers, traffic video monitoring systems, traffic signal control systems, traffic guiding systems, electronic police, communication systems and vehicle video monitoring systems. The intelligent transportation system is a good solution to insufficient management resulting from inadequate police numbers. It also works well in improving traffic efficiency and reducing traffic congestion, making traffic management in Chinese cities more reasonable and more efficient.

Environmental sanitation and forestation in cities are also being informationized. Remote space sensing technology has been widely used in both the greening plan and the greening effect monitoring of cities. Sensors in intelligent terminals found everywhere in cities can monitor the environmental sanitation target online and in real time. Even some small garbage storing devices are intelligent. For example, at the end of 2014 some underground garbage cans with capacities as big as 1.5 tons were installed in the City of Taiyuan. Not only were they large, but the remote information sensing system under intelligent control by GPS can automatically send information back to the command center as soon as the garbage can is almost full, informing garbage men to collect the garbage.

Rapid progress has been made in the informationization of emergency operation centers in cities. The current emergency operation system in Chinese cities is an integrated command system with GPS positioning and audio and video communications working together. Through the video monitoring system and the emergency consultation system, workers at the operation center can observe the site of an accident or disaster and can see the police force and rescue equipment around at the first time, making and adjusting the rescue plan at the earliest possible opportunity and giving instructions to organizations such as police stations, fire departments, hospitals and transportation agencies etc. Thus, losses from natural disasters and traffic accidents will be reduced to the minimum, ensuring the safety of people and property.

All in all, information technology is playing an increasingly important role in constructing eco cities in China and its future is promising. However, since China is a developing country with a large population, weak economic foundation and an unbalanced economy, the level of application of information technology is not yet high enough and the time in which it has been applied is quite short. So we still have a long way to go in informationization as information technology has yet to be fully manifested in construction of eco cities. However, we believe that with successive progress in informationization in China, information technology will surely help us to build highly developed and intelligent eco cities.

2.3.2 New Problems and Challenges in the Process of Informatization of Cities in China

While informationization is changing people's way of life and work, it has also brought about a lot of unexpected problems such as the widening of the digital gap, the lessening of interpersonal communication, new types of pollution, ethical issues caused by intelligent robots, privacy problems caused by intelligent cameras, unemployment caused by intelligent machines and a lot of other unforseen hazards. It seems as if a "Pandora's Box" has been opened. All these are severe challenges that China will be confronted with when eco cities are constructed.

2.3.2.1 Poor Understanding of the Role of Informationization in Constructing Eco Cities Leads to Improper Concepts and Plans Which Do Not Match the Requirement of Building Intelligent Cities

Following the modern trend, China is promoting informationization and has made some progress in constructing intelligent cities. However, misunderstandings and prejudices still occur in concepts and plans about cities due to the narrow perspectives of some people, their underdeveloped thoughts and their insufficient knowledge about intelligent cities. For example, the requirements of the smart city have not yet been manifested in the planning and design of many cities. There are still information and cooperation gaps between different government departments, resulting in discrete information islands one after another, wasting huge amounts of information resources. What is presented on the official website of the government is mostly static—or even obsolete—information, which is seriously disconnected to the needs of the people. No real time information can be found about the traffic situation on the websites of some transportation departments, nor can any real time information be found about order arrangement on the websites of some of hospitals. Most of the data published by the National Bureau of Statistics are on the overall situation of the whole nation and those on specific cities are neither in proper time nor at full scale. Information concerning education, healthcare, social insurance and other public services is clearly insufficient. The national networks of social old-age insurance and electronic medical records have not yet been completed.

2.3.2.2 Information Technology Has Not Been Made Full Use of to Develop a Circular Economy and Promote Green Production, nor Has the Industrial Structure Been Improved and Adjusted to Modern Development Standards

Owing to producers' underdeveloped concepts of technology, economy and other factors, instead of being implemented in most of the production process, green production is mostly only undertaken during the post-processing period. Fundamental changes have not taken place in production that is characterized as "three-high and one-low (high investment, high consumption, high pollution and low efficiency)". Many producers are accustomed to traditional production without any awareness of the importance of developing a circular economy and innovating production patterns by applying information technology since these people don't have any long-term perspective nor any sense of responsibility. Business managers would judge the success and failure of business reform by economic benefits rather than by taking green production and a circular economy as the fundamental path for the development of enterprise.

In the process of informatization in cities, it is inevitable that large amounts of e-waste will be generated, leaving harmful effects upon the environment. At present, China is the world's largest generator of e-waste but its e-waste recycling is far from scientific and is not regulated. In 2013, as many as 43 million waste electronic appliances were disposed of through the regular channels in China, which is only 40 % of the theoretical amount of scrappage [14]. Techniques are not standardized, businesses disposing of e-waste are not experienced and the few businesses that are engaged in disassembling waste electronic appliances mainly survive on state subsidies. Huaxin Lvyuan Environmental Protection Industry Development Co., Ltd. is one of China's earliest experimental businesses, constructed for recycling waste electronic household appliances. The business is capable of disassembling 2.4 million waste electronic appliances every year. However, its annual disposal of electronic devices in 2012 was only 300,000 [15]. The reason was that most of the discarded electronic appliances were simply collected by street purchasers and went into non-formal disassembling businesses. These businesses (or small workshops) have no basic modern dismantling facilities, and even worse, those reusable devices directly flood into second-hand markets, remote places or rural areas after being renovated. Thus, huge profits are reaped, leaving a variety of security risks and damaging the local market of electronic products. As to the discarded devices that are not reusable, precious metals are extracted by low-grade chemical methods of strong acid corrosion, and the remaining wastes are burned, buried or thrown away casually, causing serious pollution to the air, soil and water resources.

The innovation-driven development mode of high level intelligent manufacturing industries has not yet been shaped in China. Deep integration between industrialization and informationization has not yet been accomplished and green production and a circular economy occupy too low a proportion of overall economic development. All these issues are the bottleneck restricting industrial restructuring in China and as such need removing.

2.3.2.3 In the Information Age, There Exists an Abnormal Level of Consumption and Several New Forms of Pollution

Consumption in the information age, can be seen as a combination of both virtual and real consumption, but is characterized by its main feature of virtual consumption. It gives consumers entirely new experiences on the one hand, while on the other hand it brings about new problems such as abnormal levels of consumption, alienated consumption and excessive virtual consumption. Since online shopping is not limited by either time or space, shopping websites can be visited at any time, which is a great convenience to consumers. In the process of browsing, it is quite easy for consumers to buy impulsively, forgetting their original intentions and spending money on lots of things they don't need at all. For this reason, these consumers are called the "chopping hand group". Statistics show that the "chopping hand group" is made up of 1.076 million members, who are the most widely known clients of Taobao. The average annual expenditure that each person in this group makes amounts to as much as 161,600 yuan, which means that they have each made 538 purchases and have bought an average of 221.48 articles every year! [16]. Moreover, it is not easy to guarantee the quality of commodities purchased online. On January 23, 2015, China's State Administration for Industry and Commerce issued Directional Testing Results of Commodities Traded Online in the Second Half of 2014. The report stated that 92 batches of 6 types of commodities from 6 e-companies were tested, and that only 37.25 % of the goods from Taobao were certified products—the lowest proportion [17]. This indicates that there are loopholes in the supervision of online sales in China and that measures should be taken to close them.

In many cases, although the aim of constructing eco cities is to protect the environment, it actually results in the waste of resources or pollution to the environment. For example, the computer is an essential household appliance for the modern family. Power consumption of a desktop computer is relatively small at around 250–400 W per day. However, suppose a desktop computer is on for 10 h every day, a conservative estimation shows that its monthly power consumption will be 90 kWh (300 W * 10 h/d * 30 d). In some developed cities, each family may possess more than one computer, so in the long run the power consumption will be a sizeable amount. When using desktop computers, many Chinese people normally ignore power consumption. It is often the case that they turn on the computer as soon as they get home and don't turn it off even when it is not being used. From the point of view of families, they can clearly afford the cost but from the aspect of constructing eco cities it is a huge waste that should be avoided.

2.3.2.4 New Social Problems Occur in the Process of Informationization in Cities

A new set of social problems such as the unbalanced development between regions, digital gaps and human alienation etc, has been brought about through the process of informationization in cities through various means including the improper use of information technology.

Informationization in cities should be carried out according to the principle of being “people oriented” so that the general public can share in its fruits. However, it is certainly the case that in China digital gaps still exist and development in not balanced across the regions. According to the statistical report on the development of the national internet network in China, by the end of December 2014 only 34.1 % of the population of Jiangxi Province had access to the internet, while in Beijing the figure was 75.3 %—or 2.21 times the size of Jiangxi. Of all the websites established throughout China, Guangdong Province had the largest proportion at 15.9 %, corresponding to 532,787 websites while Tibet had the smallest proportion with less than 0.01 %, meaning there were only 965 websites in Tibet. The number of websites in Guangdong Province was 552.11 times bigger than that of Tibet [18].

Across Zhejiang there are 33 million internet users, about three fifths of the population of that province and 40 % of the top 100 industry websites in China are registered there. About 85 % of online sales, 70 % of cross-border e-commerce and 60 % of e-trading between businesses take place on the e-business platform in Zhejiang Province. Since “the 11th five-year plan”, the information technology industry in Zhejiang Province has increased annually by over 25 %. Moreover, it is the only national model province that has realized a deep integration between informationization and industrialization in the process of its development [19]. By contrast, the other 30 provinces, autonomous regions and municipalities directly under central government control only share 15 % of online sales, 30 % of cross-border e-commerce and 40 % of e-trading between businesses. Such an extreme imbalance of information resources seriously delays the progress of the construction of eco cities, restraining in turn the overall plan and beneficial development of eco cities in China.

China is a developing country. The overall level of education its citizens have access to is not high enough. In some traditional industries, most of the workers who are engaged in front-line work are poorly educated. In the wave of informationization, high-tech products, machinery and equipment of various types have gradually expanded into traditional industries. Businesses need to upgrade and update their manufacturing facilities in order to survive and workers need to acquire higher qualifications. Not only should workers possess higher levels of knowledge and better professional skills but they should also be capable of constantly learning new things so as to keep pace with the rapid developments of the modern age. In such a high pressure situation, some of the less educated workers are left out of industrial production and can only make a living in tertiary industries such as the service sector. Nonetheless, even in the tertiary industries, informationization requires higher and higher levels of worker knowledge. Hence, it is inevitable that some workers with lower levels of knowledge and who are less able to adapt themselves to informationization will be confronted with temporary joblessness or even permanent unemployment. Owing to a lack of knowledge and information, these workers rarely get opportunities to enter into the new economic world that is characterized by informationization, nor can they get opportunities to be involved in online education, training, shopping, entertainment and communication through the internet. There are people who are marginalized in the information age and there are digital gaps between people. These facts not only have a negative impact upon social harmony but are also a departure from the aims of constructing eco cities.

In the process of informationization in cities, normal interpersonal relationships experience major shocks. The relationship between man and information has already become "abnormal". For instance, information essentially serves man, but in an information explosion and an information ocean, it is often the case that man has "lost his self", blindly browsing websites and even forgetting his original intention. With further advances in informationization, changes are also taking place in the relationship between individuals. More and more people (especially the young) like to communicate with others online, eschewing real world interactions. These people can be supremely active on the internet but are uncommunicative in the real world. Some of them indulge themselves in virtual communication all day long. Even worse, they would rather live in a virtual world than return to real life and normal interpersonal communication.

2.4 Conclusion and Discussion

2.4.1 Countermeasures and Suggestions for Constructing Eco Cities in China in the Information Age

China is now making her way into the information age and it is only recently that we began to construct eco cities in the age of informationization so we are still at the probing stage. This means that the present problems and challenges are still preliminary ones and it is quite possible that unknown problems and risks will occur in the future. It is necessary for us to face them directly and to adhere to the principle of putting people first and to the concept of ecological civilization, while constructing modern eco cities with highly developed economies and societies with harmonious relations between man and nature.

2.4.1.1 Requirements of the Information Age Should Be Taken into Account While Concepts and Understandings of Modern Cities Should Be Improved to Construct New Eco Cities

Correct action can only occur under the guidance of correct ideas. Municipal governors should fully understand that informationization plays an important role in the construction of eco cities. Under the guidance of the concept of ecological civilization, they need to develop positive attitudes and take creative actions towards constructing eco cities and applying information technology at every stage of the process. Our cities need to further highlight the efficiency and performance of "internet plus government affairs" and we need to accelerate the process of creating a systematically unified online services standard for government affairs. We also need to establish O2O systems of government affairs, combining both online and offline service. We can educate and train city builders using online courses, video conferencing and remote education, and we can also comprehensively improve people's awareness of information and the ecological environment via media that all people can access, such as text messages, We Chat and micro blogs etc. Schools should play a key role in developing information awareness and ecological education. General qualifications of students in universities, middle schools and primary schools should be improved so that their parents are in turn influenced. When citizens are instructed to become enthusiastic and innovative contributors to the construction of a city, more and more people are sure to be willing to make full use of their wisdom and talents and voluntarily take part in the process.

2.4.1.2 Information Technology Should Be Applied Widely so that Eco Cities Are Planned Scientifically and Designed Sensibly

The scope of information technology seems boundless as far as scientific planning and the overall designing of eco cities are concerned. Relevant government departments are supposed to place emphases upon top-level designing of "open government data" so that by making use of this data businesses and citizens can be encouraged to analyze and delve into all kinds of source data such as geographic information, weather information and the economic and cultural conditions of each city, discovering the vital public statistics so as to share and use them. Mathematical modeling and visualization techniques can be applied to data processing in order to simulate the operation of cities, enabling the relevant functioning government departments to understand local natural resources and the ecological environment both macroscopically and microscopically. On the condition that we clearly know what kind of people the population comprises, how they move around and what things they need when living in the eco cities, we can scientifically program how big the business circle is and where job opportunities should be distributed. A high quality of design and a proper structure of urban development can put local residents into a harmonious relationship with the ecological environment, thereby achieving the optimum planning and design of eco cities.

2.4.1.3 By Applying Information Technology, the Pattern of Economic Growth Should Be Changed, Promoting Green Production and a Circular Economy

When constructing eco cities, we need to restructure our industries. The cultural industry and information industry need be fully developed so that capital and labor based economic growth can be transformed into technology based economic growth. Manufacturers need to take advantage of opportunities and be courageous enough to spend money on information technology. They also need to adhere to the principle of integration and innovation in order to achieve technological breakthroughs. We need to try our best to introduce advanced information technology such as big data, cloud computing, the Internet of Goods and others into production and management, to plan rationally and calculate carefully that the waste generated from industrial production is greatly reduced to maximize resource utilization. As far as the "three industrial wastes" are concerned, scientific processing is feasible through the application of information technology. Wastes can be reduced and become harmless and useful, meeting the environmental protection standards. After wastes are treated according to environmental protection standards, businesses should collect and reuse components that can be recycled. They also need to keep detailed records about what kinds of wastes they generate during production and how much waste they generate. Furthermore, they need to look for downstream network businesses, making effective matches between production and demand. In this way, quick and efficient communication systems can be established so as to promote green production and a circular economy.

In conclusion, the process of informationization is unstoppable in the development of Chinese eco cities, and macroscopically speaking, it plays a mainly positive role in the construction of eco cities. Despite this, its negative effects are not to be ignored. When constructing eco cities, we need to undertake comprehensive studies on the effect of informationization upon eco cities and we need to start with the local situation, taking measures according to regional conditions and making full use of the active effects that information technology brings about. Informationization can be employed as an important means to deal with pressing real life issues and to solve challenging developmental problems. By making the best use of the advantages, avoiding the disadvantages and by enhancing what is beneficial and avoiding what is harmful, we can achieve the rapid and benign development of Chinese eco cities.

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Chapter 3 Economic Development and Environmental Protection of the Eco City

Juheng Li

Abstract The construction of the eco city has become the main direction of urban development in the twenty first century. There are some conflicts between economic development and environmental protection in the construction of the eco city in China. This paper constructs the coupling coordinative relationship between economic development and the ecological environment, and puts forward the countermeasures of institutional change, ecological reconstruction, escorting policy and public participation, and coordinates the economic development and environmental protection of the eco city as a whole, while promoting the benign interaction between economic development and environmental protection in order to achieve a win-win situation between economic development and environmental protection.

Keywords The eco city · Economic development · Environmental protection

3.1 Introduction

The concept of the eco city is influenced by the growing understanding of the relationship between man and nature and the ultimate aim of the development of human civilization is ecological civilization. The rise of the ecological civilization is a world revolution related to the mode of production, lifestyle and values, and is an irreversible global trend and a new challenge to human society after periods of agricultural civilization and industrial civilization.[1] As an environment for human habitation the city is the most thorough transformation of nature by humans and is the true embodiment of the values and the will of the human transformation of nature via different historical stages. The eco city not only reflects humans' desire to control their own development but also reflects the wider understanding of the law

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of the relationship between man and nature.[2] Since "the plan of man and biosphere (MAB)" initiated by United Nations Educational, Scientific and Cultural Organization (UNESCO) clearly put forward the concept of "the eco city" in 1971, countries across the world have collaboratively researched the city as a human ecosystem, and the concept of "the eco city" has gradually developed into a global consensus,[3] and has become the main aim of the development of the city worldwide. Eco city construction has therefore become one of the development goals of every country.[4] Many cities are actively exploring an effective way to protect the natural environment and realize sustainable development of the city, whether they are in the east or west or in developed or developing countries.[5] In the 1984 MAB report, UNESCO put forward five principles of eco city planning[6]: ecological protection strategies (including the conservation of nature, flora and fauna, protection of resources and the prevention of pollution); ecological infrastructure (the long-term sustainability of the city from the natural landscape to the hinterland of the city); the living standard of residents; the protection of culture and history and the blending of nature into the city. These five principles sum up the main concepts of eco city planning and are also the basis for the development of other eco city theories. In 2008, scholars at the international eco city conference gave a relatively broad definition: "The eco city is an ecologically healthy city, and the cities we live in must realize the harmonious coexistence of man and nature and ultimately achieve sustainable development. The development of the eco city requires a comprehensive and systematic understanding of the complex interactive relations between urban environment, economy, politics, society and culture based on ecological principles. The design of cities, towns and villages should be aimed at promoting the physical and mental health of residents, improving the quality of life and protecting the ecological system on which survival relies."[7] With the rapid process of urbanization in China, major support has been given to the concept of the eco city and the domestic consensus is that an eco city is a necessary aspect of Chinese urbanization. *The Green Book of the Eco City: the Report on the Construction and Development of the Eco City in China* in 2012–2014 defined, extended and enriched the connotation of the eco city. That is, the eco city is a new type of city established in accordance with the principle of the coordinated development of ecology, economy, society and nature based on the concept of the ecological civilization, the efficient utilization of materials, energy and information, with culture, technology and landscape being highly integrated. It is a people-oriented and sustainable new city and is a livable home with green methods

[2]Huang and Yang [2].

[3]Li [3].

[4]Zhou et al. [4].

[5]Li [3].

[6]Ma [5].

[7]Werder and Wojtkowiak [6].

of production and green lifestyles.[8] Today, a precise concept of the eco city has not yet formed and the construction of the eco city is still being explored.[9] It can be seen that the eco city covers a wide range of topics including the harmony and benign development of resources, environment, economy, society and nature. The construction of the eco city is a huge task, entailing the systematic engineering of the coordinated development of economy, society and environment. The characteristics and the natural endowment of the city itself determine that eco city construction must be, and is bound to show, a diversified development trend.[10]

As for the goal of eco city construction, Wang Rusong and Ouyang Zhiyun (1994) believe that "through the construction of the eco city, we can fully explore the potential under the existing resources and environmental conditions, to realize a way of production and life which is neither westernized, nor traditional, but is efficient, harmonious, healthy and substantial."[11] The eco city concept had its origin in foreign countries so the practice of eco city construction was carried out much earlier in foreign countries. In recent years, the construction of the eco city has been in full swing around the world but at present there are still no eco cities in the real sense.[12] People have begun to reflect on and explore the eco city in the real sense. In practice, the coordination of economic development and environmental protection has become a major factor in the construction of the eco city. Foreign studies on the coordinated development of ecology and economy began in the 1960s[13,14,15,16] and domestic research began in the 1990s, reaching a peak in the twenty first century and has continued to the present day. We have proposed the green development model based on the sustainable development of the ecological economy and the concept of the sustainable and coordinated development of the ecological environment, and the economy and society, at the national strategic level[17,18,19]. Presently, the coordinated and sustainable development of ecology and economy has become one of the key multi- and cross-disciplinary[20] research fields.

[8] Liu et al. [7].

[9] Wenjuan [8].

[10] Xu et al. [9].

[11] Wang and Ouyang [10].

[12] Cao and Tang [11].

[13] Ojima et al. [12].

[14] Honey-Roses et al. [13].

[15] Polasky et al. [14].

[16] Holland et al. [15].

[17] Fu [16].

[18] Zhao et al. [17].

[19] Wu et al. [18].

[20] Zupriyanmu et al. [19].

3.2 The Conflict Between Economic Development and Environmental Protection in the Construction of the Eco City

Development is one of the most important ideas in the world today, while economic development is one of the most important topics of development. Economic development is the source of urban development. In China, rapid economic growth and the accelerating processes of industrialization and urbanization make the conflict between the protection of the ecological environment and the economic development more and more serious and as a result urban development is facing unprecedented challenges.

3.2.1 The Conflict Between the Mode of Economic Growth and Environmental Pollution

Since the beginning of the industrial revolution, the development of the city has been rapid, the scale of the city is increasingly large, and the function of the city has become stronger and stronger, causing the long-term stability of social structure and the natural environment of mankind to gradually deteriorate. At the same time, the social and economic status of the city in the regions has increased rapidly and it has become the center of social economic growth driving the development of other regions and bringing unprecedented economic growth to human society.

However, the development of the city has also brought many problems. Firstly, the pie style mode of economic growth has brought a surging population and rapid urban expansion, damaging the balance of the urban environment, resulting in heavy traffic, overcrowding, Unhealthy conditions and a deterioration in the living environment. Urban development has become the trigger factor of urban environmental problems. Since the reform and opening up of China, urban construction has faced the same problem, while the disorderly development of various economic sectors has resulted in the shortage of the regional resources and environment deterioration as a whole. To explore the reasons for this, the mode of economic growth is an important driving force of environmental pollution.

Viewed by the mode of economic growth in 2014, the proportion of the primary, secondary and tertiary industry sectors in the gross domestic product (GDP) of China was 9.2:42.7:48.7. Although this was a big change compared to the proportions of 13.0:45.8:41.2 in 2000, the proportion of the primary industry and the secondary industry has certainly declined and the proportion of the tertiary industry has slightly increased. For a long time, economic growth in China has mainly been driven by investment, eager for quick success, and the practices and ways of thinking that only focus on GDP cannot be easily changed in a short period of time, and the related institutional arrangement is also difficult to change. At the same time, for some of the cities in China the industrial structure is large, the service industry is small and the ability for independent innovation is weak.

Serious damage to the eco city in turn restricts the development of the economy. Global problems, such as pollution of water resources, destruction of the ecological and cultural environment, serious air pollution, energy crises and climate change have more and more seriously impacted urban economic development and threatened human survival, leading to the conflict between economic growth and the environmental bearing force has become increasingly prominent. The conflict between economic development and protection of the ecological environment in the construction of the eco city results in a dilemma for urban development. How the relationship between the two aspects should be properly coordinated is a difficult problem which the construction of the modern eco city in China must actively face and solve.

3.2.2 The Conflict Between Economic Development and Rational Utilization of Resources

China has used the extensive mode of economic development for a long time. Energy is provided mainly by coal and investment lays a particular stress on heavy industry, which has resulted in dual pressure on resources and the environment. The resource utilization rate is extremely low and although the recycling utilization rate of the main renewable resources reached 70 % in 2014 in China according to data released by the Chinese industry research network, there is a big gap between the development of the resource regeneration industry in China and that of developed countries in Europe and the United States. In 2011, 995 large-scale renewable-resource businesses achieved a total industrial output value of 2986.98 billion yuan, while the huge renewable resource recycling industry in the USA is huge, and its renewable resources recovery value yearly amounted to $240 billion, making a vast gap immediately evident. At present, the recovery rate of waste plastics in China is less than 25 % and the renewable lead consumption rate is only 33 %, while in the United States it has now reached 82 %. The non-material economy research center of the Faculty of Social Sciences in Tsinghua University released the intangible economic index in the G20 countries (except the European Union) on December 1st. In terms of the three main indicators, the resource utilization rate of China ranked the lowest and the utilization rate of resources in China is far behind various economic entities in the G20 group.

At the same time, the endowment of natural resources in China is poor and the natural resources per capita is very low. In 45 kinds of main mineral resources, 19 are in shortage at varying degrees, among which the shortage of 11 types of national economy pillar minerals is particularly prominent. The ability to be self-sufficient in important resources is poor and the supply of oil, iron ore and copper is increasingly dependent on foreign countries year on year. The emission of major pollutants greatly exceeds the capacity of the environment and some places have reached the limit of their ecological environmental carrying capacity. The conflict between economic development and the rational utilization of resources has become the shackles of further development of the city.

3.2.3 *The Conflict Between Economic Construction and Ecological Civilization*

Ecological civilization is a new phase in the development of human civilization and is the form of civilization after industrial civilization. Ecological civilization is the sum of the material and spiritual achievements human beings have made by following the objective law of the harmonious development of man, nature and society. Ecological civilization is aimed at the harmonious coexistence, benign cycle, all-round development and continued prosperity of man and nature, man and man and man and society.[21]

Human survival and economic development result in environmental pollution and ecological damage, which in turn result in an increase of environmental problems and ecological crises when they accumulate to a certain extent. Protection of the environment will more or less limit economic development within certain parameters of time and space. The economic construction of our country at present is faced with two prominent conflicts: one is the conflict between the expansion of economic output and limited natural resources and relatively low productivity of natural resources, while the other is the conflict between rapid economic growth, limited environmental capacity and the relatively low utilization efficiency of the environmental capacity. These conflicts slow down and hamper the harmonious development of man, nature and society, and the threat from economic activities to the stability and harmony of nature in some cities is increasing daily with ecological civilization becoming “the moon in the water”.

In general, since the reform and opening up experienced in the country, China’s economy has entered a period of rapid development including urbanization and industrialization, accompanied by a series of serious problems such as environmental degradation, resource depletion and ecological damage. The conflict between economic development and environmental protection has become increasingly prominent. These problems and conflicts have seriously affected the quality of human life, worsened the ecological environment of cities and become a curse difficult to eliminate through urban development. As a result, the eco city has become an elusive object of desire. At the same time, people gradually realize the mutual restraint between economic development and environmental protection as the ecological environment will be damaged by the traditional way of economic

[21] http://baike.baidu.com/link?url=Fd4YDt4YVCprSBVK4AorVPEroNLEIEPT4M8A0bKAZC7ITw6ec7JRt5Y7CqftWWmDAXLqhZcsvQ1nfoYpn7f8Qa.

development and economic development will be constrained by the environment and resources. This makes it an urgent task of current eco city construction to explore the harmonious coexistence and coordinated development of the economy and environmental protection, which is also an inevitable requirement for the sustainable development of the city.

3.3 The Integration of Economic Development and Environmental Protection in the Construction of the Eco City

Although some scholars believe the eco city is full of ideals and it is not mature enough both theoretically and in practice, the theory and practice of the eco city both at home and abroad has been gradually gaining speed since the 1990s, exploring the interconnected relationship between economic development and the ecological environment in the process of the development of a modern urban economy by following the definition and planning principles of the eco city given in the MAB report by the United Nations Educational, Scientific and Cultural Organization (UNESCO). This has an important practical significance in guiding the sustainable development of the city in the future. Theoretically speaking, the realization of the mutual docking and integration between the development of the urban economy and environmental protection needs to choose a new mode of urban economic development in order to reach all the required standards of environmental protection.

3.3.1 Selection of the Mode of Urban Economic Growth

Shang Yongmin et al. [20] concluded through cluster analysis that in terms of the relation between the scale of the economy and carbon emissions, the economic growth of the city presents three types of growth—green growth, brown growth and black growth. On the whole, it is an evolutionary process of a spiral type evolving from black growth through brown growth to green growth of which the large comprehensive city and the commerce and tourism city experience stages of brown growth and black growth alternately, before most of them gradually go into the brown growth stage and then gradually turn to the green growth stage. The modern industrial city and the traditional resource-type cities experience brown or black growth for a longer period of time.

Shang Yongmin et al. believed green growth occurs when the intensity of carbon emission reduction is faster than the rate of GDP growth and then the total amount of carbon emissions will decrease accordingly. This is the view of the overall evaluation of the mode of urban economic growth. However, from the perspective of theory and practice, for the construction of an eco city it is necessary to change the manner of urban economic growth. As shown in Fig. 3.1, in order to develop the economy of the eco city with such economic development modes as the circular economy, green economy, ecological economy, cultural economy, information economy, service economy and tourism economy can realize the eco city as described by UNESCO, thereby achieving the circulation and optimization of the urban system, the efficient use of materials and energy, the saving of resources and energy by every effort and the reduction of damage to the natural world. As to the choice of the mode of economic growth, each city can make a choice according to the local resource environment conditions, the cultural and social environment and available human resources and geographical conditions.

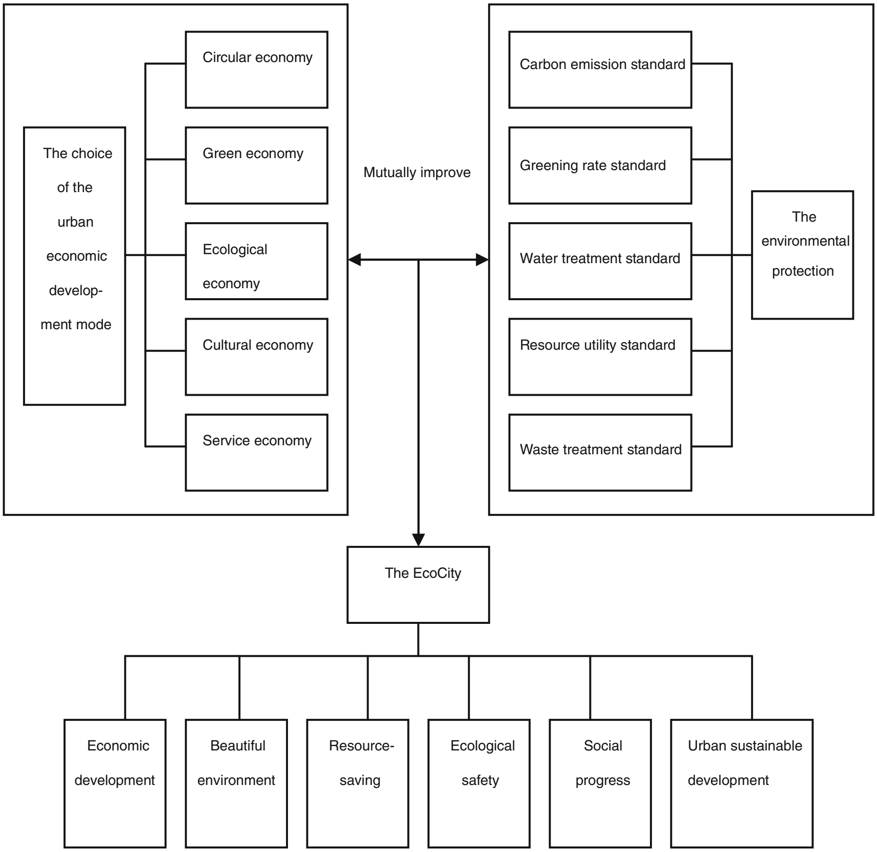

Fig. 3.1 The integration of economic development and environmental protection

3.3.2 Promotion of Environmental Protection

The ultimate goal of economic development is to protect people's living standards and to provide people with a good, comfortable and safe living environment. The fusion between economic growth and environmental protection is the intrinsic aim of the construction of a modern eco city. The active change of the economic growth mode is helpful in meeting environmental protection standards. The scientific definition and strict implementation of the environmental protection standards is the external pressure and driving force for the change to the mode of economic growth and both of them interact and promote each other. Generally, the degree of environmental protection can be evaluated from carbon emission standards, afforestation rate standards, water treatment standards, resource utility standards and waste treatment standards (Fig. 3.1). Thereafter, the production of businesses and the behaviors of residents can be normalized in terms of environmental protection.

Therefore, to develop the economy rapidly, we need to use natural resources rationally, adhere to the scientific concept of development, and to continuously explore and innovate in order to seek a new path and promote the sustainable development of economy and society. As an important component of the soft power of economic and social development, the ecological environment has an important role in the promotion of harmony between man and nature and man and society, the formation of a virtuous cycle of improvement to the quality of urban economic development and the construction of a resource-saving society.

3.3.3 The Integration of Economic Development and Environmental Protection

Eco city construction involves the systematic engineering of the balanced development of economy, society and environment, and is a process of integrated coordination and benign interaction between economic development and environmental protection. In the process of economic development, as long as we can gradually form an industrial structure with a mode of growth and consumption pattern that will save energy and resources and protect the ecological environment, and as long as we can change the mode of the economic growth and establish scientific standards of environmental protection, then it will be possible to achieve the aim of integrating urban economic development and environmental protection.

At the same time, economic development and environmental protection are a comprehensive systematic engineering involving many fields and industries. We have to advocate ideas of civilization, conservation, greenness, a low-carbon society, the promotion of a sustainable mode of production, green lifestyles, the creation of an atmosphere that encourages the wider participation of society as a whole and the balanced development of man, nature and society.

3.4 Countermeasures to the Coordinated Development of the Economy and Environmental Protection

In the modern era, eco city construction needs to follow a new mode of development conducive not only to economic development but also to an environmentally-friendly and harmonious society. Innovation and transformation of structures has become an urgent task and we have to change institutions, reconstruct ecology and develop the market economy, have a correct attitude towards environmental challenges, establish new economic development and environmental protection agendas, establish a proactive and preventive environmental policy, and establish strategic environmental management with the participation of the whole of society in order to achieve the effective coexistence of economy, society and ecology.

3.4.1 Speeding Up Reform of the Evaluation System of Government Performance

The evaluation system of government performance in China has been reformed and improved but there are still many problems in the original concept of performance and the mechanism of evaluation. The consensus now is to put the task of environmental protection and construction into the performance evaluation system. The first phase is the implementation of the system for the accountability of environmental protection, emphasizing the responsibility tracing system, implementing the outgoing responsibility audit and lifelong responsibility and strengthening the pressure and motivation of the government to implement the national policy of environmental protection. The second phase is the establishment of a reward and punishment mechanism. At all levels, government should put forward environmental protection targets, set the reward and punishment mechanism and relate environmental protection closely to performance appraisal according to the present environmental condition, governance defects, economic structure and so forth. The third phase is to implement the “one vote veto” system of performance assessment and take the comprehensive index of environmental quality as the most important basis for the use of people and job promotion etc.

3.4.2 Establishing an Incentive and Restraint Mechanism for Saving Energy and Reducing Emissions

Scientific development, energy conservation and emission reduction are the focus, hot spots and challenges for current environmental protection. In the process of economic development we have to establish the incentive and restraint mechanism of energy-saving and emission reduction under the guidance of the systematic policy of an industrial development plan and scientifically informed structural adjustment. The first phase of this is to establish the system of eliminating backward production capacity and then eliminate backward production capacity according to plans through the development of environmental protection laws and regulations. The second phase is the promotion of the idea of the paid use of environmental resources, emission trading, and the effective operation of the CDM mechanism in order to encourage businesses to strengthen the introduction of environmental technology, control environmental pollution, save energy and reduce emissions and use resources intensively and efficiently by taking total control as the core effective action. The third phase is the setting up of environmental access standards in the approval process of the establishment of companies, so as to improve the efficiency of allocation of environmental resources in order to ensure a successful relationship between economic growth and environmental protection.

3.4.3 Developing the Green Credit Policy and the Fiscal Subsidy Policy

The government should make full use of fiscal policy and financial policy to guide the flow of social capital into the environmental protection industry.

The first phase is to increase financial subsidies to the environmental protection industry, increase the government's investment in energy conservation, emission reduction and the environmental protection industry, and raise environmental awareness in wider society and guide the flow of funds to the environmental protection industry.

The second phase involves the formulation of a green credit policy, giving of support and preferential policy to clean methods of production and the environmental protection industry in terms of the amount, scale and scope of the loan, and also interest rates, loans, cash deposits and discounts, the setting of punitive high interest rates on the financing of polluting businesses and the provision of different credit options according to the degree that businesses and projects pollute, and finally the implementation of "green loans".

The third phase is to establish governmental environmental protection funds to be used to protect the urban environment, organize public environmental protection activities and deal with unexpected environmental events in order to improve the government's regulatory response capacity to control pollution and protect the environment.

3.4.4 Perfecting the Intelligent Support System of the Eco City

Realizing a smart, multi-collaborative planning system for the city is an important aim and requirement of eco city construction. Therefore, it is necessary to create a smart support platform for the eco city to make scientific and smart multi-collaborative plans. Among them, the national spatial planning and decision support system platform is the basis of intelligent planning and construction.[22] The construction of the multi-collaborative national spatial planning and decision support system platform unifies the overall planning of the national economy and social development, overall urban planning, overall planning of land use, environmental protection planning and overall planning of the development of tourism to the same map in order to share multiple planning comprehensively, to realize the transparent spatial planning information system, to help establish and implement planning and to create a smart planning system. We should consider smart action and smart designing of infrastructures, information networks, management plans, industrial development (fostering emerging industries and transforming traditional industries), living environments, public services and social governance. Of course, the smart city is the organic combination of the human-centered city and the information city, which not only requires a dependence on the new generation of information technology such as large data, the internet of things and cloud computing, but also needs to implement the human-oriented service concept.[23] Therefore, in addition to building a technical support platform, the construction of the support system of the eco city also includes the smart design and benign operation of the governmental organization and management systems, the national legal system and the safeguard system.

3.4.5 Promoting Eco City Construction Through the Participation and Joint Efforts of Multiple Subjects

Eco city construction is a systematic project, which needs to optimize the configuration and function of the whole system in order to ensure that all aspects of the system are in place.

1. Government safeguards should be in place. Setting up a special organization and establishing a perfect management and safeguard mechanism is the government's public responsibility to ensure the long-term and orderly development of the eco city. The government should establish and improve relevant policies and regulations through the establishment and improvement of the system of policies

[22] Fang [21].
[23] Chai et al. [22].

and regulations of the construction industry, environmental protection and finance and energy, in order to provide eco city planning, construction and management with an institutional guarantee and related services.[24] To establish a scientific and acceptable development plan, the government should adhere to human-oriented, characteristics-highlighting principles, so as to develop a scientific and sensible development plan for the eco city, clarifying objectives and positioning mode and creating a blueprint. In the process of building and improving the governance system of the eco city and modernizing the governance capacity of the eco city, we should deal with the relationship between the government and the ruling party, the relationship between the government and the people's congress, the relationship between the government and wider society and the relationship between the government at all levels (including government departments at the same level) very well.[25] The main subjects should also be positioned sensibly in the construction of the eco city and their work should be thoughtfully divided in order to gain their effective cooperation.

2. Market regulations should be in place. We should mobilize market subject's positivity to develop a circular economy, an environmental protection industry, ecosystem services and ecological construction, through system innovation to give full play to the positive role of the market, to promote intensive and energy-saving businesses, green environmental protection and low-carbon production actively, to steer social demand towards green consumption, and to grow the benign development trend of government guidance and the market driven participation of the whole of society.
3. Public participation should be in place. The essence of eco city construction is to build a harmonious living environment for individuals, which can't be done without the participation of the public. The public nature of the ecological environment, the alienated role of the government's management of the environment, the theoretical support of the social contract theory, the relevant laws and policies and regulations have contributed to the necessity of public participation in the construction of the eco city.[26] As a major part of urban life, the ways people pursue their self value include the right to know of, participate in and make decisions and to require that these rights be recognized and protected by law. Public participation is the foundation and precondition of eco city construction. To this end, we need first to enhance education and publicity, strengthen ecological education in the construction of eco cities and improve the public's understanding of ecological issues. Secondly, we should establish a sound mechanism of social participation, a mechanism for stakeholder negotiation,[27] public participation in eco city governance and put social and public

[24] Chen [23].

[25] Li et al. [24].

[26] Zheng and Lu [25].

[27] Li et al. [24].

participation at the heart of the system.[28] Thirdly, we should advocate the idea of green ecology and of living a green lifestyle.[29] People's philosophy of life and their way of life exist alongside the urban ecological environment. The concept of the green eco city should be integrated into people's daily lives, and the concept of green living reflected in clothing, food, housing and transportation, so as to gradually adjust the production structure and consumption structure of the city. We should form a green, healthy way of life with green consumption and environmental protection at the core in order to achieve a viable, greener society. Fourthly, we should establish an environmental information disclosure system under public supervision. Fifthly, we should disclose environmental accidents in a timely fashion to create pressure from social supervision on the relevant responsible party, carry out education and raise awareness among wider society of environmental crises. Sixthly, we should strengthen environmental communication activities within schools and communities, organize scientific propaganda and lectures on environmental protection regularly in schools and communities to introduce the effect of the environment on the development of the economy and the advanced mode of production to the masses from a scientific point of view, with detailed historical information and data. Seventhly, we should build green schools and communities to create an "all inclusive" atmosphere. We should set up the concept of the trinity of government, businesses and the public, and mobilize and promote environmental protection action of the whole society and multi aspects so as to achieve the goal of effective environmental protection.

3.4.6 Speeding up the Transformation of the Urban Economic Growth Mode

Eco city construction needs to change some of the inappropriate aspects of the traditional urban economic construction process. It also needs to change the traditional concept of the industrial city and the resource city and the adjustment of the industrial structure. First of all, this requires free thinking in order to fully understand the essence of the idea that "the environmental resource is an endogenous factor of productive forces, that environmental protection is the development of productivity, and that the paid use of environmental resources is to rationally adjust the relations of production", and to make economic development and environmental protection mesh together rather than conflict. Next, we should reorganize and transform traditional industries, actively develop ecological industries, and choose green, environmental protection and an energy-saving mode of economic development such as circular economy, green economy and

[28] Hou [26].

[29] Chen [23].

culture economy, information economy, service economy and tourism economy, according to the situation on the ground in the region in question. Subsequently, we should establish intensive, efficient, low consumption ecological industry groups of new, advanced technologies and emerging industries by relying on industrial parks and high-tech development zones led and established by government planning.

Comprehensive utilization of resources is an effective way to solve the two key issues of rational utilization of natural resources and reduction of environmental pollution in the course of sustainable development, which is conducive to alleviating the shortage of resources and reducing waste emissions. At the macro level, transformation of the mode of economic growth is to fundamentally change the original urban economic development mode through the transformation of economic growth to economic development, from seeking growth to focusing on the efficiency of resource use and from the pursuit of the quantity of production to a greater emphasis on quality. We should speed up the construction of a resource-saving, environmentally-friendly mode of production and consumption and improve the ability to sustainably develop a city.

3.4.7 Constructing the Ecological System with Characteristics of the City According to Local Conditions

There is no unified template of eco city construction, thus all localities must build the ecosystem with the characteristics of the local city and make adjustments according to the situation on the ground, taking original features, resource environment, history and culture of the city comprehensively into consideration, including the establishment of an ecological environment protection system for the city, such as forest coverage in parks, a green belt along roads, green areas in communities, forming a green space layout at the intersection of point, line and plane. Also required are the establishment of comprehensive channels to dredge sewage and floodwater and prevent the problems caused by waste water and floods. Furthermore, rational planning and construction of the eco city landscape and creating features and card of the city by relying on advantageous resources and local features such as topography and cultural relics, and driving the development of the related environmental protection industry with characteristics of the city in order to realize the coordinated development and symbiosis of the urban economy and the ecological environment.

3.4.8 *Aiming at the Transformation of the New Urbanization Strategy to Enrich the Development Model of the Eco City*

China's new urbanization process is a process of simultaneously promoting the urbanization of population, land, economy and society and the coordinated development of man and land. Urbanization in China has entered a critical period of rapid development and transformation. To steer the transformation of China's urbanization from the traditional mode to a new mode and to embark on an intensive, smart, green and low-carbon road of a new type of urbanization needs to achieve five urbanization strategy transformations. These are moving from quantity to quality, from the radical to the gradual, from the passive to the active, from the land-oriented to the human-oriented and from being government led to being market led so as to ultimately realize urbanization not by accelerating the speed of growth, but by the promotion of quality, from sub-healthy to healthy.[30] The focus of transformation can be crystallized as: "efficient, low-carbon, ecology, environmental protection, energy-saving, innovation, wisdom and peace",[31] or the six types of pattern of eco city development—environmentally friendly, conserving resources, circular economy, being landscape and leisure oriented, consuming in a green way and integrating innovation.

3.5 Conclusion

In some areas of China, the building of an affluent society and modernization have been realized only at a basic level and the development of the economy and the improvement of living standards have made people pay more attention to the ecological environment. It can be predicted that the most important indicator of a city's competitiveness in the future will be the ecological environment. How do we further improve the theoretical system of eco city construction? How do we integrate eco city planning, construction and management as a whole? How do we guide public behavior to be sympathetic to the eco city? How do we strike a balance between economic development an environmental protection. How do we promote the interaction between economic development and environmental protection to create a win-win situation, and how we can break through the bottleneck of the resource environment with regard to urban economic and social development, and move forward to the goal of ecological civilization and ecological modernization, are the problems that future research on eco city theory and practice need to focus on.

[30] Fang [21], pp. 44–49, [27].

[31] Fang [21], p. 50.

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Chapter 4
The Spatial Layout and Planning and Construction of the Eco City in China

Yongzhen Wang

Abstract The eco city is a healthy, coordinated and sustainable settlement for humans. Aiming at the establishment and implementation of planning for China's major function-oriented zones, the promotion of the "Two Horizontal and Three Longitudinal Transportation Corridors" as the main body for the strategic pattern of urbanization, and the construction of "Two Protective Screens, Three Zones" as the main body for the ecological security, this study—based on domestic and foreign theories and practices of spatial layout and planning of city construction—puts forward the strategy of active implementation of the major function-oriented zones and the scientific construction of the strategic pattern of urbanization, with the expectation of carrying out the policy of improving the protection and reconstruction of old cities through the development of new cities, and exploring the idea of the "compact city" pattern and any related countermeasures to ecological construction and planning suitable for China.

Keywords China · The eco city · Space layout · Development plan

The city holds most of the world's productive forces and material resources and has a huge impact on the environment. Urbanization in developing countries will be the most significant demographic and spatial structural change in the twenty first century according to the quadruple from 2000 to 2030. If developing countries consume resources in the same way as developed countries did in the past, then at least four earths will be required to provide the ecological resources needed to sustain growth in these countries.[1] China is the largest developing country in the world and industrialization and urbanization has exerted a large impetus to the rapid economic and social development of Chinese cities,[2] but the extensive mode of

[1]The World Bank [1].
[2]Gu et al. [2].

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economic growth in cities has been hampering the implementation of the strategy of sustainable development in China. Therefore, in order to find a development mode for cities towards intensive transformation is very important. The concept of "the eco city" originated in European countries and is very much in line with the demand for global urban development through the use of a healthy, integrated and sustainable city layout and energy-saving society to achieve a sustainable development pattern in a city. This is the best choice for effectively solving the current "urban disease", especially for large developing countries such as China. Through analyzing the relevant theories of the eco city and combining these with a large number of examples of the layout and planning in the domestic and international construction of the eco city, this article puts forward the spatial layout and planning countermeasures for the construction of eco cities suitable for China's national conditions.

4.1 Connotation, Characteristics and Types of Eco City

4.1.1 Connotation of the Eco City

In 1984, the United Nations pointed out in the report of *The Man and Biosphere Program* "eco city planning is to create an optimal environment which can fully integrate technology and natural human activities, to induce creativity and productivity and provide a high-level material and lifestyle from the two aspects of natural ecology and social psychology".[3] In 1987, Soviet scientist O. Yanitsky believed that "the eco city is an ideal city pattern, in which technology and nature are fully integrated, and human creativity and productivity are maximally played, the physical and mental health and the quality of the environment of the residents are protected to the maximum extent, and the material wealth, energy and information are used efficiently, and which is an ideal habitat of the virtuous cycle of ecology".[4] In 1996, Ruijisite, an American ecologist, regarded the eco city as a city of high quality which promotes human and natural health and vitality and he proposed the ten principles of eco city construction.[5] P.F. Downton, an Australian architect, believes that "the eco city is a city which can achieve an ecological balance between man and man, and man and nature and points out that creating a dynamic environment, building a healthy economy consistent with ecological principles, promoting social equality and improving social welfare are keys to the construction of the Eco City".[6] In 2002, the *Shenzhen Declaration of the Eco City*

[3]Huang and Yang [3].

[4]Yanitsky [4].

[5]Jester [5].

[6]Australian City Ecology Association Website: http://www.urbanec-logy.orb.au/whyalla/EcoCity_defn.html.

was approved at the fifth international eco city congress and stated that the eco city refers to an ecologically healthy city of sustainable development, which applies ecological engineering technology to its design, planning and management, constructs efficient ecological industry, creates an ecological landscape of a harmonious ecological culture and function integration and achieves the organic combination of nature and the living environment.

Chinese scholars Wang et al. put forward the idea of the Chinese eco city creating a union of nature and city, and they believe that the construction of the eco city should satisfy the ecological principle of human satisfaction, the efficient principle of economic ecology and the harmonious principle of natural ecology.[7] Huang Guangyu contended that "the eco city is a form of human settlement of social harmony, economic efficiency and an ecological virtuous circle, which integrates nature, the city and man in an organic whole and forms a reciprocal symbiotic structure".[8] In 2001, Huang and Yang put forward a perfect definition of the eco city, based on summarizing domestic and foreign research on eco city theory and combined it with the latest green economic theories, namely "the eco city is a sustainable subsystem sharing and bearing the system equally in the global or regional ecological system. It is a composite system of natural harmony, social justice and economic efficiency based on ecological principles and it is an ideal human living environment coordinating the natural and the artificial with its own cultural characteristic of harmony among people".[9] Song et al. propose that the eco city can be understood as a composite system of natural harmony, social justice and economic efficiency established on the basis of the principles of urban ecology and ecological economics and it is an ideal human settlement environment with its own cultural characteristics, coordinating nature and the artificial system, harmonizing man and man.[10] Yao et al. stated that the concept of the modern eco city includes three aspects: harmony of overall social development, high efficiency of urban social productive activities and sustainability of development of modern cities.[11] Wang put forward that the construction of the eco city is an urban ecological system with a perfect structure and clear function transformed and constructed on the basis of the natural ecological system through human activities. This system is a complex human ecological system with the urban population as the main body, with urban space, secondary natural elements, natural resources, artificial material elements and spiritual elements as the environment, keeping in close contact with nearby regions.[12] Li et al. proposed that the low-carbon eco city is the implementation of a low-carbon economic development model and an ecological development concept

[7]Wang and Ouyang [6].

[8]Huang and Chen [7].

[9]Huang and Yang [8].

[10]Song et al. [9].

[11]Yao et al. [10].

[12]Wang [11].

in the development of a city.[13] Shen et al. discussed the connotation and characteristics of the low-carbon eco city including harmonious relations, low-carbon, recycling, efficiency and compact composition.[14] Yan et al. thought that a low carbon eco city is the human settlement of a forward looking ecological civilization embodying the integration and harmony between man and nature, a low-carbon economy and ecological culture.[15]

In conclusion, it is believed that the eco city is an ideal city pattern integrating into the global or regional ecological system and fully mixing technology and nature. It is a composite system of natural harmony, social equality and economic efficiency established on the basis of ecological principles, providing the best human settlements with efficient ecological industries, harmonious ecological culture and diverse ecological landscapes. Therefore, the concept of the eco city can be summarized as health, harmony and sustainability, which represent respectively the problem orientation, goal orientation and ethical orientation of the eco city.

4.1.2 Characteristics of the Eco City

At present, researchers of eco city theory have developed a comprehensive urban ecological theory including the concept of urban natural ecology, urban economic ecology, urban social ecology and composite ecology from the initial application of ecological principles to the city. The characteristics of the eco city have been forming both in research and practice. In the 1990s, a large number of ecological urban developments both at home and abroad emerged including overseas developments such as Berkeley, Curitiba, Halifax, Masdar and domestic developments in recent years such as the Dongtan Eco City, the Sino-Singaporean Tianjin Eco City, Caofeidian Eco City, etc. Based on the summary of these theories and examples of the construction of the eco city at home and abroad, we summarize the characteristics of the eco city as the following aspects:

(a) Highly Efficient Conversion System

In the conversion process of natural substance—economic substance—exhaust gas, we must input less natural material, output more economic material and discharge less waste. The effective operation of the system displays in the aspect of industrial structure in the form of the inverted pyramid structure. Namely, the third industry is greater than the second industry, which is greater than the first industry.

[13] Li et al. [12].

[14] Shen et al. [13].

[15] Yan et al. [14].

(b) Highly Efficient Circulation System

We should regard modern urban infrastructure as the supporting skeleton creating the necessary conditions for the movement of logistics, and the flows of energy, information, value and people in order to reduce economic loss and pollution of urban ecology in the accelerating orderly movement of various flows.

(c) Integrity and Forward-Looking

The eco city not only strives to create a beautiful environment and its own prosperity but it also seeks development under the overall coordination of the new order. The planning, construction and management of the city not only takes the overall interests and coordinated development of society, economy and the environment into account, but it also meets the demands of the different regions, the development of society and future generations and not only attaches great importance to economic development and a harmonious ecological environment, but also pays more attention to the improvement of the quality of human life. The planning, construction and management of the city won't seek its own temporary "prosperity" by "predating" other regions because of its immediate interests or keep current development at the expense of the interests of the offspring.

(d) High Quality of the Social Cultural Environment

The developed education system and higher population quality are part of the foundations and conditions of intelligence of the sustainable development of the eco city. The eco city should also be in a condition of good health and a suitable community environment.

(e) Internationalization of Environmental Quality Indicators

The eco city should possess a beautiful living environment and an advanced level of management and the indicators of environmental quality such as urban air pollution, water pollution and noise pollution should accord with international levels. Indicators such as the green coverage rate and green area per capita of the city should also meet international requirements. At the same time, the eco city should efficiently implement the management of urban population control, resource utilization, social services, employment and urban construction in order to guarantee sensible development and utilization of resources.

(f) Harmony between Man and Nature and Man and Man

The harmony of the eco city is reflected not only in the relationships between man and nature, symbiosis of nature and man, a return to nature, getting closer to nature and harmony between nature and the city, but more importantly in the relationship between man and man. Human activities have promoted economic growth but have not also been able to realize the synchronous development of human beings. The eco city can result in an environment able to meet the needs of human evolution and human emotions with a rich cultural atmosphere and powerful mutual aid groups, full of vigor and vitality. The eco city is not a dead living environment dotted with natural green spaces, but actively cares for people and cultivates man's "organ of love". Culture is the most important function of the eco city, while cultural identity and charm are the soul of the eco city. This harmony is the core concept of the eco city.

(g) Regional Unity

As a continuum between urban and rural areas, the eco city itself is a regional concept and is based on regional balance. The relationship between cities is also mutually connected and restricted. Only when regions are in a balanced state will the eco city be in a balanced state. The value goal of the eco city is harmony between man and nature. In broad terms, in order to achieve this goal, the whole world must strengthen cooperation, share technology and resources, form reciprocal symbiosis network systems and establish global ecological balance.

4.1.3 Types of Eco City

Based on synthesizing the construction practices of the eco city at home and abroad, the eco city can be divided into four types according to location, scale and differing dominant functions, namely the ecological community, the comprehensive new town, updating and innovating, and technological innovation (see Table 4.1). Because China and the developed western countries are at different stages of development, the construction of the eco city in western developed countries uses more forms of the ecological community, upgrading and innovating, and technological innovation, while in China, the construction of the eco city more often takes the form of the comprehensive new town.

4.2 Examples of Planning and Constructing the Eco City in China

Against the background of sustainable development, China has carried out a series of planning works on the sustainable development of urban areas. Based on their unique natural conditions or ecological advantages some cities have respectively carried out planning for landscape, botanical gardens, pastoral, low-carbon city, and regional circular economy under the concept of sustainable development. Generally speaking, all of the plans follow common principles—including the sustainable development principle—in the planning and guidance of the practice of urban construction. Therefore, this section focuses on ecological urban planning and discusses related planning using examples.

Table 4.1 Types of eco city

Type	The ecological community	The comprehensive new town	The updating and innovating	Technology innovation
Typical case	Halifax	Dongtan eco city in Tianjin	Masda: a French project of the eco city	The Berkeley Eco City
Location	The built urban area	The urban suburbs	The innovating urban area	The city suburbs
Scale	Several hectares to dozens of hectares	More than a few square kilometers	More than a few square kilometers	More than a few square kilometers
Function	Residential mainly, supported by business and leisure	Comprehensive features of residential, office and culture	Residential, office, and new industries	Technology innovation, science and technology and residential
Experience	Such ecological technology as green building and energy-saving	The balance between work and residential, ecological technology	Applicable ecological technology, functional upgrade replacement	Self circulation, high tech application
Shortcomings	Smaller scale, weak popularization	Lack of regional linkages, fewer constraints, weak replicability	Updating projects mainly, lack of systematic planning measures	Higher cost, weak popularization

4.2.1 The Background to Carrying Out Planning for the Eco City in China

The concept of sustainable development was first officially discussed at the human environment conference held in 1972 by the United Nations in Stockholm. After the conference on environment and development held by the United Nations in 1992, the Chinese government took the lead to document *The twenty first Century Agenda of China—the White Paper on Population, Environment and Development of China in the twenty first Century,* which is a programmatic document guiding the development of the national economy and society in China and which began the process of China's sustainable development. As a response to the sustainable development strategy of China, some local governments began planning practice based on the sustainable development of their city and applied the concept of sustainable development to the field of overall urban planning and such fields as urban and architectural design. Although planning at that time usually just mentioned integration of the principles of sustainable development and the concept of sustainable development into the planning in the compiling process during these years, some cities have begun to regard the concept of sustainable development as the guideline to city planning such as eco city planning, pastoral city planning and landscape and garden city planning, which are different from traditional urban planning and apply the principle to a layer of further planning and directly employ planning for sustainable development to guide urban development. In China, there are many regions including the ecological province and the ecological county, promoting the construction of the eco city and practicing the compilation of systematic overall planning of the eco city, such as *The Planning of the Eco City in Yuxi*, *The Ecological Planning of the Landscape and Garden City in Huairou District*, *The Construction Planning of the Ecological County in Cangnan*, *The Overall Planning of the Ecological Civilized City in Guiyang (2007–2020)*, and *The Overall Planning the Sino-Singapore Tianjin Eco City (2007–2020)*, etc. The following focuses on the planning practice of the eco city and the low-carbon city in China against a background of sustainable development.

4.2.2 The Basic Principles of Carrying Out Eco City Planning in China

The eco city is the developmental goal of the city. To carry out eco city planning in a city is to gradually realize the development goals of the eco city through making such plans. All the plans and arrangements for the development of the city in eco city planning should reflect the coordinated development of society, the economy and the environment. As early as 2003, the Ministry of Environmental Protection (the state environmental protection administration of environmental protection at that time) issued *The Trial Implementation of the Construction Indicators of the Ecological County, the Eco City and the Ecological Province*, and, on December 26th, 2007, the Ministry of Environmental Protection again issued notice about the "revised draft of the construction indicators of the ecological county, the eco city and the ecological province (hereinafter referred to as *Indicators*)". The *Indicators* clearly put forward the specific standards for the construction of the ecological county, the eco city, and the ecological province in China. To the ecological county (including the eco city), the *Standards* put forward three categories containing 22 items of related binding indicators or reference indicators relating to economic development, environmental protection and social progress. To the eco city (including the local administrative region), the *Standards* put forward three categories of related binding indicators or reference indicators concerning economic development, environmental protection and social progress. To the ecological province, the *Standards* put forward for three categories containing 16 items of related binding indicators or reference indicators on economic development, environmental protection and social progress. It can be said that the basic principle of carrying out the planning of the ecological county and the ecological province in China is to satisfy these indicators especially the most basic aspects of the binding indicators. A series of construction activities put forward in eco city planning must be carried out under the conditions of binding indicators—the most basic principles of the construction of Chinese eco cities. However, it should be made clear that although the eco city is the ideal state of a city, it is not the ultimate eco city which can be achieved through eco city planning. The goal of the eco city is a process of constant adjustment and eco city planning as a guarantee of achieving that goal can only move the city forward through continuous adjustment.

4.2.3 Judgment of the Attributes of Eco City Planning in China

As for the planning of the eco city, the garden city and the landscape city as the goal of urban development, we believe that the style of planning has some differences from traditional spatial and urban planning. Often, at a higher level, planning does not take a form but an idea, and the reason why overall urban planning is modified by ecology, the biological garden, landscape, forest and garden is to make the concept of sustainable development more obvious. From the point of view of the practice of eco city planning there are three types (Table 4.2). The first is the continuation of traditional spatial planning and its aim is to place ecology at the forefront of overall urban planning. For example, *The Overall Planning of the Civilized Eco City in Guiyang City (2007–2020)* whose technical route basically makes use of the way of compiling the overall urban planning in the past, only

Table 4.2 Major types of preparation of ecological urban planning in China

Types	Characteristics	The dominant compiling department	Cases
1	Traditional spatial planning as the leading factor, supplemented by ecological planning	Urban planning department	The overall planning of the civilized eco city in Guiyang City (2007–2020)
2	Ecological planning mainly in accordance with the indicators of the eco city	Environmental protection department	The construction planning of the ecological county in Cangnan (2004–2020), the construction planning of the eco city in Yangzhou (2000–2020)
3		Government domination not by a single department	The Sino-Singaporean Tianjin Eco City planning (2007–2020)

slightly differently. The second category is placing less emphasis on the concept of space and putting more emphasis on the construction and protection of the environment through coercion during planning in order to comply with the nation's *Indicators* and especially the standards of the binding indicators, such as *The Construction Plan of the Ecological County in Cangnan*. The third type is placed between the first and the second or is a combination of the two. It will not only continuously use the traditional method of planning—taking spatial planning as the core of urban planning—but will also implement a series of standards of environmental protection at every stage of planning. These links not only include spatial planning but also involve such planning elements as development of industry, transportation and community etc., as well as economic development and social progress, which is reflected most obviously in *Sino-Singapore Tianjin Eco City Planning (2007–2020)*. It can be said that *Sino-Singapore Tianjin Eco City Planning (2007–2020)* is the model of how to carry out eco city planning in China and on the basis of further improvement it is worth exporting the model to other regions throughout the country by adjusting measures to local conditions, which, however, has a premise. That is, *Sino-Singapore Tianjin Eco City Planning (2007–2020)* was compiled with the support and guidance of Singapore (a developed country), and it has too many characteristics specific to itself that other places can't copy. Firstly, the construction of the Sino-Singaporean Eco City was carried out under the strategy of national construction of Tianjin Binhai new area and most other cities in China still do have that advantage. Secondly, the Sino-Singaporean Eco City is a new city and its original site comprises abandoned saltland, wasteland and parts of small villages. It can also be said that the city was built on almost "blank" land. Thus, it was constructed completely according to the latest concept of eco city planning and so didn't need to be under the restrictions of traditional urban development. The construction of the eco city in cities in other parts of China is expected to be implemented more on the basis of the original city with pressure coming from the adjustment to the industrial structure, urban spatial structure and the layout of land utility. Furthermore, ecological protection will be significantly higher than that of the Sino-Singaporean Tianjin Eco City.

4.2.4 Typical Cases of Chinese Eco City Planning

1. Eco City Construction Planning in Yangzhou (2000–2020)

The construction plan for the eco city of Yangzhou city began in 2000. After more than three years of research and compilation, the construction planning of Yangzhou Eco City (2000–2020) was finally realized. The main contents of the planning include:

(a) Building the index system of eco city construction in Yangzhou. The index system includes 3 types (economy, environment and society) of first level index, 18 types of second level index (6 economic indices, 4 environmental indices and 8 social indices), and 91 types of third level index (22 economic indices, 31 environmental indices and 38 social indices);

(b) The division of compound ecosystem districts. There are five kinds of compound ecological zones such as Binjiang, the main body of the suburbs, Binhu, the western uplands and Lixiahe;
(c) Environmental protection planning: four categories including the water environment, the atmospheric environment, waste and noise;
(d) Resource conservation planning: including farmland, water resources, wetlands, the development and restoration of mineral resources, forest resources and biodiversity etc.
(e) The ecological construction of the urban system and the landscape of the main body of the city;
(f) The transformation of industrial ecology and the development of ecological industries;
(g) Construction of ecological culture;
(h) The safeguarding measures of sustainable development construction ability and eco city planning implementation (Fig. 4.1).

2. The Overall Planning of the Civilized Eco City in Guiyang City (2007–2020)

The overall planning of the civilized eco city of Guiyang City barely mentioned the process of establishing the index system of the eco city and followed instead the traditional spatial layout pattern. It only used some of the ideas of the eco city in the process of the spatial layout in order to achieve the urban ecological pattern of "the integration of landscape, forest and the city" (Fig. 4.3) through the construction of the urban spatial structure of "one city, three zones and multiple groups" (Fig. 4.2). The overall plan also did not reflect the coordinated development of the three systems—the systems of society, economy and environment—which eco city planning should emphasize. Therefore, to a large extent, the overall planning of the civilized eco city in Guiyang city is still similar to the traditional overall planning of the city.

3. Overall Planning of the Sino-Singaporean Tianjin Eco City (2008–2020)

The significance of the construction of the Sino-Singaporean Eco City. The Sino-Singaporean Tianjin Eco City is a strategic cooperation project between the Chinese and Singaporean governments and is the new highlight of cooperation between the two countries after Suzhou Industrial Park. The construction of the eco city shows the determination of both the Chinese government and the Singaporean government in response to climate change to strengthen environmental protection resources and improve energy-saving, and provide typical examples of the construction of the resource-saving and environmentally friendly society.

The construction of the index system of the Sino-Singapore Tianjin Eco City. According to the resources, environment and living status of the chosen area and highlighting the people-oriented concept, the planning of the eco city proposed 22 items from the controlling indices involving three aspects—economy, society and

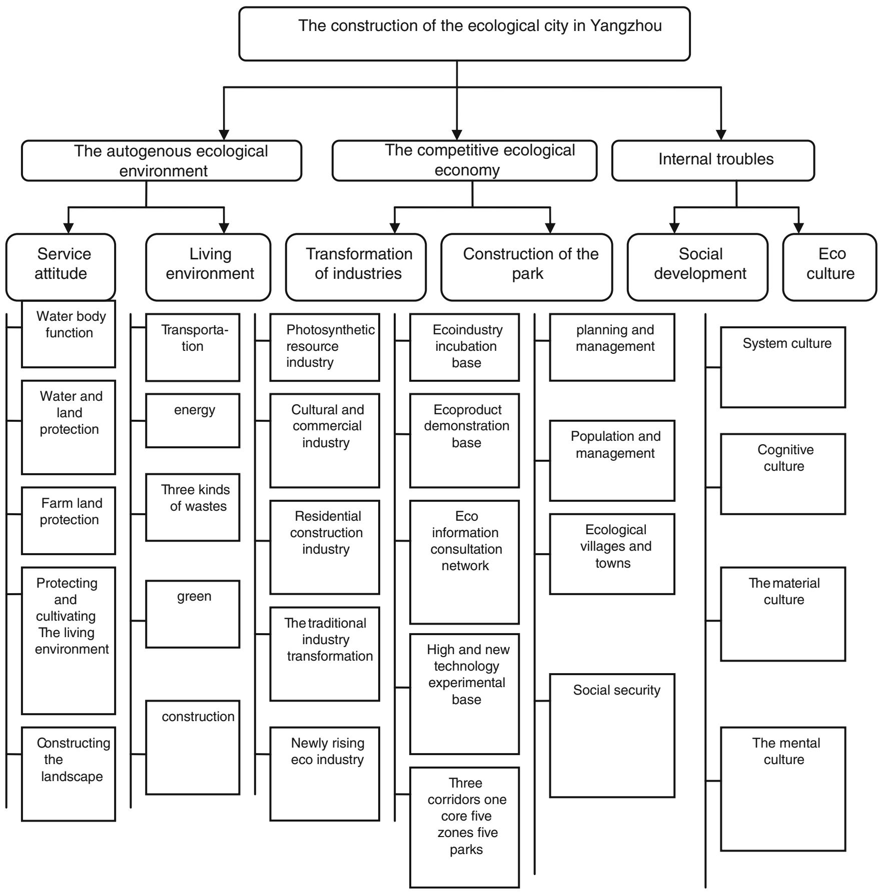

Fig. 4.1 The picture of the construction structure framework of the eco city in Yangzhou City

environment—such as the healthy natural environment, coordination of the artificial environment, healthy lifestyles, perfect infrastructure, sound management mechanisms, sustainable economic development, active science and technological innovations, the comprehensive balance of employment and 4 items from the leading indicators of regional harmonious integration—the coordination of natural ecology, regional policy, society and culture and the regional economy etc. to guide the development and construction of the eco city and to provide technical support and construction paths to be copied, carried out and expanded. According to the principle of combining the scientific and the practical, the qualitative and the quantitative, the features and the commonness, and accessibility and expansibility, the index system retained the essence of traditional urban planning indices, improved related standards of traditional urban planning, reflected new demands of ecological construction, highlighted protection and restoration of the original ecology, constructed the natural ecological system of a suitable ecological structure, a perfect

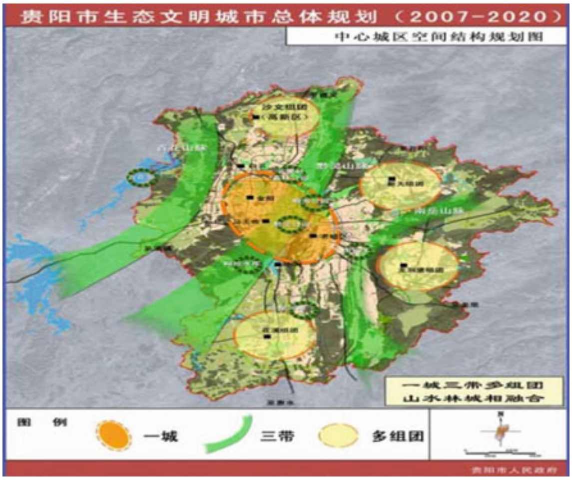

Fig. 4.2 Overall planning of the civilized eco city in Guiyang City (2007–2020)—A picture of the spatial structure plan of the central city. *Source* Overall planning of the civilized eco city in Guiyang City (2007–2020), Guiyang Municipal People's Government, Guiyang City

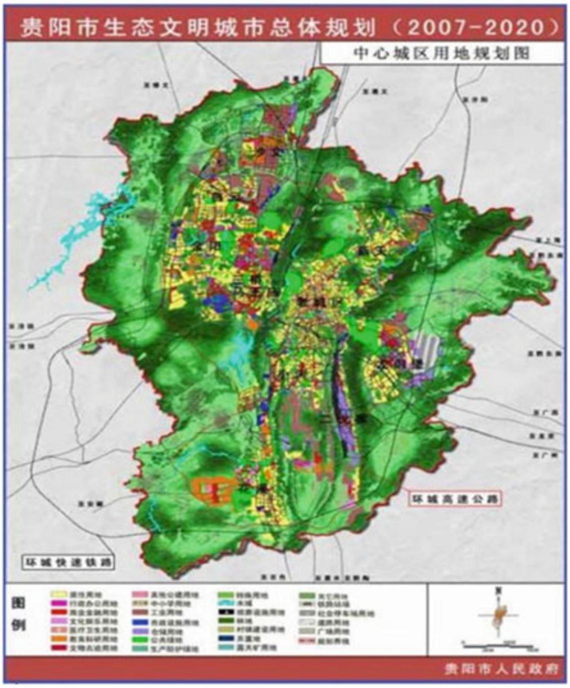

Fig. 4.3 Overall planning of the civilized eco city in Guiyang City (2007–2020)—Map of land use planning of the central area of the city. *Source* Overall planning of the civilized eco city in Guiyang City (2007–2020), Guiyang Municipal People's Government, Guiyang City

service function, excellent environment quality and the coordinated system of the artificial environment.

The core contents of Sino-Singapore Tianjin Eco City's overall planning include: ecological protection and ecological restoration, spatial layout structure,

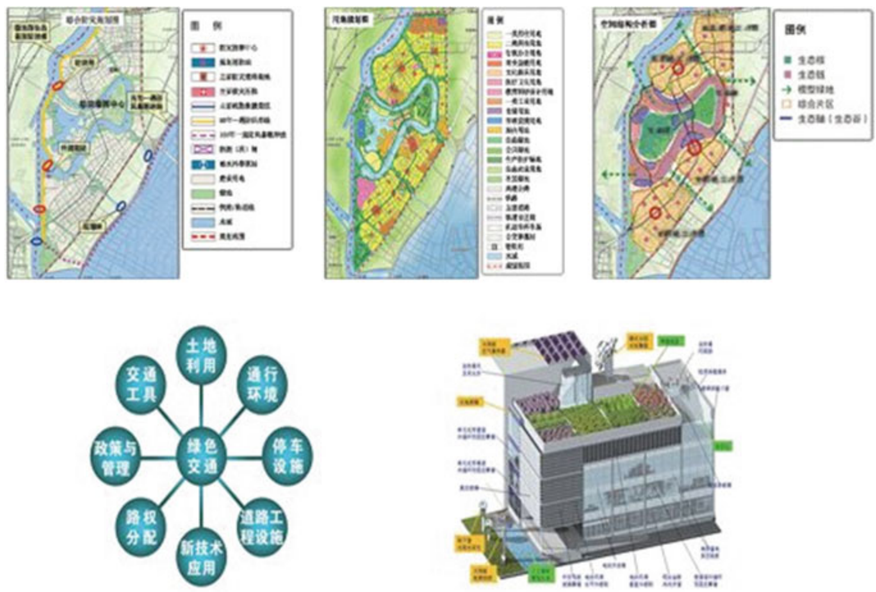

Fig. 4.4 Overall planning of the Sino-Singaporean Tianjin Eco City (2008–2020). *Source* The Urban Management Committee of the Sino-Singaporean Eco City. Overall planning of the Sino-Singaporean Tianjin Eco City (2008–2020)

ecological community, public facilities, green transportation, the comprehensive utilization of water resources, the comprehensive utilization of energy, landscape systems, environmental protection and environmental health, the digital city and urban safety (Fig. 4.4). It can be said that each item in the core contents of overall planning is integrated into the concept of the eco city.

4.3 Developmental Trend of Spatial Planning in Foreign Countries and Its Implications for China

4.3.1 Spatial Planning in Foreign Countries

With the deepening of globalization, regionalization, localization, marketization and informationization, spatial planning in foreign countries shows the following trends:

(a) In the concept of spatial planning, besides the continuous emphasis on traditional ideas such as equal opportunities for people and balanced regional development, every country pays attention to sustainable development, environmental conservation and cultural development according to the recommendations of the United Nations Conference on environment and development.

(b) With the deepening of the localization process, spatial planning also pays attention to enhancing the competitiveness of the regional economy, encouraging local places to use their wisdom and expertise to plan and implement national projects, strengthen coordination both longitudinally and transversely and support regional self-reliance and encourage cooperation across administrative regions.

(c) In the international process of globalization of the economy and environment and the integration of certain parts the world, spatial planning must consider the influencing factors of globalization and sustainable development. For example, in the European Union multinational formulation and implementation of spatial planning appeared.

(d) Spatial planning has begun paying attention to the improvement of the country's software services such as the excellent quality of public services to ensure people enjoy nearby public services and enjoy an equality opportunity of knowledge.

(e) In spatial planning, the macro-control role of central government has been strengthened, planning information has been announced in a timely manner, the public has been encouraged to participate, and development and construction in which the government and the residents have been partners has appeared.

(f) In spatial planning, designing a centrally located city within a surrounding rural area is becoming more and more important as it strives to build a new relationship between the city and the rural areas.

4.3.2 The Implications of Foreign Spatial Planning for China

Although the national organizational structure and administrative system is different, the successful experiences of spatial planning and management in foreign countries do not fully meet the requirements of spatial planning and management of China, but the following aspects are still worth exploring.

(a) China is a country with a vast territory, diverse regions, poor resources per capita, an especially serious shortage of arable land and fresh water, a conflict between the new and old systems in the primary stage of socialism, and the transition from a planned economy to a market economy has exacerbated the imbalance between regions. Because the laws for space planning in foreign countries are relatively rigorous, China should draw lessons from the successful experiences of foreign countries. Combined with national conditions, China should develop and perfect a legal system of spatial planning as soon as possible in order to guarantee the coerciveness and binding nature of spatial planning.

(b) Additional comprehensive policies and measures which can guarantee the implementation of planning should be added to the contents of spatial planning so as to transform the current lack of emphasis on planning and oversight strategies in China's spatial planning, improve the operability of spatial planning, avoid making spatial planning difficult to implement, ensure the overall strategic position of spatial planning and help it to become the major method of national macro-control. For example, we can learn from the European Union's structural fund and establish a similar national fund in China in order to guide coordinated development across different regions.

(c) China is in the process of developing industrialization and urbanization, and its resources and environment are important factors in restricting the sustainable development of society and the economy. The idea that planning should aim to follow is that of combining protection of the ecological environment with the sustainable development of society and the economy. The formulation of planning should proceed from the spatial characteristics of the region in question, coordinate and balance the spatial structure system, implement the concepts of ecology and environmental protection, protect nature and promote harmony between man and nature and the sustainable development of economy.

(d) Learning from the experience of localization in foreign countries, all aspects of spatial planning should include public participation, and that public participation should be clarified in the form of laws or regulations to avoid it becoming a mere formality and to accelerate the establishment of an effective localized mode of spatial planning and management based on the principles of joint participation, joint responsibility and mutual benefit.

(e) Setting up a scientific system of spatial planning and establishing a planning system of controlling planning, guiding planning and construction planning. The contents of spatial planning should be different from the upper to the lower levels, but the contents between different levels are closely linked, and the planning from strategic planning, concept planning and the national program for land remediation to regional planning and urban and regional planning, are divided into instructional nature (national land planning outline and district planning), operability (overall urban planning) and control property (detailed urban planning) respectively, with every layer constraining another in order to create a perfect spatial planning system.

(f) China is short of spatial planning theories and methods and should selectively introduce foreign spatial planning theories and methods aligned to China's current situation, especially the historical, cultural and geographical conditions and characteristics of the system, as well as continuously innovating, developing and forming theories and methods of the spatial planning system that are suitable for China's national environment.

(g) Spatial planning at every level should be in accordance with the corresponding administrative region. We should establish a centralized and unified management mechanism of a planning team and then implement and strengthen the macroeconomic regulation and control functions of the planning, introduce and strengthen the expected evaluation of the implementation effect of the plan and thereby compare different plans.

4.4 The Development Strategy of Spatial Planning of Eco City Construction in China

4.4.1 Actively Implementing the Strategy of the Main Function Area

We should fully implement the planning of the main function area and improve supporting policies in areas such as finance, investment, industry, land, population and environment, and the performance appraisal and evaluation system, with different foci. We should also speed up the orientation of the main function of the cities and counties and promote the integration of multiple planning into a unitary plan, such as the planning of economic and social development, urban and rural areas, land use and ecological environment protection, resulting in one plan or one blueprint for one city or one county. Regional planning and the layout of major projects must sit in agreement with the main function. As for industrial projects in different development priority zones, we should implement differentiated market access policies, clarify access issues surrounding prohibited development areas and limited development areas, and industries prohibited and limited in the optimized development area and the key development area. In addition, we should design and implement a national land planning outline, accelerate comprehensive land improvement, establish a balanced and suitable spatial system for urban and rural construction, increase living space, ecological land and protect and expand such ecological spaces as green areas, water and wetlands.[16]

4.4.2 Scientific Construction of the Strategic Pattern of Urbanization

In accordance with the principle of overall planning, rational layout, perfect function and of big cities being guides for smaller ones, we should follow the objective law of urban development and gradually create an urban agglomeration

[16]The Central Committee of the Communist Party of China & the State Council. The Views of the CPC Central Committee and the State Council on Accelerating the Construction of the Ecological Civilization ([2015]12, Z), April 25, 2015.

with strong radiative effects by relying on big cities and focusing on small and medium-sized cities in order to promote the coordinated development of large, medium and small-sized cities and small towns. We should establish a strategy pattern of urbanization, with the land bridge channel and the channel along the Yangtze River as two axes, with the coastal area, Jingha-Jingguang and Bao Kun channel as three vertical axes, relying on the urban agglomerations along the axes, and with other urbanized areas and cities as important components so as to promote economic growth and market expansion from east to west and from south to north. In eastern regions, we should gradually build urban agglomerations with more international competitiveness while fostering and developing a number of urban agglomerations in central and western conditional regions. We should also scientifically plan the function orientation and industrial layout of each city in the groups of cities, alleviate the pressure at the center of large cities, strengthen the function of industries in small and medium-sized cities, enhance public services and living functions of small towns, and promote the integration of infrastructure and network development in large, medium and small cities. In addition, we should actively explore the development potential of existing small and medium-sized cities, give priority to the development of small and medium-sized cities which have obvious advantages due to their location and resource-rich environment, focus on the development of small towns and gradually develop the central towns in eastern areas, the counties in central and western parts and important border ports into small and medium-sized cities.[17]

4.4.3 Implementing the Spatial Policy of Promoting the Protection of the Old City Through the Development of the New City

In the rapid development stage, many big cities often follow the path of constructing the new city in order to expand urban space and transfer industries and population outward to ease the pressure on urban operations caused by overpopulation and intense social economic activity in the old city.

(a) Continuous promotion of the development of new towns according to the schedule of the development of urban space development. Quick and effective promotion of the development of the new city is the basis of the protection of the old city and open green spaces. The difficulty that development of the new city has is to develop in accordance with the schedule of urban space development and we should give priority to cultivating new towns by means of cultivating "a region and maturing the region", and create the center to disperse

[17]The Central Committee of the Communist Party of China and the State Council. The twelfth five-year plan for the national economy and social development of the People's Republic of China. Z, March 16, 2011.

the "pushing" forces of the old city as soon as possible to avoid any dispersion of development. However, this does not mean that all projects will be concentrated in a new town as a result of differing schedules. In fact, in the creation of the excellent urban spatial form, a city may plan more than two new cities and the new towns may be divided into different functions, some integrated and some professional (such as industry, education and housing etc.).

A correct development strategy ensures that the professional function will be concentrated in professional new towns and at the same time gathers the general function into the new cities having developmental priority according to the timing of urban space development. In order to accelerate the construction of new cities the corresponding policies also need to be followed: accelerate the implementation of either zoning adjustment or a unified management system in accordance with the planning unit, give the new city the management authority at municipal level, establish a unified management system of land reserves, supply and management, end the policy of compensating land with projects, encourage the construction of municipal traffic facilities and public welfare facilities in the new urban area through TOD and SOD models, give priority to putting large facilities that the municipal government can control into the construction of the new district and establish an evaluation system that corresponds to the orientation of the overall urban function and spatial layout of the city.

(b) Strict protection of old cities and the promotion of city functions and structural adjustment. To evacuate the old city population, it is necessary to strictly control the construction of the old city housing, especially in the area of high-rise residential buildings. Protection of the old city is not to control its development, but rather to transform the development from simple expansion to the adjustment of structure and function. One aim is to gradually move polluting businesses in the old city through land replacement, retaining only a small amount of non-polluting urban industries. The second aim is to increase the amount of green land and improve municipal construction facilities, the traffic condition of the old city and the quality of the living environment. A third aim is the gradual improvement of public service facilities in order to better serve the community and strictly control the concentration of large-scale high-grade large public facilities in the construction of the old city.

(c) The selective development of a small town policy. To gather production factors and exploit the effect of gathering, we need to selectively develop key small towns and develop many small towns which have favorable development conditions and are good at seizing the opportunities for their development into small or even medium-sized cities. Such small towns are most likely to appear around big cities and through reasonable fostering they will become the heart of small and medium-sized cities or large cities. That is, selecting small towns and cities which have a good foundation and great potential for development in accordance with urban system planning, establishing the system of basic construction investment biased towards the towns and cities of the key construction, avoiding disorderly competition between small towns and cities, establishing a system of construction investment and management through the District Development Zone and forming policies of encouraging the urbanized rural population to settle, invest and work in key towns and cities.

4.4.4 Exploring the Development and Layout Pattern of the "Compact City" Suited to China's National Conditions

Learning from the developmental experience of the European "compact city", through the coordination of the layout of urban morphology, rational organization of the road traffic system and control of the development and guide of cities to ensure that the city conforms to the pattern of the compact layout of modern development is entirely achievable. Despite the fact that the problems Chinese cities are now facing are different from those that western countries faced, learning from the experience and lessons of the development of the European compact city in order to guide urban construction in China is very necessary and we have every reason to believe cities in China can find a sustainable development method that is completely different from the development of any kind of western city. A type of diversified, vibrant urban central space with pedestrianization, no pollution and low energy consumption is not out of reach. Given that the nature of the spatial form of Chinese cities has basically been determined, small and medium-sized cities are at the forefront of urban development and construction. We can learn from the developmental processes of good European cities and absorb the essence of their development, while avoiding the mistakes made during the development processes of European urbanization and follow a development route for compact cities that are suited to China's national conditions.

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Chapter 5
The Evaluation Report of the Health Conditions of the Eco Cities in China

Tinggang Zhao, Haitao Liu, Jianmin Xie, Xiaojun Zhu, Zhibing Zhang and Tao Liu

Abstract *The Evaluation Report of the Construction of Ecological Civilized Cities in China* is a think-tank report concentrating on the research, decision making command and engineering practice of eco city construction due to deterioration of the ecological environment and the grim reality of increasingly serious "urban diseases". It is the leading source of provision of research achievements, theoretical guidance, decision making consultation and implementation of eco city construction. This report carried out a statistical analysis and comprehensive ranking of the health conditions of Chinese eco cities in 2013, following the basic theories and methods given in *The Report of the Construction and Development of Eco Cities in China (2012)*, *The Report of the Construction and Development of Eco Cities in China (2013)* and *The Report of the Construction and Development of Eco Cities in China (2014).*

Keyword The health evaluation index of the eco city

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5.1 Introduction

The comprehensive evaluation of the health conditions of eco cities is very important. A more objective evaluation can reflect reality and provide a theoretical basis and support for government decisions. This report is one of a series in *The Report of the Construction and Development of the Eco Cities in China*. It is based on Chinese statistical data for 2013 and on the whole it follows the evaluation model of the past, aside from some slight modifications.

5.2 Methodology and Modeling

The report continues to use the dynamic evaluation model established in “The Report of the Construction and Development of Eco Cities in China (2012)”. Therefore, the following reviews the theoretical results of the model.

5.2.1 The Evaluation Model of Health Indices of the Eco City

5.2.1.1 The Major Features of Eco Cities

Generally speaking, eco cities have the following basic characteristics:

The first is harmony. Harmony is the core content of the concept of the eco city, reflecting the harmony between man and nature, man and man, artificial and natural environments and the development of economic society and environmental protection, the purpose of which is to seek to establish a new order of a virtuous circle of development.

The second is high efficiency. The eco city will change the operating mechanisms of “high energy consumption” and “non-cycle” of the modern city and will instead improve the efficiency of resource utilization and aim to make the best use of everything—materials, land and talents, with matter and energy got multi-level utilization, therefore form the circular economy.

The third is persistency. The eco city, guided by the idea of sustainable development can fairly meet the needs of both contemporary people and future generations in terms of development and the environment and also guarantee healthy, sustainable and stable development.

The fourth is balance. The eco city is a compound system, composed of interdependent subsystems of economy, society, nature and ecology etc., and each subsystem develops under the overall coordination of the system of the eco city in balance.

The fifth is regionality. The eco city is the product of the perfect combination of human activities and the use of natural ecology in a certain regional area and is a strongly regional entity. The eco city also stresses the maintenance of a strong correlation and aggregation relationship with its surrounding cities, the formation of a symbiotic relationship and active participation in international economic and technical cooperation.

5.2.1.2 Quantitative Criteria for Eco City Construction

Supposedly, there are international and national standards of quantitative criteria in the construction of an urban environmental system, but we consider that these standards are just the ultimate standards a city makes every effort to reach in the construction of the environmental system. Some can be used as the quantitative standard of construction within a certain period, while some cannot be used as the construction standards within a certain period. For example, in terms of total vehicle emissions of a city each day, how the quantitative criteria are determined is a problem worth discussing. Here we discuss such a problem: By the end of 2014 in every city in China, what should the standards of total vehicle emission every day be? The only scientific approach is to determine them using the following steps:

The first step is to measure the total amount of vehicle emissions per day at the end of 2013 in each city in China;

The second step is to calculate the max and min of the above statistics;

The third step is to establish the standard for total vehicle emission per day for every city in China by the end of 2014, according to the following formula:

$$bzl = \lambda \max + (1 - \lambda) \min$$

in which $0 \leq \lambda \leq 1$.

Obviously, at the end of 2014 the standard for total vehicle emissions per day for every city in China lies between a minimum and a maximum. This is because the min should be the ideal standard for total vehicle emissions per day for every city in China at the end of 2014, but if the min is regarded as a standard at this stage, then by the end of 2014 the total vehicle emissions in most cities is likely to be beyond the min. So, the standards for total vehicle emissions per day for every city in China by the end of 2014 are between the min and max. So, how to establish λ is the key problem. We believe that the choice of λ can enable the number of cities whose amount of daily vehicle emissions at the end of 2013 is lower than *bzl* to become greater than one-third of the total number of cities. That is to say, the construction standards established can ensure that more than one-third of the cities are at the required standard.

The fourth step is that the standard indicators of total vehicle emissions per day for every city in China at the end of 2014 are:

$$bz = \frac{\frac{1}{bzl} - \frac{1}{\max} + 1}{\frac{1}{\min} - \frac{1}{\max} + 1}$$

So, the quantitative standard of eco city construction is a dynamic quantity. The construction standard for the following year is determined on the basis of the construction effects and construction standards of the previous year. Also, the construction effects of every city during the year are evaluated according to the construction standards of the year.

Generally speaking, suppose that X is a collection consisting of all the cities in China. For any given moment t, and for any given city $C \in \mathrm{X}$, when C is at the moment t, then the construction index of the eco city is a $m \times n$ matrix, that is:

$$C(t) = \left(c_{ij}(t)\right)_{m\times n} = \begin{pmatrix} c_{11}(t) & c_{12}(t) & \cdots & c_{1n}(t) \\ c_{21}(t) & c_{22}(t) & \cdots & c_{2n}(t) \\ \vdots & \vdots & \vdots & \vdots \\ c_{m1}(t) & c_{m2}(t) & \cdots & c_{mn}(t) \end{pmatrix}$$

And it must satisfy the condition:

$$0 \le c_{ij}(t) \le 1.$$

Suppose $X \subseteq \mathrm{X}$ is a collection consisting of certain kinds of city in X, making

$$x_{ij}(t)_1 = \min\left\{c_{ij}(t) \middle| C \in X\right\} \quad i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n$$

$$x_{ij}(t)_2 = \max\left\{c_{ij}(t) \middle| C \in X\right\} \quad i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n$$

and then say

$$X(t)_1 = \left(x_{ij}(t)_1\right)_{m\times n} = \begin{pmatrix} x_{11}(t)_1 & x_{12}(t)_1 & \cdots & x_{1n}(t)_1 \\ x_{21}(t)_1 & x_{22}(t)_1 & \cdots & x_{2n}(t)_1 \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1}(t)_1 & x_{m2}(t)_1 & \cdots & x_{mn}(t)_1 \end{pmatrix}$$

is the present condition of the lowest development of X at the moment t, believing

$$X(t)_2 = \left(x_{ij}(t)_2\right)_{m\times n} = \begin{pmatrix} x_{11}(t)_2 & x_{12}(t)_2 & \cdots & x_{1n}(t)_2 \\ x_{21}(t)_2 & x_{22}(t)_2 & \cdots & x_{2n}(t)_2 \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1}(t)_2 & x_{m2}(t)_2 & \cdots & x_{mn}(t)_2 \end{pmatrix}$$

to be the present condition of the highest development of X at the moment t, especially when $X = \mathrm{X}$, believing that

$$X_1(t), X_2(t)$$

are respectively the present condition of the lowest development and the highest development of eco city construction in China at the moment t.

Suppose $X \subseteq$ X is a collection consisting of certain kinds of city in X, $X_1(t), X_2(t)$ are respectively the present condition of the lowest development and the highest development when X is at the moment t. The construction standard $B(t+1)$ when X is at the moment $t+1$, satisfying

$$B(t+1) = \lambda_1(t)X_1(t) + \lambda_2(t)X_2(t)$$

in which

$$\lambda_1(t) + \lambda_2(t) = 1$$
$$0 \leq \lambda_1(t) \leq 1$$
$$0 \leq \lambda_2(t) \leq 1$$

To establish the evaluation standard of the construction of eco cities in China, we must analyze the present situation of construction of eco cities in China, establish the present conditions of the lowest development and the highest development of Chinese eco city construction at moment t, so as to establish the development standard at the moment $t+1$, that is, when we establish standards, we should first, through the statistical investigation, establish the present conditions of the lowest development and the highest development of the city at the moment t

$$X_1(t), X_2(t)$$

Then, according to $X_1(t), X_2(t)$, we should select suitable $\lambda_1(t), \lambda_2(t)$ and establish the construction standard $B(t+1)$ when X is at the moment $t+1$. Generally, $B(t+1)$ should satisfy the condition:

$$P_1)\ b_{ij}(t) \leq b_{ij}(t+1) \quad i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n$$

And $b_{ij}(t)$ must reach the min norms of the nation.
In the collection P_2), the number of

$$\{C \in X | c_{ij}(t) \geq b_{ij}(t+1),\ i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n\}$$

is not less than one-third of the number in the collection X.

In P_3) under the conditions that P_1) and P_2) are established, $\lambda_1(t)$ and $\lambda_2(t)$ are the solutions to the optimization problem:

$$\begin{cases} \min\left\|\lambda_1(t)\sum\limits_{C\in X}(C(t)-X(t)_1)+\lambda_2(t)\sum\limits_{C\in X}(X(t)_2-C(t))\right\| \\ \text{s.t} \qquad \lambda_1(t)+\lambda_2(t)=1 \\ \qquad\quad 0\le\lambda_1(t)\le 1 \\ \qquad\quad 0\le\lambda_2(t)\le 1 \end{cases} \tag{5.1}$$

That is to say, the setting of eco city construction standards must conform to the objective reality, take action accordingly and must not be impatient for success. The standards that are set must have the standard demonstration city, and the number of the standard demonstration cities can be neither less than a third of the total number of cities, nor higher than one-half of the total number of cities.

The standard provided by the model (5.1) does not take the specific characteristics of each city into account, so when this standard is set the construction standards in accordance with the development characteristics of each city must be set according to the actual situation of the specific city, with reference to this standard. In the course of the ecological construction, those which can be built must be built well and those which cannot be built for sound reasons cannot be forced to be built ahead of time. Construction standards should be set by taking the specific development characteristics of each city into full consideration and a unified index to measure each city should not be used otherwise the eco city construction will lose its significance. Therefore, in formulating construction standards for some projects which cannot be achieved objectively in some cities, the indices of these projects should be set at max when setting indicators of these projects in the city. However, we should be determined to put an end to the occurrence of the phenomenon that some projects which cannot be achieved are still being built. So, in establishing the construction standard for each city, we must fully consider the two aspects above.

5.2.1.3 The Basic Concept of Eco City Construction

Suppose $R^{m\times n}$ is the collection consisting of all the $m\times n$ matrices,the norm $\forall A \in R^{m\times n}$ can be defined as:

$$\|A\| = \sup\{\|Ax\| \,|\, \|x\| = 1, x\in R^n\}.$$

Then in the above norms $R^{m\times n}$ is a *Banach* space.

Written as

$$\mathrm{P} = \left\{A\in R^{m\times n} | 0\le a_{ij}\le 1, i=1,2,\ldots,m; j=1,2,\ldots,n\right\}.$$

And then P is a convex closed set containing interior points in $R^{m\times n}$ and satisfies the following two conditions:

$$P_4)\, A \in \mathrm{P}, \lambda \geq 0 \Rightarrow \lambda A \in \mathrm{P};$$

$$P_5)\, A \in \mathrm{P}, -A \in \mathrm{P} \Rightarrow A = \theta, \text{here}\, \theta\, \text{indicates zero element in}\, R^{m\times n};$$

Introducing the semi-order in P: $A \leq B(A, B \in \mathrm{P})$, if $B - A \in \mathrm{P}$.
If $A \leq B, A \neq B$, then written as $A < B$; 若 $B - A \in \mathrm{P}^0$
.

1. **Sustainable Development of the Construction of the Eco City**

Suppose X is a collection consisting of all the cities in China, $C \in \mathrm{X}$ is certain city, then the construction indicator of the eco city C at the moment t is an $m \times n$ matrix:

$$C(t) = \left(c_{ij}(t)\right)_{m\times n} = \begin{pmatrix} c_{11}(t) & c_{12}(t) & \cdots & c_{1n}(t) \\ c_{21}(t) & c_{22}(t) & \cdots & c_{2n}(t) \\ \vdots & \vdots & \vdots & \vdots \\ c_{m1}(t) & c_{m2}(t) & \cdots & c_{mn}(t) \end{pmatrix}$$

As for any given moment t, if

$$C(t) < C(t+1)$$

then the construction of the eco city is sustainable. In other words, the sustainable development of the eco city indicates that the construction of the eco city is better year on year with the passage of time, and the indicators may not be able to fully meet the requirements of the construction standards, but it cannot be good for a period of time and then bad for a period of time.

2. **Benign and Healthy Development of the Construction of the Eco City**

Suppose T_i indicates the year $T_i(i = 0, 1, 2, \ldots s)$ and $B(T_i)$ indicates the construction standard $(i = 0, 1, 2, \ldots s)$ achieved in the year T_i in the construction and planning of the Eco City, if

$$\mathrm{B}(T_i) \leq \mathrm{C}(T_i) < B(T_{i+1}) \leq C(T_{i+1}) \quad i = 0, 2, \ldots, s-1$$

we can say the development of the ecological construction of the city C is benign and healthy from year T_0 to year T_s. This shows that the benign and healthy development of the construction of the eco city means that the ecological construction is better year after year, and the indicators can fully meet the requirements of the construction standard.

3. **Classification of the Construction of the Eco City**

Suppose X is a collection consisting of all the cities in China. Suppose T_i indicates the year $T_i(i = 0, 1, 2, \ldots, s)$, written as

$X[T_0, T_S]_1$ = {$C \in X$| the development of the ecological construction of the city C is benign and healthy from year T_0 to year T_s}.
$X[T_0, T_S]_2$ = {$C \in X - X[T_0, T_1]_1$| the development of the ecological construction of city C is sustainable}.

$$X[T_0, T_s]_3 = X - X[T_0, T_s]_1 - X[T_0, T_s]_2.$$

That is to say, eco cities in China can be divided into three kinds: The first of which are those whose ecological construction is healthy and benign; the second are sustainable but not healthy and benign; the third are neither healthy nor benign or sustainable.

4. The Elementary, Intermediate and Advanced Stages Experienced in the Construction of the Eco City in China

The construction of the eco city in China has gone through elementary, intermediate and advanced stages. From the present to a specific year T_{s_1} in the future, the construction of the eco city in China is at the elementary stage and the basic characteristics of this stage are: as for the arbitrary $s < s_1$, it should satisfy:

$$X[T_0, T_s]_i \neq \phi \quad i = 1, 2, 3.$$

That is to say, the elementary stage exists in all the three kinds of eco city.

From year T_{s_1} to year T_{s_2}, the construction of the eco city in China is at the intermediate stage, and the basic characteristics are:

As for the arbitrary $s_1 < s < s_2$ it should satisfy:

$$X[T_0, T_s]_1 \neq \phi, X[T_0, T_s]_2 \neq \phi, X[T_0, T_s]_3 = \phi.$$

This means that at the intermediate stage, there exists both cities whose development of the construction of the eco city is benign and healthy, and cities whose development of the ecological construction is sustainable. There is no city whose development is not benign and healthy, nor is there a city whose development is not sustainable.

From the year T_{s_3}, the construction of the eco city in China is at the advanced stage, and the basic characteristics of this stage are:

As for the arbitrary $s < s_3$, it should satisfy:

$$X[T_0, T_s]_1 \neq \phi, X[T_0, T_s]_2 = \phi, X[T_0, T_s]_3 = \phi.$$

That is to say, at the advanced stage, beginning at year T_{S_3} in the ecological construction, all the cities are benignly and healthily developing cities.

The fundamental purpose of eco city construction is to enable the ecological construction in each city to be developed benignly and healthily. After the establishment of the standards of the construction of each city, we should scientifically and sensibly formulate construction planning and implementation planning, and set up a complete set of an information feedback mechanism and an evaluation mechanism of the construction effects, in order to enable the capital of the ecological construction and manpower investment to accord with the construction effects. That is to say, in the ecological construction, the city whose development is healthy and benign must also be the city whose construction planning, implementation planning, fund and human resources investment are consistent with the construction effects.

For cities whose ecological construction is at the primary stage, the construction effect is good for a period of time and then bad for a period of time, suggesting that in the ecological construction of the city, problems appear in some areas and the construction of these areas should be strengthened, including the planning, implementation plan, improvement of specific programs and the improvement of the construction system and operation mechanism.

For cities whose ecological construction is at the intermediate stage, then the construction effect is getting better and better, showing that in the ecological construction of the cities the various aspects have a good start but there is still a gap between their construction and the standards for their construction, so they still have to continuously improve their way of working in order to improve building capacity and they must make every effort to enable the ecological construction to proceed in both a scientific and orderly manner on a healthy development track.

For cities whose ecological construction is at the advanced stage and whose construction is getting better and better, then the construction effect has reached the standard construction requirements and the ecological construction has embarked in both a scientific and orderly manner on a healthy development track. Therefore, for each city to accurately and scientifically predict the timetable of the three development statuses is of great significance.

5.2.1.4 The Evaluation System of Eco City Construction by Society

When the urban ecological construction is at the primary or intermediate stage, then government should strengthen the leading, guidance and supervision of the urban ecological construction so as to enable the city to proceed on a sound, fast track of healthy development. When the urban ecological construction has embarked on a track of healthy development, even if the city's ecological construction is complete, we still need another index, namely the degree of satisfaction experienced by all urban citizens in order to test it. Therefore, the quality of the ecological construction of a city should ultimately be tested by the degree of satisfaction experienced by its citizens.

1. The Social Satisfaction Index

Suppose $C \in X$ is a collection consisting of all the cities in China. $C \in X$ is certain city. Y indicates the collection consisting of all citizens 18 years of age and above living in this city, and the citizens in Y are called the residents of the city. To the residents of the city, due to their knowledge, social experience, cognitive structure and so on, their cognition of the ecological construction of the city is not the same, and some of them may have never even heard of it, but they do have an objective understanding of their living environment, travel environment, eating environment, culture and entertainment environment.

Suppose each citizen uses one of the following three answers to evaluate the ecological construction of the city: (A) satisfied (B) not very satisfied or (C) unsatisfied

At any moment *t*, all the residents in Y can be classified into the following three types:

$Y_1(t) = \{y \in Y | y$ the citizens are satisfied with the ecological construction in the city they live in at the moment $t\}$
$Y_2(t) = \{y \in Y | y$ the citizens are not very satisfied with the ecological construction in the city they live in at the moment $t\}$
$Y_3(t) = \{y \in Y | y$ the citizens are not satisfied with the ecological construction in the city they live in at the moment $t\}$

then

$$Y_1(t) \cap Y_2(t) = \phi$$
$$Y_2(t) \cap Y_3(t) = \phi$$
$$Y_3(t) \cap Y_1(t) = \phi$$

and

$$Y = Y_1(t) \cup Y_2(t) \cup Y_3(t).$$

$\alpha_i(t)$ is used to indicate the quantity of the elements in $Y_i(t)$, making

$$\gamma_i(t) = \frac{\alpha_i(t)}{\sum_{j=1}^{3} \alpha_j(t)} \quad (i = 1, 2, 3)$$

$y_1(t)$, $y_2(t)$ and $y_3(t)$ are respectively called the index of the social satisfaction degree, the index of the degree of societies being not very satisfied, and the index of the degree of societies being unsatisfied with the ecological construction of the city *C* at the moment *t*.

2. **Complete Eco City Construction**

That the ecological construction of the city C is complete refers to the existence of the moment t_0, enabling the following conditions to be established at the same time for the arbitrary $t > t_0$:

P_6) the development of the ecological construction of the city C from the moment t_0 to the moment t is benign and healthy.
P_7) y_1 is increasing monotonously in the closed interval $[t_0, t]$
P_8) y_2 is decreasing monotonously in the closed interval $[t_0, t]$
P_9) y_3 is decreasing monotonously in the closed interval $[t_0, t]$

Otherwise, it is thought to be incomplete.

When a city's ecological construction has embarked on a benign and healthy development track from a certain point in time, then more and more people are satisfied with it and fewer and fewer people are not very satisfied or are unsatisfied with it and the ecological construction of the city is complete.

When the ecological construction of each city in China is complete it can be said that China's urban ecological construction is complete.

3. **The Degree of Balance of Ecological Construction**

That urban ecological construction in China is complete will be the final step taken when the development of the urban ecological construction in China has reached the advanced stage. But it is not enough for China's urban ecological construction just to reach the complete state, we should also pay attention to the fact that the development of the ecological construction of different cities is not balanced.

Suppose $X_1(t)$ and $X_2(t)$ respectively are the present status of the min development and the max development of the construction of the eco city in China at the moment t, making

$$\beta(t) = \|X_1(t) - X_2(t)\|$$

Saying the development of Chinese ecological construction is coordinated and orderly refers to the existence of the moment t_0, and from the moment t_0, that China's eco city construction is complete, and $\beta(t)$ is monotonously diminishing.

The basic characteristics of coordinated and orderly development of ecological construction in China are: The value of the various indices of the ecological construction of each city in China is increasing over time, and it has reached the standard of construction, people are more and more satisfied with the ecological construction of each city in China and the difference between the ecological construction of each city in China is smaller and smaller.

5.2.1.5 The *i* Kind of Cities

Suppose X is a collection consisting of all the cities with certain properties. $C \in X$ and $C(t) = (c_{ij})_{m \times n} \in R^{m \times n}$ is the present status of eco city construction in city C at the moment t, and $B(t) = (b_{ij})_{m \times n} \in R^{m \times n}$ is the max present status of X at the moment t, making

$$C(t)_{\mathrm{i}} = \{j \in \{1, 2, \ldots, \mathrm{n}\} | \mathrm{c_{ij}}(t) = b_{\mathrm{ij}}(t), \text{the } j \text{ project of the } i \text{ kinds of } C \text{ that exist}\}$$
$$a_i(t) = \max\left\{\left|C(t)_i\right| \middle| C \in X\right\}$$
$$X(t)_i = \left\{C \in X \middle| \left|C(t)_i\right| = a_i(t)\right\}$$

$C \in X(t)_i$ is called the cities of the i kind at the moment t, in which $\left|C(t)_i\right|$ indicates the quantity of the elements $(i = 1, 2, \ldots m)$ of $C(t)_i$. That is to say, the cities of the i kind refer in the ecological construction projects of the i kind, to the quantity of the projects j whose construction effects $c_{ij}(t)$ reached the max construction status $b_{ij}(t)$ and is larger than that of the other cities in X.

If $t_0 < t_1$ exists, $C \in X(t)_i$ is the cities of the i kind at the moment t as for the arbitrary $t_0 \le t \le t_1$, then C is the city of the i kind $(i = 1, 2, \ldots m)$ at the interval $[t_0, t_1]$. Making

$Y_{\mathrm{i}}\,(t_0, t_1)$ = {C ∈ X|∀t ∈ $[t_0, t_1]$, C is the city of the i kind in $[t_0, t_1]\}$ $(i = 1, 2, \ldots m)$
$Y_{\mathrm{ij}}\,(t_0, t_1)$ = {C ∈ $Y_{\mathrm{i}}(t_0, t)$|∀t ∈ $[t_0, t_1]$, C is the city of the j kind in $[t_0, t]\}(i = 1, 2, \ldots, m; j = 1, 2, 3)$.

And $C \in Y_{ij}(t_0, t_1)$ is called the city of j in the i kind at the interval $[t_0, t_1]$.

Obviously for the arbitrary $t_0 < t_1$, there are

$$Y_i(t_0, t_1) = Y_{i1}(t_0, t_1) \cup Y_{i2}(t_0, t_1) \cup Y_{i3}(t_0, t_1) \neq \phi \quad i = 1, 2, \ldots, m$$
$$Y_{i1}(t_0, t_1) \cap Y_{i2}(t_0, t_1) = \phi \quad i = 1, 2, \ldots, m$$
$$Y_{i2}(t_0, t_1) \cap Y_{i3}(t_0, t_1) = \phi \quad i = 1, 2, \ldots, m$$
$$Y_{i3}(t_0, t_1) \cap Y_{i1}(t_0, t_1) = \phi \quad i = 1, 2, \ldots, m.$$

That is, the cities of the i kind are not a null set at any point, and any two of the $Y_{i1}(t_0, t_1), Y_{i2}(t_0, t_1), Y_{i3}(t_0, t_1)$ do not intersect. Especially when the construction of the civilized eco city in China is at the intermediary stage, there is

$$Y_{i3}(t_0, t_1) = \phi.$$

That is the i kind, the city of the 3rd kind does not exist.

When the construction of the civilized eco city in China is at the advanced stage, there are

$$Y_{i2}(t_0, t_1) = \phi, \quad Y_{i3}(t_0, t_1) = \phi.$$

That is the i kind, the city of the 3rd kind and the 2nd kind does not exist.

When the construction of the civilized eco city in China is at the preliminary stage, the situation is rather complex, the following conditions exist and only one exists:

1. $Y_{i1}(t_0, t_1), Y_{i2}(t_0, t_1)$ is a null set, $Y_{i3}(t_0, t_1)$ is not a null set;
2. $Y_{i1}(t_0, t_1)$ is a null set, $Y_{i2}(t_0, t_1), Y_{i3}(t_0, t_1)$ is not a null set;
3. $Y_{i1}(t_0, t_1), Y_{i3}(t_0, t_1)$ is a null set, $Y_{i2}(t_0, t_1)$ is not a null set;
4. $Y_{i2}(t_0, t_1)$ is a null set, $Y_{i1}(t_0, t_1), Y_{i3}(t_0, t_1)$ is not a null set;
5. $Y_{i1}(t_0, t_1), Y_{i2}(t_0, t_1)$, $Y_{i3}(t_0, t_1)$ are not null sets;
6. $Y_{i3}(t_0, t_1)$ is a null set, $Y_{i1}(t_0, t_1), Y_{i2}(t_0, t_1)$ is not a null set;
7. $Y_{i2}(t_0, t_1), Y_{i3}(t_0, t_1)$ is a null set, $Y_{i1}(t_0, t_1)$ is not a null set.

When the construction of the ecological civilization city in China is at the primary stage, the evaluation of the task is very complex.

5.2.1.6 Comprehensive Evaluation of Eco City Construction at a Given Time

1. **The Absolutely Integrated and Balanced Order**

Suppose X is a collection consisting of all the cities with certain properties, $\lambda_{ij} \geq 0, \sum_{i=1}^{m} \sum_{j=1}^{n} \lambda_{ij} =$ ‘1 $C \in X$, $C(t) = (c_{ij}(t))_{m\times n} \in R^{m\times n}$ is the present status of eco city construction of the city C at the moment t, calling

$$\mu(\Gamma)(C(t)) = \sum_{i=1}^{m} \sum_{j=1}^{n} \lambda_{ij} c_{ij}(t)$$

the comprehensive evaluation index with the weigh $\Gamma = (\lambda_{ij})_{m\times n}$.

As for two arbitrarily given cities C_1 and C_2, if

$$\mu(\Gamma)(C_1(t)) < \mu(\Gamma)(C_2(t))$$

then the ecological construction effect of the city C_2 is better than the ecological construction effect of the city C_1; if

$$\mu(\Gamma)(C_1(t)) > \mu(\Gamma)(C_2(t))$$

then the ecological construction effect of the city C_1 is better than the ecological construction effect of the city C_2; if

$$\mu(\Gamma)(C_1(t)) = \mu(\Gamma)(C_2(t))$$

then there is no difference in the ecological construction effect of the city C_1 and the city C_2.

So for the given weight $\Gamma = (\lambda_{ij})_{m\times n}$, every city is ranked from biggest to smallest according to the comprehensive evaluation indices, and the construction effects of the cities ranked at the top of the list are better than the construction effects of those cities ranked towards the bottom. This way of ranking is closely related to $\Gamma = (\lambda_{ij})_{m\times n}$. Generally, the different ways of choosing $\Gamma = (\lambda_{ij})_{m\times n}$ can even result in big differences in rankings. Therefore, establishing the weight $\Gamma = (\lambda_{ij})_{m\times n}$ is very important.

To do this, more concepts should be introduced.

As for the two arbitrarily given cities C_1 and C_2, if there is no difference in various aspects of the eco city construction of city C_1 and city C_2, then the construction effects of the cities are completely consistent. That is

$$C_1(t) = C_2(t).$$

If the effect of various aspects of the eco city construction of city C_1 is better than that of the city C_2, but not wholly consistent, then the construction effect of the eco city of city C_1 is absolutely better than that of the city C_2, that is

$$C_2(t) \leq C_1(t)$$
$$C_1(t) \neq C_2(t)$$

If the effect of various aspects of the eco city construction of city C_1 is worse than that of city C_2, but not wholly consistent, then the construction effect of the eco city of city C_1 is absolutely worse than that of city C_2, that is

$$C_1(t) \leq C_2(t)$$
$$C_1(t) \neq C_2(t)$$

If the relationship between two arbitrarily given cities C_1 and C_2 is not one of the above three relationships, then the relationship of the eco city construction effect between city C_1 and city C_2 belongs to other situations. That is, some of the construction effects of city C_1 are better than those of city C_2 and some are not.

$X_1(C)$ is used to indicate the collection of all the cities in X whose construction effects are absolutely better than that of city C at the moment t, that is

$$X_1(C) = \{X \in X | C(t) \leq X(t), C(t) \neq X(t)\}.$$

$X_2(C)$ is used to indicate the collection of all the cities in X whose construction effects are absolutely consistent with that of city C at the moment t, that is

$$\mathrm{X}_2(C) = \{X \in \mathrm{X} | C(t) \neq X(t)\}.$$

$\mathrm{X}_3(C)$ is used to indicate the collection of all the cities in X the relationship of the construction effects at the moment t between which and that of city C belong to other situations, that is

$$\mathrm{X}_3(C(t)) = \left\{X \in \mathrm{X} | \exists i_1, j_1, i_2, j_2, c_{i_1 j_1}(t) > x_{i_1 j_1}(t), c_{i_2 j_2}(t) < x_{i_2 j_2}(t)\right\}.$$

$\mathrm{X}_4(C)$ is used to indicate the collection of all the cities in X whose construction effects at the moment t is absolutely worse than that of city C, that is

$$\mathrm{X}_4(C) = \{X \in \mathrm{X} | X(t) \leq C(t), C(t) \neq X(t)\}.$$

Obviously

$$\begin{aligned} &\mu(\Gamma)(X(t)) > \mu(\Gamma)(C(t)), \quad \forall X \in \mathrm{X}_1(C(t)), \\ &\mu(\Gamma)(X(t)) = \mu(\Gamma)(C(t)), \quad \forall X \in \mathrm{X}_2(C(t)), \\ &\mu(\Gamma)(X(t)) < \mu(\Gamma)(C(t)), \quad \forall X \in \mathrm{X}_4(C(t)). \end{aligned}$$

and $\forall X \in \mathrm{X}_3(C(t))$ are possibly established in one of the following three conditions:

$$\begin{aligned} &\mu(\Gamma)(X(t)) > \mu(\Gamma)(C(t)) \\ &\mu(\Gamma)(X(t)) = \mu(\Gamma)(C(t)) \\ &\mu(\Gamma)(X(t)) < \mu(\Gamma)(C(t)) \end{aligned}$$

In other words, the result of the comprehensive ranking distributes the elements in the collection $\mathrm{X}_3(C(t))$ into the collections $\mathrm{X}_1(C(t))$, $\mathrm{X}_2(C(t))$ and $\mathrm{X}_4(C(t))$, thus if Γ is different, its distributed result is also different, which is caused mainly by the change of rankings or choosing different ranking for $\Gamma = (\lambda_{ij})_{m \times n}$, so how should we determine $\Gamma = (\lambda_{ij})_{m \times n}$?

Making

$$\begin{aligned} &\mathrm{Y}_1(\Gamma)(C(t)) = \{X \in \mathrm{X} | \mu(\Gamma)(X(t)) > \mu(\Gamma)(C(t))\} \\ &\mathrm{Y}_2(\Gamma)(C(t)) = \{X \in \mathrm{X} | \mu(\Gamma)(X(t)) = \mu(\Gamma)(C(t))\} \\ &\mathrm{Y}_3(\Gamma)(C(t)) = \{X \in \mathrm{X} | \mu(\Gamma)(X(t)) < \mu(\Gamma)(C(t))\} \end{aligned}$$

Using $\mu_i(\Gamma)(C(t))$ to indicate the quantity of the elements $(i = 1, 2, 3)$ in the collection $\mathrm{Y}_i(\Gamma)$, and using Γ_k to indicate the optimized solution to the optimization problem

$$\begin{cases} \max \sum\limits_{C \in X} \mu_k(\Gamma)(C(t)) \\ \sum\limits_{i=1}^{m} \sum\limits_{j=1}^{n} \lambda_{ij} = 1 \\ \lambda_{ij} \geq 0 \ (i = 1, 2, \ldots, m, j = 1, 2, \ldots, n) \end{cases},$$

then

$$\mu(\Gamma_k)(C(t)) \quad (k = 1, 2, 3)$$

are the three ways of ranking, respectively called the absolutely balanced order of the k kind. Making

$$\mu(C(t)) = \frac{1}{3} \sum_{k=1}^{3} \mu(\Gamma_k)(C(t)),$$

$\mu(C(t))$ is called the absolute integrated balanced order.

Obviously, $\mu(C(t))$ has the following natures:

$$\begin{aligned} &\forall X \in X_1(C(t)), \quad \text{with}\, \mu(X(t)) > \mu(C(t)); \\ &\forall X \in X_2(C(t)), \quad \text{with}\, \mu(X(t)) = \mu(C(t)); \\ &\forall X \in X_4(C(t)), \quad \text{with}\, \mu(X(t)) < \mu(C(t)). \end{aligned}$$

2. The Absolutely Balanced Order

Suppose X is the collection consisting of all the cities with certain properties, $C(t) = (c_{ij}(t))_{m \times n} \in R^{m \times n}$ is the present status of the ecological construction of city C at the moment t, calling

$$\rho_1(C(t)) = \min\{\max\{c_{ij}(t) | j = 1, 2, \ldots, n\} | i = 1, 2, \ldots, n\}$$

the balanced order from the max to the min; calling

$$\rho_2(C(t)) = \max\{\min\{c_{ij}(t) | j = 1, 2, \ldots, n\} | i = 1, 2, \ldots, n\}$$

the balanced order from the min to the max; calling

$$\rho_3(C(t)) = \max\{\max\{c_{ij}(t) | j = 1, 2, \ldots, n\} | i = 1, 2, \ldots, n\}$$

the order of the max.

Calling

$$\rho_4(C(t)) = \min\left\{\min\left\{c_{ij}(t)\middle|j = 1, 2, \ldots, n\right\}\middle|i = 1, 2, \ldots, n\right\}$$

the order of the min, calling

$$\rho(C(t)) = \frac{1}{4}\sum_{i=1}^{4} \rho_k(C(t))$$

the absolutely balanced order.

The absolutely balanced order is a simple, fair, easily carried out and transparent ranking method.

5.2.2 The Evaluation Index System of the Health Indices of the Eco City

The eco city is a new type of city with coordinated development of its economy, society and nature, established in accordance with the concept of ecological civilization and the principles of ecology. It is a new type of city which uses environmental resources effectively and realizes people-oriented sustainable development. It is the necessary direction of development for Chinese urbanization and has an important strategic significance to drive, improve and promote the construction of ecological civilization, to promote the civilization paradigm transformation, accelerate the coordinated development of the national economy, politics, society, culture and ecological civilization, improve people's living quality and standards and construct a prosperous society. China's eco city construction has experienced more than ten years of development and has made some remarkable achievements. Despite this, it is still at the primary stage and various aspects of the ecological construction in each city are imbalanced and there is wide variation. So to enable the hazard-free treatment of household garbage, industrial wastewater treatment, the comprehensive treatment of industrial solid waste, the air quality index, the quality of lake water, urban greening, saving energy and reducing consumption in each city to all be fully up to standard is still the basic task and requirement of eco city construction. The task to promote green development, circulation development, low-carbon development and fully implement sustainable development is still a hard one.

This report is based on the idea of an evaluation method and evaluation model in "the development report on eco city construction in China (2014) [1]," and fine-tuned according to "the evaluation index system of the eco city health index (ECHI) (2014)" and to the situation on the ground in order to improve the evaluation index system and make it more scientific—the adjusted "evaluation index system of the eco city health index (ECHI) (2015)" (see Table 5.1). Then, in 2013,

Table 5.1 The evaluation index system of the eco city health index (ECHI) (2015)

The first grade indicators	The second grade indicators	The weight of the indices	No	The third grade indicators	The relative weight of the third grade indicators with the second grade indicators
The health indices of the eco city	Ecological environment	0.30	1	Forest coverage rate (%) [green coverage of built-up areas (%)]	0.29
			2	PM2.5 [good air quality days (days)]	0.26
			3	The water quality of lakes [water consumption per capita (ton/per person)]	0.10
			4	public green areas per capita [green areas per capita (m^2/per person)]	0.05
			5	Hazard-free treatment rate of household garbage (%)	0.3
	Ecological economy	0.37	6	Comprehensive energy consumption per unit of GDP (tons of standard coal/ten thousand yuan)	0.2
			7	Comprehensive utilization of general industrial solid waste (%)	0.2
			8	The rate of urban sewage treatment (%)	0.3
			9	Informationized infrastructure [internet broadband access subscribers (ten thousand families)/ the total number of urban households at the end of a year]	0.2
			10	GDP per capita (yuan/per person)	0.1
	Ecological society	0.33	11	Population density (population/km^2)	0.1
			12	The rate of popularization of ecological environmental protection knowledge and rules and regulations, and that of infrastructure readiness [water resources, environment and public facilities management practitioners in the city (ten thousand people)/ urban population at the end of the year (ten thousand people)]	0.3
			13	The public satisfaction with the urban ecological environment [the number of civilian vehicles/urban road length (km)]	0.3
			14	The effect of government investment and construction (expenditure of urban maintenance and construction/city GDP)	0.3

Note The number of the cities in which major pollution accidents happened during the year was deducted from the total index, from 5 to 7 %

Table 5.2 Evaluation criteria of the eco city health index (ECHI)

Types	Very healthy	Healthy	Sub-healthy	Unhealthy	Very unhealthy
The index range	≥85	≥65	≥50	≥45	<45

we evaluated the ecological construction effect of 284 cities in China according to the principles of eco city construction—"classified evaluation, classified guidance, classified construction and step-by-step implementation", on the basis of "the evaluation index system of the eco city health index (ECHI) (2015)" and the most recently collected data. By introducing such concepts as the construction focus, difficulty of construction and the comprehensive degree of construction, we try to provide a dynamic guidance for China's eco city construction.

We evaluated the health status of the eco city in accordance with the "Following the Way the Human Body Works" theory, and divided it into the five types: very health, healthy, sub-healthy, unhealthy and very unhealthy, according to the comprehensive evaluation results (the classification standards are shown in Table 5.2).

5.3 Results and Findings

The idea of an ecological civilization is not only the result of a deeper understanding of the relationship between man and nature, but also represents a leap of human self-awareness. To take the construction of ecological civilization as a part of the overall plan of Chinese-style socialism shows that our party's understanding of the development law of the development of human society, the laws of socialist construction and the ruling law of the communist party have reached a new stage. It also shows that our party and our nation's understanding of ecological problems has entered a new era, mirrored by people's raised expectations for ecological civilization. The construction of an ecological civilization is essential if we are to build a landscape and leisure-oriented society that is resource-saving, environmentally-friendly, has green industries and circular economy on the basis of the bearing capacity of the resource environment, all guided by natural law with the ultimate aim of sustainable development (see Table 5.3).

On the basis of "the evaluation index system of the eco city health index (ECHI) (2015)" and "the evaluation criteria of the eco city health index (ECHI)", we comprehensively ranked the health status of the 284 eco cities in China in 2013.

Table 5.3 The assessment rankings of the health status of the 284 eco cities in 2013 in China

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Zhu hai	0.8923	1	Very healthy	1.0000	1	0.8882	145	0.3302	257	0.8488	15	1.0000	1	0.8411	10
San ya	0.8755	2	Very healthy	0.8865	23	0.8931	138	0.4830	209	0.8343	24	1.0000	1	0.8423	9
Xiamen	0.8708	3	Very healthy	0.8491	90	0.9295	99	0.4560	220	0.8547	10	0.9920	153	0.8391	16
Tongling	0.8662	4	Very healthy	0.8888	20	0.9004	130	0.8380	111	0.8456	17	1.0000	1	0.7264	147
Xinyu	0.8657	5	Very healthy	0.9500	2	0.9271	101	0.9680	20	0.8296	38	1.0000	1	0.6289	195
Huizhou	0.8621	6	Very healthy	0.7641	236	0.8664	163	0.8551	96	0.8263	54	0.8816	232	0.8271	86
Zhoushan	0.8615	7	Very healthy	0.8092	193	0.8882	145	0.9562	23	0.8750	5	1.0000	1	0.8285	79
Shenyang	0.8600	8	Very healthy	0.8528	78	0.6262	241	0.8454	103	0.8334	26	1.0000	1	0.7541	137
Fuzhou	0.8521	9	Very healthy	0.8576	68	0.9465	87	0.9388	34	0.7131	79	0.9897	160	0.8375	22
Dalian	0.8503	10	Very healthy	0.8778	30	0.8174	179	0.8741	76	0.8299	37	1.0000	1	0.8297	68
Hailou	0.8502	11	Very healthy	0.8556	70	0.7027	224	0.6543	169	0.8289	39	1.0000	1	0.8381	18

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Jingdezhen	0.8498	12	Healthy	0.9448	4	0.9976	26	0.9109	46	0.8267	49	1.0000	1	0.8310	58
Guanghzou	0.8447	13	Healthy	0.8409	112	0.7384	211	0.3986	238	0.8839	3	0.8705	239	0.8392	15
Nanning	0.8437	14	Healthy	0.8516	82	0.7792	196	0.9070	49	0.8395	19	1.0000	1	0.8307	64
Wuhu	0.8435	15	Healthy	0.8306	146	0.8761	152	0.9999	1	0.7069	82	0.9620	186	0.8320	50
Huangshan	0.8408	16	Healthy	0.8935	15	0.9951	32	0.8735	77	0.8543	12	1.0000	1	0.8435	6
Xi’an	0.8385	17	Healthy	0.8526	79	0.4298	268	0.9024	54	0.8250	66	0.9986	145	0.8341	42
Suzhou	0.8365	18	Healthy	0.8513	85	0.7537	203	0.7391	150	0.8306	35	1.0000	1	0.8654	3
Yangzhou	0.8354	19	Healthy	0.8626	52	0.6823	230	0.9773	16	0.6622	94	1.0000	1	0.8361	32
Yantai	0.8352	20	Healthy	0.8617	54	0.9150	114	0.8719	78	0.7657	75	1.0000	1	0.8308	59
Qingdao	0.8351	21	Healthy	0.8774	31	0.7384	211	0.9188	45	0.8321	32	1.0000	1	0.8348	38
Weihai	0.8334	22	Healthy	0.9094	9	0.9441	90	0.8877	63	0.8272	47	1.0000	1	0.8279	81
Zhenjiang	0.8322	23	Healthy	0.8543	75	0.6466	236	0.8970	56	0.8283	42	1.0000	1	0.8323	47
Wuhan	0.8317	24	Healthy	0.8037	201	0.4860	263	0.5513	192	0.8260	58	1.0000	1	0.8268	92
Bengbu	0.8310	25	Healthy	0.8144	183	0.8421	169	0.9862	8	0.5490	120	1.0000	1	0.8308	59
Huzhou	0.8305	26	Healthy	0.9124	8	0.5676	257	0.9449	31	0.7157	78	1.0000	1	0.8118	118
Changzhou	0.8301	27	Healthy	0.8592	62	0.6237	242	0.8664	83	0.8261	57	0.9999	141	0.8286	77
Hangzhou	0.8301	28	Healthy	0.8332	139	0.6186	246	0.8288	124	0.8353	22	1.0000	1	0.8367	30
Tongchuan	0.8274	29	Healthy	0.8707	41	0.9149	118	0.8357	116	0.8260	59	0.8830	231	0.4915	237
Karamay	0.8267	30	Healthy	0.8598	60	0.9660	65	0.3041	268	0.8634	8	0.9895	161	0.4601	249
Jinan	0.8263	31	Healthy	0.8178	175	0.2795	279	0.9230	40	0.8256	60	0.9482	196	0.8252	108

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Huainan	0.8252	32	Healthy	0.8282	156	0.8149	182	0.9912	6	0.7484	77	0.9813	171	0.7973	123
Chongqing	0.8228	33	Healthy	0.8473	94	0.6033	248	0.9256	39	0.6523	100	0.9943	148	0.8135	117
Hebi	0.8210	34	Healthy	0.8132	187	0.8396	171	0.9393	33	0.6179	107	0.9250	207	0.6050	200
Tianjin	0.8210	35	Healthy	0.7450	243	0.4478	265	0.8529	99	0.8265	53	0.9680	182	0.8870	2
Beijing	0.8191	36	Healthy	0.9010	12	0.5268	261	0.5856	183	0.8388	20	0.9930	151	0.8447	5
Panjing	0.8188	37	Healthy	0.8266	159	0.9587	74	0.9054	51	0.8250	65	1.0000	1	0.4800	243
Hefei	0.8185	38	Healthy	0.8495	89	0.8123	184	0.9314	36	0.8254	61	1.0000	1	0.8325	46
Jiangmen	0.8178	39	Healthy	0.8619	53	0.7435	209	0.9310	37	0.8288	40	1.0000	1	0.8346	39
Qinhuangdao	0.8173	40	Healthy	0.9172	6	0.6109	247	0.9806	11	0.7661	74	1.0000	1	0.7541	137
Dongying	0.8142	41	Healthy	0.8579	67	0.4070	271	0.9433	32	0.8323	31	1.0000	1	0.7373	146
Urumqi	0.8123	42	Healthy	0.7987	210	0.8518	167	0.6870	160	0.8563	9	0.9149	216	0.4532	251
Foshan	0.8118	43	Healthy	0.8280	157	0.7078	222	0.6654	166	0.8266	50	0.9935	150	0.8361	32
Shaoxing	0.8113	44	Healthy	0.8385	121	0.6899	227	0.8612	88	0.7065	83	1.0000	1	0.8268	91
Harbin	0.8105	45	Healthy	0.7659	233	0.6874	229	0.9719	18	0.6399	103	0.8729	236	0.7533	139
Beihai	0.8101	46	Healthy	0.8150	182	0.6950	225	0.9197	42	0.6440	102	1.0000	1	0.8259	105
Kunming	0.8095	47	Healthy	0.8250	163	0.9222	110	0.8762	72	0.8282	43	0.8900	228	0.6869	172
Nantong	0.8093	48	Healthy	0.8523	80	0.6492	235	0.9033	53	0.4899	141	1.0000	1	0.8377	19
Shantou	0.8070	49	Healthy	0.8488	91	1.0000	1	0.9279	38	0.7883	69	0.8041	257	0.8393	14
Jiujiang	0.8066	50	Healthy	0.9482	3	0.9441	90	0.7539	142	0.4994	135	1.0000	1	0.8268	95
Shuozhou	0.8064	51	Healthy	0.8589	64	0.8225	177	0.7781	138	0.4775	143	1.0000	1	0.6384	191

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Nanjing	0.8051	52	Healthy	0.8710	40	0.5829	252	0.4549	222	0.8737	6	0.9083	222	0.8277	82
Zaozhuang	0.8043	53	Healthy	0.8328	140	0.4452	266	0.8712	79	0.6373	104	1.0000	1	0.5887	205
Fangchenggang	0.8043	54	Healthy	0.7124	254	0.9951	32	0.9804	12	0.5338	125	0.9500	194	0.6948	162
Lianyungang	0.8041	55	Healthy	0.8302	147	0.6950	225	0.8360	115	0.8329	29	1.0000	1	0.8287	75
Nanchang	0.8040	56	Healthy	0.8547	73	0.6645	232	0.8545	97	0.8251	64	0.9999	141	0.8330	45
Changchun	0.8037	57	Healthy	0.6063	273	0.6645	232	0.9491	29	0.6517	101	0.8563	244	0.8350	37
Liaoyuan	0.8036	58	Healthy	0.8227	167	0.8907	142	0.9189	44	0.6615	95	1.0000	1	0.6999	158
Wuxi	0.8027	59	Healthy	0.8584	66	0.5854	251	0.8300	123	0.8332	27	1.0000	1	0.8307	61
Taizhou	0.8022	60	Healthy	0.8695	43	0.7588	201	0.8686	81	0.4558	154	1.0000	1	0.8451	4
Shizuishan	0.8005	61	Healthy	0.8290	152	0.9004	130	0.7602	141	0.8543	11	0.9400	197	0.2681	281
Pingxiang	0.8000	62	Healthy	0.8383	123	0.9903	38	0.8440	106	0.5130	129	1.0000	1	0.4847	240
Ezhou	0.7996	63	Healthy	0.7352	249	0.8251	176	0.9604	22	0.6971	85	1.0000	1	0.5733	213
Liuzhou	0.7990	64	Healthy	0.8464	96	0.8858	148	0.6248	173	0.8252	62	1.0000	1	0.5092	234
Shenzhen	0.7989	65	Healthy	0.8810	29	0.9004	130	0.2447	277	0.9491	2	0.9836	168	0.8435	6
Taiyuan	0.7960	66	Healthy	0.8297	149	0.4911	262	0.8349	117	0.8284	41	1.0000	1	0.5816	210
Guilin	0.7944	67	Healthy	0.8511	86	0.9247	105	0.8504	100	0.3343	219	0.8102	254	0.7653	131
Xianyang	0.7941	68	Healthy	0.8361	133	0.8741	156	0.8742	74	0.3400	212	0.9335	203	0.8287	76
Zhanjiang	0.7933	69	Healthy	0.8384	122	0.9879	40	0.7176	155	0.3389	214	1.0000	1	0.8363	31
Zibo	0.7932	70	Healthy	0.8720	39	0.5472	260	0.8901	61	0.8331	28	1.0000	1	0.5196	229
Chuzhou	0.7932	71	Healthy	0.8207	171	0.8615	166	0.6217	174	0.4649	148	1.0000	1	0.8307	61

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Ningbo	0.7927	72	Healthy	0.8049	198	0.7843	193	0.8464	102	0.8021	68	1.0000	1	0.8271	87
Huai'an	0.7926	73	Healthy	0.8382	124	0.7741	197	0.9539	27	0.5460	121	0.7911	261	0.8261	101
Liaoyang	0.7915	74	Healthy	0.8398	115	0.9465	87	0.8909	60	0.8261	56	1.0000	1	0.4482	254
Baoji	0.7914	75	Healthy	0.8318	143	0.8758	155	0.7870	135	0.5067	133	1.0000	1	0.8259	104
Huaibei	0.7914	76	Healthy	0.8764	32	0.9052	125	0.8843	67	0.8231	67	1.0000	1	0.7129	153
Zhuzhou	0.7912	77	Healthy	0.8454	102	0.6237	242	0.9781	14	0.6109	108	1.0000	1	0.8259	103
Changsha	0.7907	78	Healthy	0.8175	178	0.5803	254	0.8496	101	0.6581	98	1.0000	1	0.8268	92
Yingkou	0.7905	79	Healthy	0.8264	160	0.9563	76	0.9201	41	0.7576	76	0.9000	226	0.4475	255
Shanghai	0.7902	80	Healthy	0.8064	196	0.7052	223	0.4154	234	0.8536	13	0.9058	224	0.8354	36
Dongguan	0.7898	81	Healthy	0.8896	19	0.7486	206	0.1925	283	1.0000	1	0.6321	272	0.8339	43
Datong	0.7895	82	Healthy	0.8639	51	0.8955	134	0.8864	65	0.5924	112	0.9060	223	0.5564	217
Jingzhou	0.7894	83	Healthy	0.8478	93	0.9538	78	0.9771	17	0.5061	134	0.8742	234	0.7099	154
Chizhou	0.7886	84	Healthy	0.8391	119	0.9660	65	0.7736	139	0.4566	153	0.9991	144	0.6666	178
Zhaoqing	0.7884	85	Healthy	0.7543	238	0.7129	220	0.8885	62	0.5881	113	0.9873	164	0.8319	51
Jilin	0.7867	86	Healthy	0.8877	21	0.8785	151	0.9484	30	0.6807	89	0.9362	201	0.7164	151
Chengdu	0.7848	87	Healthy	0.8326	141	0.4325	267	0.8824	68	0.7105	80	1.0000	1	0.8292	71
Maanshan	0.7847	88	Healthy	0.8686	45	0.7460	207	0.8610	89	0.8270	48	0.9750	177	0.4698	247
Xiangfan	0.7823	89	Healthy	0.8824	26	0.8761	152	0.8961	58	0.4267	163	0.9942	149	0.6911	166
Yingtan	0.7812	90	Healthy	0.8354	134	0.9757	56	0.7448	146	0.4940	138	1.0000	1	0.8359	34
Yinchuan	0.7785	91	Healthy	0.8414	111	0.7180	216	0.8760	73	0.8350	23	0.8756	233	0.4794	245

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Ji'an	0.7776	92	Healthy	0.8877	21	1.0000	1	0.3380	256	0.3190	230	1.0000	1	0.8375	21
Yichang	0.7775	93	Healthy	0.8433	105	0.8688	161	0.8928	59	0.6307	106	0.9157	215	0.5694	214
Meizhou	0.7774	94	Healthy	0.8593	61	1.0000	1	0.4421	226	0.2941	243	1.0000	1	0.7630	132
Guiyang	0.7755	95	Healthy	0.8655	47	0.7868	192	0.8604	92	0.8416	18	0.9543	190	0.5521	219
Uhai	0.7754	96	Healthy	0.8377	125	0.8299	175	0.8571	95	0.8342	25	0.8716	237	0.5221	226
Daqing	0.7737	97	Healthy	0.8832	25	0.9636	69	0.7442	147	0.8501	14	0.9003	225	0.6409	188
Benxi	0.7730	98	Healthy	0.9271	5	0.9684	61	0.5112	200	0.8819	4	0.9995	143	0.3065	279
Shiyan	0.7722	99	Healthy	0.8611	56	0.8907	142	0.9076	48	0.4728	145	1.0000	1	0.6622	179
Quzhou	0.7712	100	Healthy	0.8425	108	0.7103	221	0.8392	109	0.4945	137	1.0000	1	0.5855	207
Putian	0.7699	101	Healthy	0.8906	18	1.0000	1	0.9944	4	0.3919	176	0.9910	154	0.8382	17
Quanzhou	0.7693	102	Healthy	0.8556	70	0.9903	38	0.8400	108	0.5268	127	0.9921	152	0.8317	52
Yangjiang	0.7693	103	Healthy	0.8053	197	1.0000	1	0.7041	156	0.3854	180	1.0000	1	0.8346	39
Erdos	0.7680	104	Healthy	0.8589	65	0.9125	119	0.8596	93	0.8462	16	0.9510	193	0.7224	149
Fuzhou	0.7674	105	Healthy	0.9133	7	0.9951	32	0.5891	182	0.3722	187	1.0000	1	0.8369	24
Xuqian	0.7671	106	Healthy	0.8516	82	0.6466	236	0.5910	181	0.6583	97	1.0000	1	0.8339	44
Huangshi	0.7664	107	Healthy	0.6922	262	0.8931	138	0.9934	5	0.5095	131	1.0000	1	0.5140	231
Longyan	0.7656	108	Healthy	0.8564	69	0.9854	43	0.8655	85	0.3682	188	0.9909	155	0.8270	90
Nanping	0.7641	109	Healthy	0.9037	11	0.9976	26	0.4437	225	0.2978	238	0.9900	157	0.7707	129
Jiaxing	0.7628	110	Healthy	0.8517	81	0.6237	242	0.9553	25	0.6588	96	1.0000	1	0.8296	69
Guangyuan	0.7621	111	Healthy	0.7795	222	0.9636	69	0.5392	197	0.3662	189	0.7928	260	0.6535	184

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Dandong	0.7612	112	Healthy	0.8139	185	1.0000	1	0.8818	69	0.4772	144	1.0000	1	0.5675	215
Qitaihe	0.7611	113	Healthy	0.8126	188	0.8737	157	0.8982	55	0.8281	45	1.0000	1	0.4555	250
Lishui	0.7600	114	Healthy	0.8690	44	0.9660	65	0.7430	148	0.3441	209	1.0000	1	0.8367	26
Zhongwei	0.7587	115	Healthy	0.7763	225	0.9295	99	0.3755	244	0.5792	114	1.0000	1	0.4032	270
Chaozhou	0.7580	116	Healthy	0.8731	36	0.9951	32	0.8361	114	0.3805	182	1.0000	1	0.6991	159
Taizhou	0.7579	117	Healthy	0.8361	132	0.6390	239	0.8135	128	0.4086	170	1.0000	1	1.0000	1
Mudanjiang	0.7567	118	Healthy	0.8137	186	0.9101	122	0.8377	112	0.8251	63	1.0000	1	0.7396	144
Tai’an	0.7565	119	Healthy	0.8699	42	0.6415	238	0.5850	184	0.4644	149	1.0000	1	0.7771	127
Lijiang	0.7542	120	Healthy	0.8364	129	0.9733	59	0.6762	164	0.4387	161	1.0000	1	0.6600	180
Tonghua	0.7534	121	Healthy	0.7493	239	0.9344	97	0.8090	129	0.4028	172	0.9745	179	0.6425	187
Shijiazhuang	0.7523	122	Healthy	0.8604	57	0.2030	283	0.9536	28	0.4809	142	0.8136	253	0.6343	192
Zhongshan	0.7521	123	Healthy	0.8370	127	0.7588	201	0.8265	125	0.8266	51	1.0000	1	0.8371	23
Mianyang	0.7519	124	Healthy	0.8015	204	0.8955	134	0.7798	137	0.4150	164	1.0000	1	0.6014	201
Linxin	0.7512	125	Healthy	0.8468	95	0.3738	273	0.7948	132	0.4909	140	1.0000	1	0.8255	107
Shaoguan	0.7512	126	Healthy	0.8912	17	0.9806	51	0.8868	64	0.5780	115	0.9814	170	0.5839	208
Yichun	0.7504	127	Healthy	0.5979	274	1.0000	1	0.9869	7	0.8327	30	1.0000	1	0.5020	236
Yangquan	0.7498	128	Healthy	0.8431	106	0.9125	119	0.9775	15	0.6646	92	0.8898	229	0.5177	230
Yichun	0.7492	129	Healthy	0.8614	55	1.0000	1	0.4016	237	0.3256	227	1.0000	1	0.8252	110
Rizhao	0.7476	130	Healthy	0.8601	59	0.6594	234	0.8645	87	0.6350	105	1.0000	1	0.8367	26
Zhengzhou	0.7463	131	Healthy	0.7999	208	0.4197	269	0.9804	13	0.6623	93	0.8972	227	0.8311	56

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Xining	0.7451	132	Healthy	0.7956	211	0.6288	240	0.8798	71	0.6564	99	0.8345	250	0.3403	275
Fushun	0.7448	133	Healthy	0.8464	96	0.9028	127	0.7907	134	0.8266	52	1.0000	1	0.5456	221
Lanzhou	0.7439	134	Healthy	0.7377	247	0.8396	171	0.8656	84	0.7708	72	0.2100	283	0.4043	269
Xuancheng	0.7431	135	Healthy	0.8408	113	0.8931	138	0.5408	195	0.5690	117	1.0000	1	0.8262	97
Laiwu	0.7428	136	Healthy	0.8743	34	0.5982	249	0.9559	24	0.8376	21	1.0000	1	0.3106	278
Jinhua	0.7424	137	Healthy	0.8003	207	0.5752	255	0.6358	170	0.3655	191	0.9873	164	0.8307	61
Xuzhou	0.7420	138	Healthy	0.8592	62	0.5676	257	0.8649	86	0.6803	90	1.0000	1	0.4323	261
Haozhou	0.7416	139	Healthy	0.8302	147	0.9052	125	0.3015	270	0.2506	272	1.0000	1	0.8320	49
Liu’an	0.7407	140	Healthy	0.7872	217	0.9393	95	0.3656	248	0.2983	236	1.0000	1	0.8320	48
Anqing	0.7406	141	Healthy	0.8398	115	0.8021	187	0.6724	165	0.3479	204	0.9816	169	0.8286	78
Xiangtan	0.7400	142	Healthy	0.8351	135	0.5599	259	0.9968	3	0.5117	130	1.0000	1	0.6435	186
Changzhi	0.7382	143	Healthy	0.8835	24	0.7511	205	0.8606	90	0.4103	168	1.0000	1	0.4389	259
Fuxin	0.7355	144	Healthy	0.8510	87	0.9490	85	0.9995	2	0.7042	84	0.9955	147	0.5940	203
Baotou	0.7355	145	Healthy	0.8537	76	0.8149	182	0.8589	94	0.8309	34	0.9513	192	0.5221	226
Yulin	0.7346	146	Healthy	0.8171	180	0.8953	137	0.3247	259	0.3352	218	0.9132	218	0.7571	133
Jingmen	0.7320	147	Healthy	0.8277	158	0.8858	148	0.8742	75	0.3734	184	1.0000	1	0.6806	175
Leshan	0.7315	148	Healthy	0.7486	240	0.8858	148	0.6206	175	0.4592	152	0.8064	256	0.4179	264
Laibin	0.7309	149	Healthy	0.7437	244	1.0000	1	0.4904	206	0.3375	215	1.0000	1	0.6948	162
Handan	0.7292	150	Healthy	0.8962	13	0.2158	282	0.6836	161	0.4399	159	1.0000	1	0.4362	260
Zhangzhou	0.7292	151	Healthy	0.8457	101	0.9976	26	0.4987	203	0.3342	220	0.9906	156	0.8290	73

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Wuzhong	0.7285	152	Healthy	0.8309	144	0.9271	101	0.9091	47	0.7709	71	0.9888	162	0.3659	274
Dezhou	0.7273	153	Healthy	0.8603	58	0.3305	276	0.6032	179	0.4136	166	1.0000	1	0.7565	134
Jiuquan	0.7268	154	Healthy	0.7720	229	0.8445	168	0.8383	110	0.6013	110	1.0000	1	0.5561	218
Suizhou	0.7262	155	Healthy	0.8661	46	0.8174	179	0.6936	157	0.7699	73	0.9552	189	0.8274	84
Luohe	0.7249	156	Healthy	0.8228	166	0.5727	256	0.9626	21	0.4111	167	1.0000	1	0.8266	96
Yiyang	0.7245	157	Healthy	0.8143	184	0.9174	113	0.5606	190	0.3460	207	1.0000	1	0.8274	83
Yulin	0.7239	158	Healthy	0.7735	228	0.9951	32	0.4457	223	0.2930	244	1.0000	1	0.8077	122
Deyang	0.7231	159	Healthy	0.8292	151	0.8882	145	0.6640	167	0.3734	185	1.0000	1	0.6546	182
Ankang	0.7223	160	Healthy	0.8362	131	0.9809	50	0.3133	265	0.3438	210	1.0000	1	0.8250	113
Binzhou	0.7199	161	Healthy	0.8730	37	0.6798	231	0.8364	113	0.5992	111	1.0000	1	0.7211	150
Wenzhou	0.7197	162	Healthy	0.8012	206	0.7180	216	0.9364	35	0.4605	151	1.0000	1	0.8401	12
Loudi	0.7179	163	Healthy	0.8263	161	0.9101	122	0.5692	187	0.3276	225	1.0000	1	0.8260	102
Tangshan	0.7174	164	Healthy	0.8422	109	0.3433	275	0.9551	26	0.6084	109	0.9134	217	0.4419	257
Hohhot	0.7170	165	Healthy	0.6421	268	0.6211	245	0.9057	50	0.8300	36	0.9874	163	0.6394	190
Huludao	0.7164	166	Healthy	0.8076	194	0.9125	119	0.8860	66	0.5329	126	0.8564	243	0.3115	277
Songyuan	0.7155	167	Healthy	0.8534	77	1.0000	1	0.8310	122	0.3881	178	0.9575	188	0.7563	135
Wulanchabu	0.7141	168	Healthy	0.8175	178	0.9879	40	0.3251	258	0.4390	160	0.9806	172	0.4869	239
Jiamusi	0.7130	169	Healthy	0.8464	96	0.9636	69	0.8964	57	0.7086	81	0.9211	209	0.7035	157
Qingyuan	0.7130	170	Healthy	0.8367	128	1.0000	1	0.7978	131	0.3486	203	1.0000	1	0.6562	181
Suining	0.7128	171	Healthy	0.7026	257	0.9198	112	0.4914	205	0.6934	86	0.9373	200	0.7468	142

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Baishan	0.7118	172	Healthy	0.6111	272	0.9538	78	0.9195	43	0.4438	157	1.0000	1	0.4520	253
Yueyang	0.7117	173	Healthy	0.8363	130	0.8931	138	0.9044	52	0.3769	183	1.0000	1	0.7973	123
Heihe	0.7115	174	Healthy	0.7033	256	1.0000	1	0.3707	246	0.2813	252	1.0000	1	0.8262	97
Anshan	0.7108	175	Healthy	0.8117	190	0.9271	101	0.8331	118	0.7827	70	1.0000	1	0.5228	225
Jiaozuo	0.7105	176	Healthy	0.8289	153	0.8174	179	0.8540	98	0.4929	139	0.9732	181	0.7099	154
Nanchong	0.7087	177	Healthy	0.8408	113	0.8396	171	0.5397	196	0.3477	205	0.8706	238	0.6942	164
Weifang	0.7086	178	Healthy	0.8375	126	0.4605	264	0.8015	130	0.5350	124	1.0000	1	0.7475	141
Jining	0.7080	179	Healthy	0.7622	237	0.3076	277	0.8326	119	0.4517	155	1.0000	1	0.8179	114
Qiqihar	0.7078	180	Healthy	0.8109	192	0.9538	78	0.7935	133	0.5389	123	0.4971	277	0.6882	170
Guyuan	0.7076	181	Healthy	0.6179	271	0.9247	105	0.3496	251	0.4073	171	0.9342	202	0.8367	29
Jinchang	0.7072	182	Healthy	0.7659	233	0.8907	142	0.8810	70	0.8281	44	1.0000	1	0.4704	246
Tongliao	0.7071	183	Healthy	0.8935	15	0.9271	101	0.7472	144	0.4440	156	0.8181	252	0.6546	182
Bayannaoer	0.7070	184	Healthy	0.8042	200	0.9441	90	0.5747	186	0.4634	150	0.9750	177	0.4803	242
Jixi	0.7066	185	Healthy	0.8321	142	0.9247	105	0.9811	9	0.6756	91	0.8474	246	0.6911	166
Xiaogan	0.7054	186	Healthy	0.8818	27	0.8712	159	0.3780	242	0.2891	248	1.0000	1	0.6309	194
Fuyang	0.7022	187	Healthy	0.7151	253	0.9004	130	0.3689	247	0.2924	246	0.9400	197	0.7391	145
Jiayuguan	0.7014	188	Healthy	0.7888	215	0.9150	114	0.4743	212	0.8692	7	1.0000	1	0.2143	283
Luzhou	0.7000	189	Healthy	0.8294	150	0.8372	174	0.8451	104	0.4675	147	1.0000	1	0.5859	206
Binzhou	0.6990	190	Healthy	0.8546	74	0.8664	163	0.6116	176	0.3641	192	1.0000	1	0.8281	80
Meishan	0.6982	191	Healthy	0.7998	209	0.8712	159	0.4679	215	0.3270	226	1.0000	1	0.5029	235

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Panzhihua	0.6982	192	Healthy	0.8212	168	0.9344	97	0.6816	162	0.8262	55	0.9762	176	0.3738	273
Xinxiang	0.6978	193	Healthy	0.8388	120	0.7384	211	0.8420	107	0.3969	175	1.0000	1	0.7931	125
Ningde	0.6971	194	Healthy	0.8515	84	0.9951	32	0.3154	264	0.2668	262	0.9101	220	0.8406	11
Weinan	0.6962	195	Healthy	0.7913	213	0.8643	165	0.4895	207	0.2636	264	0.7554	263	0.4666	248
Heyuan	0.6954	196	Healthy	0.8736	35	1.0000	1	0.7236	152	0.2926	245	1.0000	1	0.8305	65
Xuchang	0.6944	197	Healthy	0.8205	172	0.7843	193	0.4646	216	0.3727	186	0.9629	184	0.8295	70
Luoyang	0.6940	198	Healthy	0.7867	218	0.7919	190	0.8666	82	0.4694	146	0.8372	249	0.8261	100
Siping	0.6920	199	Healthy	0.7232	251	0.9514	81	0.5684	188	0.3557	197	0.9600	187	0.7547	136
Hanzhong	0.6910	200	Healthy	0.8015	204	0.9636	68	0.3762	243	0.2635	265	0.8400	248	0.6671	177
Sanming	0.6907	201	Healthy	0.8458	100	0.9854	43	0.8696	80	0.3320	223	0.9785	174	0.6150	196
Jincheng	0.6898	202	Healthy	0.8815	28	0.5829	252	0.8225	127	0.5689	118	1.0000	1	0.5383	222
Zhangjiakou	0.6893	203	Healthy	0.8452	103	0.8047	186	0.8254	126	0.4144	165	0.8700	240	0.5273	223
Tieling	0.6879	204	Healthy	0.8237	165	0.9806	51	0.5808	185	0.4004	173	1.0000	1	0.4800	243
Yancheng	0.6871	205	Healthy	0.8351	135	0.7180	216	0.4613	217	0.3363	216	1.0000	1	0.8368	25
Zigong	0.6858	206	Healthy	0.8260	162	0.7843	193	0.7517	143	0.5526	119	0.9200	212	0.4896	238
Yongzhou	0.6856	207	Healthy	0.7754	226	0.9879	40	0.6580	168	0.2825	249	1.0000	1	0.7692	130
Hegang	0.6845	208	Healthy	0.8488	91	0.9028	127	0.9809	10	0.8280	46	0.5374	276	0.5266	224
Ya'an	0.6836	209	Healthy	0.8461	99	1.0000	1	0.7262	151	0.4004	174	0.8425	247	0.7138	152
Pingdingshan	0.6826	210	Healthy	0.8309	144	0.6899	227	0.8441	105	0.3336	221	0.9210	210	0.6857	173
Jingzhou	0.6818	211	Healthy	0.8187	174	0.7154	219	0.6097	177	0.2980	237	1.0000	1	0.8271	87

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Xianning	0.6813	212	Healthy	0.7795	222	0.9150	114	0.5075	201	0.5698	116	1.0000	1	0.6911	166
Shuangyashan	0.6808	213	Healthy	0.8655	47	0.9465	87	0.8320	120	0.6883	87	0.8091	255	0.5140	231
Xinyang	0.6800	214	Healthy	0.8548	72	0.8737	157	0.2914	272	0.3392	213	0.9273	205	0.8399	13
Yan'an	0.6787	215	Healthy	0.8284	154	0.9078	124	0.4238	232	0.3657	190	0.8877	230	0.8316	54
Shangluo	0.6781	216	Healthy	0.4984	282	0.9663	64	0.2732	275	0.2390	276	1.0000	1	0.8357	35
Hengyang	0.6781	217	Healthy	0.7475	241	0.9514	81	0.8319	121	0.3354	217	1.0000	1	0.8262	99
Suihua	0.6767	218	Healthy	0.5923	276	0.9222	110	0.2521	276	0.2294	278	0.7811	262	0.8268	92
Suzhou	0.6755	219	Healthy	0.8028	203	0.9247	105	0.4276	229	0.2944	242	0.9870	166	0.8270	89
Kaifeng	0.6745	220	Healthy	0.7858	219	0.7409	210	0.7227	154	0.3845	181	0.6796	266	0.8315	55
Baoding	0.6719	221	Healthy	0.8345	137	0.2668	280	0.4412	227	0.3325	222	1.0000	1	0.6917	165
Changde	0.6694	222	Healthy	0.8651	50	0.7690	200	0.6796	163	0.3570	196	1.0000	1	0.8252	108
Zhangye	0.6681	223	Healthy	0.7242	250	0.9514	81	0.7452	145	0.6842	88	1.0000	1	0.5131	233
Chengde	0.6659	224	Healthy	0.8397	117	0.7537	203	0.6913	158	0.5455	122	0.8585	242	0.6081	199
Yunfu	0.6651	225	Healthy	0.8284	155	1.0000	1	0.5039	202	0.2900	247	1.0000	1	0.6881	171
Ziyang	0.6646	226	Healthy	0.8211	169	0.9441	90	0.3025	269	0.2749	257	1.0000	1	0.7923	126
Liaocheng	0.6630	227	Healthy	0.8953	14	0.3025	278	0.5422	194	0.3290	224	1.0000	1	0.6991	159
Jieyang	0.6629	228	Healthy	0.6539	267	1.0000	1	0.5979	180	0.3578	195	0.9300	204	0.8299	67
Guang'an	0.6626	229	Healthy	0.7704	231	0.9854	43	0.2809	273	0.2790	253	0.9260	206	0.4175	265
Shangrao	0.6615	230	Healthy	0.9093	10	0.9976	26	0.3435	252	0.2614	268	1.0000	1	0.8367	28
Nanyang	0.6613	231	Healthy	0.5707	277	0.7715	198	0.4276	230	0.3546	198	0.6783	267	0.8376	20

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Anyang	0.6595	232	Healthy	0.8211	169	0.5905	250	0.7685	140	0.3209	229	1.0000	1	0.5940	203
Pingliang	0.6575	233	Healthy	0.7432	245	0.9757	56	0.3218	260	0.3861	179	0.9973	146	0.5493	220
Bazhong	0.6568	234	Healthy	0.8035	202	0.9684	61	0.3422	254	0.2762	254	0.9779	175	0.6973	161
Wuwei	0.6560	235	Healthy	0.4789	283	0.9636	69	0.4749	211	0.2962	239	0.9898	159	0.6409	188
Huaihua	0.6505	236	Healthy	0.7466	242	0.9854	43	0.4780	210	0.3004	234	0.9167	214	0.8083	121
Wuzhou	0.6489	237	Sub-healthy	0.8177	177	0.9830	48	0.7413	149	0.3916	177	1.0000	1	0.6893	169
Lvliang	0.6478	238	Sub-healthy	0.8241	164	0.8955	134	0.2149	281	0.2414	275	1.0000	1	0.4004	271
Maoming	0.6471	239	Sub-healthy	0.6999	258	1.0000	1	0.3981	240	0.3115	231	0.9381	199	0.8118	118
Sanmenxia	0.6452	240	Sub-healthy	0.8652	49	0.7256	215	0.4885	208	0.3488	201	0.8739	235	0.7244	148
Zunyi	0.6429	241	Sub-healthy	0.8422	109	0.9514	81	0.3752	245	0.2717	259	1.0000	1	0.5749	212
Qingyang	0.6421	242	Sub-healthy	0.6598	266	0.9684	61	0.2233	279	0.2524	271	0.9231	208	0.8300	66
Yibin	0.6418	243	Sub-healthy	0.6960	260	0.8688	161	0.3404	255	0.3546	199	0.8036	258	0.5773	211
Heze	0.6415	244	Sub-healthy	0.8397	117	0.3534	274	0.3041	267	0.2945	241	1.0000	1	0.7084	156
Hulunbuir	0.6412	245		0.5157	281	0.9806	51	0.4554	221	0.3506	200	0.6344	271	0.6676	176

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
			Sub-healthy												
Jinzhong	0.6407	246	Sub-healthy	0.7717	230	0.7460	207	0.5118	199	0.3452	208	0.7500	264	0.3255	276
Baoding	0.6398	247	Sub-healthy	0.7162	252	1.0000	1	0.4056	236	0.2744	258	0.9900	157	0.6500	185
Yuxi	0.6384	248	Sub-healthy	0.7736	227	0.9976	26	0.6283	172	0.3488	202	0.8300	251	0.5996	202
Qinzhou	0.6370	249	Sub-healthy	0.7366	248	1.0000	1	0.6069	178	0.4102	169	0.9118	219	0.8287	74
Lasa	0.6350	250	Sub-healthy	0.7928	212	0.9417	94	0.4718	214	0.8314	33	1.0000	1	0.8317	53
Cangzhou	0.6343	251	Sub-healthy	0.7829	221	0.4172	270	0.3200	261	0.2630	266	0.9627	185	0.6141	197
Guigang	0.6342	252	Sub-healthy	0.5569	279	0.9393	95	0.7856	136	0.2694	261	0.9850	167	0.4281	263
Tianshui	0.6314	253	Sub-healthy	0.7380	246	0.9587	74	0.4567	219	0.2953	240	0.1750	284	0.8250	112
Shangqiu	0.6312	254	Sub-healthy	0.8449	104	0.8225	177	0.2757	274	0.2492	273	0.8487	245	0.8252	110
Zhangjiajie	0.6297	255	Sub-healthy	0.8203	173	0.7715	198	0.7228	153	0.4432	158	0.2119	282	0.8311	56

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Langfang	0.6291	256	Sub-healthy	0.8753	33	0.3891	272	0.5642	189	0.5170	128	0.2604	281	0.6333	193
Chaoyang	0.6286	257	Sub-healthy	0.7063	255	0.9854	43	0.6885	159	0.3008	233	1.0000	1	0.4317	262
Baicheng	0.6284	258	Sub-healthy	0.6305	270	0.9490	85	0.4742	213	0.3599	194	0.3995	280	0.8257	106
Puyang	0.6280	259	Sub-healthy	0.8162	181	0.7919	190	0.6332	171	0.3218	228	0.9096	221	0.7410	143
Hezhou	0.6255	260	Sub-healthy	0.8725	38	1.0000	1	0.5578	191	0.3607	193	1.0000	1	0.4831	241
Baiyin	0.6235	261	Sub-healthy	0.6854	263	0.9247	105	0.9713	19	0.4973	136	0.6570	268	0.4060	268
Shanwei	0.6224	262	Sub-healthy	0.8506	88	1.0000	1	0.4577	218	0.2327	277	0.7978	259	0.8428	8
Shaoyang	0.6213	263	Sub-healthy	0.7645	235	0.9028	127	0.4918	204	0.2564	270	0.9540	191	0.8100	120
Dingxi	0.6204	264	Sub-healthy	0.5941	275	0.9757	56	0.1943	282	0.2047	282	0.9800	173	0.7508	140
Neijiang	0.6167	265	Sub-healthy	0.7912	214	0.8761	152	0.4396	228	0.3476	206	0.6545	269	0.4400	258
Lincang	0.6152	266	Sub-healthy	0.8073	195	0.9830	48	0.2997	271	0.2593	269	0.9739	180	0.8274	84

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Chifeng	0.6147	267	Sub-healthy	0.8125	189	0.9150	114	0.8604	91	0.4385	162	0.9635	183	0.2726	280
Anshun	0.6146	268	Sub-healthy	0.5313	280	1.0000	1	0.4234	233	0.5083	132	0.6989	265	0.3875	272
Ganzhou	0.6122	269	Sub-healthy	0.8116	191	1.0000	1	0.4441	224	0.2998	235	1.0000	1	0.8343	41
Baise	0.6093	270	Sub-healthy	0.7838	220	0.9563	76	0.5470	193	0.2757	256	1.0000	1	0.4085	267
Zhumadian	0.6076	271	Sub-healthy	0.8344	138	0.7970	188	0.3428	253	0.2623	267	0.9189	213	0.4421	256
Hechi	0.6074	272	Sub-healthy	0.6371	269	0.9781	55	0.3523	250	0.2202	279	1.0000	1	0.8164	115
Qujing	0.6071	273	Sub-healthy	0.7665	232	0.9976	26	0.3618	249	0.2715	260	1.0000	1	0.5824	209
Xingtai	0.6063	274	Sub-healthy	0.7878	216	0.1750	284	0.5378	198	0.3411	211	1.0000	1	0.5202	228
Huanggang	0.6038	275	Sub-healthy	0.6954	261	0.8421	169	0.3192	263	0.2174	280	0.5822	274	0.8161	116
Dazhou	0.5973	276	Sub-healthy	0.6969	259	0.9611	73	0.4257	231	0.2823	250	0.8635	241	0.4133	266
Xinzhou	0.5960	277	Sub-healthy	0.6770	264	0.8098	185	0.3983	239	0.2652	263	0.4208	278	0.4527	252
Yuncheng	0.5926	278	Sub-healthy	0.8046	199	0.7970	188	0.3959	241	0.2759	255	0.9500	194	0.2677	282
Hengshui	0.5868	279	Sub-healthy	0.8427	107	0.2566	281	0.3193	262	0.3022	232	0.6505	270	0.6090	198

(continued)

Table 5.3 (continued)

Cities	The health index	Rank	Grades	The green coverage rate of built-up area (%)		The number of days of good air quality (day)		Water consumption per capita (ton/person)		The greening area per capita (m^2/person)		Hazard-free treatment rate of household garbage (%)		The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	
				Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Zhoukou	0.5798	280	Sub-healthy	0.8178	175	0.7307	214	0.2236	278	0.2417	274	0.9209	211	0.8290	72
Liupanshui	0.5637	281	Sub-healthy	0.5601	278	1.0000	1	0.4124	235	0.2003	283	1.0000	1	0.1750	284
Chongzuo	0.5525	282	Sub-healthy	0.7779	224	0.9806	51	0.3078	266	0.2819	251	0.6102	273	0.5617	216
Zhaotong	0.5152	283	Sub-healthy	0.6756	265	1.0000	1	0.2172	280	0.2064	281	0.5474	275	0.6815	174
Longnan	0.5103	284	Sub-healthy	0.1750	284	0.9708	60	0.1750	284	0.1750	284	0.4083	279	0.7746	128

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Zhu hai	0.9300	127	0.8852	146	0.8915	5	0.8925	11	0.8683	98	0.9198	2	0.8844	6	0.8867	17
San ya	1.0000	1	0.7882	224	0.8439	29	0.8460	51	0.8784	88	1.0000	1	0.8257	107	0.8522	44
Xiamen	0.9433	115	0.9162	88	0.8904	6	0.8654	35	0.5770	220	0.8792	15	0.8293	84	0.9032	11
Tongling	0.8356	189	0.8551	180	0.8302	58	0.8783	24	0.8838	83	0.8390	55	0.8505	29	0.8992	13
Xinyu	0.9260	131	0.9680	24	0.7851	90	0.8557	41	0.9521	27	0.6488	150	0.8544	24	0.8633	32

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Huizhou	0.9500	107	0.9703	21	0.8495	19	0.8368	77	0.8803	86	0.8284	89	0.8405	47	0.8441	55
Zhoushan	0.9983	23	0.6677	254	0.8430	32	0.8654	34	0.8628	106	0.8768	17	0.8673	16	0.8556	37
Shenyang	0.9288	129	0.9500	40	0.8270	71	0.8716	30	0.9124	57	0.8894	10	0.8273	98	0.8565	35
Fuzhou	0.9447	112	0.8504	186	0.8424	35	0.8449	55	0.9480	30	0.8262	102	0.6019	163	0.8396	61
Dalian	0.9058	150	0.8670	168	0.8284	65	0.8993	10	0.9707	18	0.8287	86	0.8255	109	0.6576	133
Hailou	0.9392	118	0.8900	140	0.8444	28	0.7446	133	0.8486	121	0.8885	11	0.8328	66	0.8282	82
Jingdezhen	0.9758	72	0.7379	239	0.7977	88	0.7414	134	0.8924	75	0.8257	106	0.8404	48	0.6533	136
Guanghzou	0.9530	102	0.9138	92	0.9174	3	0.9100	9	0.6260	212	0.8909	8	0.8387	52	0.8386	63
Nanning	0.9478	110	0.7286	242	0.8322	49	0.6876	149	0.9010	69	0.8406	48	0.7096	135	1.0000	1
Wuhu	0.9815	58	0.9004	120	0.7276	105	0.8340	83	0.8734	96	0.5505	174	0.8623	18	0.8711	26
Huangshan	0.7661	214	0.9136	94	0.6201	139	0.6143	165	0.5738	222	0.8370	57	0.8370	57	0.8357	67
Xi'an	0.9555	95	0.9150	90	0.8474	22	0.8367	78	0.8131	151	0.8401	51	0.6890	140	0.9675	3
Suzhou	0.9796	64	0.7814	226	0.8546	14	0.9141	8	0.8291	143	0.8441	43	0.6426	150	0.8389	62
Yangzhou	0.9776	67	0.8771	156	0.7975	89	0.8551	42	0.8522	117	0.6753	141	0.8425	45	0.7695	106
Yantai	0.8414	185	0.9524	34	0.8258	78	0.8640	36	0.9709	17	0.8305	78	0.5438	183	0.7061	121
Qingdao	0.9500	107	0.9433	52	0.8402	38	0.8750	28	0.8565	114	0.6899	136	0.8323	69	0.6079	147
Weihai	0.9349	121	0.9390	59	0.8368	43	0.8764	26	0.9971	3	0.8460	40	0.6171	156	0.4458	194
Zhenjiang	0.9815	58	0.8222	204	0.8275	68	0.8783	23	0.8492	120	0.8398	53	0.8471	35	0.6358	141

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Wuhan	0.9513	105	0.9290	73	0.8555	13	0.8741	29	0.6992	188	0.8376	56	0.8463	38	0.8527	42
Bengbu	0.9907	34	0.9274	76	0.5330	165	0.5588	185	0.8848	82	0.6554	147	0.8574	21	0.9029	12
Huzhou	0.9637	85	0.9101	97	0.8417	36	0.8425	61	0.9866	8	0.8264	101	0.5780	171	0.8115	99
Changzhou	0.9825	54	0.8508	185	0.8374	41	0.8788	22	0.7836	162	0.8319	75	0.8285	92	0.6502	137
Hangzhou	0.9416	116	0.9550	33	0.8654	11	0.8806	18	0.9914	7	0.8701	23	0.4637	207	0.8351	68
Tongchuan	1.0000	1	0.8926	134	0.5616	155	0.6748	151	0.7585	171	0.8460	41	0.8578	20	0.9250	5
Karamay	0.9053	151	0.9387	60	0.8484	21	0.9444	3	0.2944	276	0.8423	47	0.8492	32	0.8436	56
Jinan	0.9875	46	0.9083	103	0.8391	40	0.8577	39	0.8352	138	0.8279	92	0.8466	36	0.8632	33
Huainan	0.8911	165	0.7782	228	0.6433	132	0.6173	163	0.7143	183	0.8430	46	0.8638	17	0.8734	24
Chongqing	0.8442	183	0.9290	73	0.6421	133	0.7528	131	0.9751	14	0.7081	131	0.8374	56	0.8745	23
Hebi	0.9440	114	0.8301	196	0.8255	81	0.6618	153	0.8320	141	0.8287	85	0.8279	96	0.8413	59
Tianjin	0.9941	30	0.8920	135	0.8253	83	0.8865	13	0.7795	164	0.8582	30	0.8298	82	0.7077	120
Beijing	0.8693	172	0.8289	199	0.8459	24	0.8790	20	0.8107	152	0.9137	4	0.5715	173	0.9262	4
Panjing	0.9236	135	1.0000	1	0.7400	99	0.8800	19	0.8934	74	0.8953	6	0.7007	138	0.5086	175
Hefei	0.9345	123	0.8749	158	0.6833	117	0.8420	63	0.8822	84	0.5656	169	0.8287	91	0.7200	117
Jiangmen	0.9108	146	0.8885	143	0.8316	52	0.7828	119	0.9803	13	0.5021	193	0.8382	54	0.7280	113
Qinhuangdao	0.5598	252	0.9501	39	0.8258	79	0.6796	150	0.9457	32	0.8272	98	0.7681	121	0.8446	54
Dongying	0.9854	49	0.9378	63	0.8339	48	0.9528	2	0.7848	161	0.7907	114	0.6104	159	0.8251	91

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Urumqi	0.8796	169	0.8219	205	0.8448	27	0.8457	53	0.6851	194	0.8276	96	0.8369	58	0.9039	10
Foshan	0.9332	124	0.9428	53	0.8844	8	0.8826	17	0.6793	199	0.8306	77	0.4415	217	0.8162	98
Shaoxing	0.9289	128	0.8826	148	0.8373	42	0.8638	37	0.9277	44	0.8262	103	0.5869	168	0.6594	132
Harbin	0.9401	117	0.9047	107	0.6436	131	0.8291	95	0.6764	201	0.8471	38	0.8311	76	0.7777	105
Beihai	0.9987	19	0.8348	193	0.8283	66	0.8173	111	0.9440	36	0.8328	72	0.4296	223	0.8337	71
Kunming	0.4915	262	0.9504	37	0.8318	51	0.8309	90	0.8420	132	0.8341	65	0.5334	187	0.9982	2
Nantong	0.9805	61	0.8824	149	0.6757	119	0.8508	45	0.7047	187	0.5233	183	0.7987	116	0.8961	15
Shantou	0.9767	69	0.9195	85	0.8350	46	0.5104	207	0.3590	264	0.4999	194	0.8377	55	0.8863	18
Jiujiang	0.5442	258	0.9763	18	0.7018	115	0.5934	173	0.8475	124	0.5646	170	0.8337	64	0.8310	75
Shuozhou	0.8702	171	0.9772	16	0.4185	222	0.8390	68	0.6099	213	0.8354	59	0.7269	131	0.8312	74
Nanjing	0.9143	139	0.6586	256	0.8433	30	0.8846	15	0.6945	190	0.8344	64	0.8622	19	0.8745	22
Zaozhuang	0.9998	13	0.9314	71	0.7442	98	0.8266	103	0.7615	170	0.7492	124	0.8319	72	0.8253	89
Fangchenggang	0.9954	29	0.4895	270	0.8266	75	0.8388	70	0.5705	223	0.8451	42	0.8480	34	0.8428	57
Lianyungang	0.9542	98	0.6948	247	0.7186	110	0.7120	142	0.8575	112	0.6656	143	0.8387	51	0.8526	43
Nanchang	0.9786	65	0.9097	99	0.8345	47	0.8457	54	0.8553	116	0.8330	70	0.7189	133	0.4010	203
Changchun	0.9980	25	0.8002	221	0.7122	111	0.8475	48	0.9368	40	0.8520	34	0.8338	63	0.7575	107
Liaoyuan	0.9589	90	0.9613	29	0.5276	170	0.8372	76	0.8133	150	0.6770	140	0.8289	88	0.5452	164
Wuxi	0.9124	142	0.8955	131	0.8403	37	0.9157	7	0.6713	204	0.8284	90	0.8335	65	0.4283	197

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Taizhou	0.9653	83	0.8909	137	0.8354	45	0.8313	88	0.8781	89	0.6069	157	0.8257	108	0.4877	181
Shizuishan	0.7672	213	0.9440	50	0.6493	129	0.8396	67	0.5568	229	0.8526	33	0.8757	9	0.8529	41
Pingxiang	0.9557	94	0.8299	198	0.7269	106	0.7480	132	0.9456	33	0.5184	185	0.8253	110	0.8279	86
Ezhou	0.9048	153	0.8073	216	0.6659	124	0.8399	66	0.8557	115	0.5794	166	0.9073	5	0.8490	48
Liuzhou	0.9371	119	0.4838	272	0.8272	70	0.8312	89	0.7114	185	0.8656	26	0.8313	73	0.9182	6
Shenzhen	0.7979	205	0.9622	28	1.0000	1	0.9301	5	0.4954	244	0.8555	32	0.8273	99	0.2385	269
Taiyuan	0.6019	246	0.8500	187	0.8512	16	0.8362	81	0.9319	42	0.8779	16	0.7987	117	0.8659	28
Guilin	0.8870	167	0.9153	89	0.6618	125	0.6039	169	0.6759	202	0.8390	54	0.5949	165	0.8727	25
Xianyang	0.9581	91	0.8271	200	0.5684	151	0.6653	152	0.9339	41	0.8293	83	0.4739	202	0.8639	30
Zhanjiang	0.9779	66	0.8996	127	0.5512	159	0.5138	203	0.8891	77	0.5603	172	0.7097	134	0.7922	101
Zibo	0.9531	101	0.9510	36	0.8266	74	0.8669	33	0.8470	126	0.8338	67	0.8173	112	0.4596	191
Chuzhou	0.9685	80	0.9331	67	0.4806	198	0.4900	209	0.9072	63	0.5344	181	0.8309	77	0.8409	60
Ningbo	0.9032	156	0.7519	235	0.8487	20	0.8790	21	0.8965	70	0.8347	63	0.4309	221	0.7256	114
Huai'an	0.9776	67	0.7087	243	0.5315	166	0.7867	118	0.9186	54	0.7882	115	0.8714	14	0.7210	116
Liaoyang	0.7599	216	1.0000	1	0.7383	100	0.8381	72	0.9502	28	0.8746	18	0.8503	30	0.2568	263
Baoji	0.5679	250	0.9352	66	0.5885	146	0.7276	141	0.7462	177	0.5871	163	0.8288	89	0.8555	38
Huaibei	0.9272	130	0.8961	128	0.6672	122	0.5847	175	0.8257	147	0.2666	269	0.8571	22	0.8770	21
Zhuzhou	0.8915	163	0.7348	241	0.7845	91	0.8282	98	0.9273	45	0.6233	154	0.8269	103	0.6888	124

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Changsha	0.8605	175	0.9654	25	0.8306	55	0.8864	14	0.9120	58	0.7980	111	0.5089	190	0.6276	143
Yingkou	0.8638	174	1.0000	1	0.7292	103	0.8425	62	0.9927	6	0.8483	37	0.6148	157	0.5172	174
Shanghai	0.9720	77	0.8712	162	0.8431	31	0.8754	27	0.3906	256	0.8838	13	0.7514	125	0.5824	154
Dongguan	0.8000	204	0.9520	35	0.9615	2	0.8473	49	0.8298	142	0.4913	197	0.8537	27	0.8972	14
Datong	0.9110	145	0.6679	253	0.6147	140	0.5117	205	0.8180	149	0.8360	58	0.8313	74	0.9114	8
Jingzhou	0.9350	120	0.7665	231	0.8105	85	0.7648	128	0.8819	85	0.7647	121	0.4533	210	0.8253	88
Chizhou	1.0000	1	0.9138	92	0.5153	173	0.5769	179	0.6990	189	0.4071	225	0.8722	11	0.8602	34
Zhaoqing	0.5356	259	0.9410	55	0.8861	7	0.7302	139	0.8676	100	0.4885	199	0.8302	80	0.8917	16
Jilin	0.8238	194	0.9405	56	0.6767	118	0.8412	65	0.5942	216	0.8354	60	0.8288	90	0.3136	235
Chengdu	0.9903	35	0.8518	184	0.8264	76	0.8448	56	0.6930	191	0.8511	35	0.4066	231	0.8299	77
Maanshan	0.7292	222	0.8700	165	0.7281	104	0.8387	71	0.9103	60	0.5588	173	0.8387	50	0.8517	45
Xiangfan	0.9815	58	0.8812	150	0.4641	205	0.8291	94	0.8794	87	0.7849	116	0.8270	102	0.3278	229
Yingtan	0.9250	133	0.9378	63	0.7842	92	0.8268	102	0.9231	49	0.6922	135	0.6669	143	0.2410	267
Yinchuan	0.8518	181	0.9940	9	0.8258	80	0.8430	60	0.6867	193	0.8725	21	0.5097	189	0.7139	118
Ji’an	0.9733	75	0.9087	102	0.5456	163	0.4222	237	0.7145	182	0.5853	164	0.6518	146	0.8368	65
Yichang	0.5483	256	0.9100	98	0.6588	126	0.8505	46	0.6825	197	0.7787	117	0.8462	39	0.6752	126
Meizhou	0.9903	35	0.8062	219	0.4903	189	0.3379	269	0.9057	65	0.5409	177	0.8293	85	0.8708	27
Guiyang	0.6525	238	0.8888	142	0.8359	44	0.8160	112	0.9700	19	0.8269	99	0.6930	139	0.5311	169

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Uhai	0.6572	237	0.9301	72	0.8504	17	0.8911	12	0.8917	76	0.8949	7	0.8552	23	0.3158	233
Daqing	0.9651	84	0.4659	274	0.7081	112	0.9433	4	0.5213	236	0.5901	160	0.8716	13	0.8229	94
Benxi	0.2916	282	0.9224	81	0.8270	72	0.8508	44	0.6586	207	0.8846	12	0.8509	28	0.6561	134
Shiyan	0.4810	265	0.8857	145	0.8269	73	0.5692	181	0.5630	226	0.5633	171	0.8497	31	0.8553	39
Quzhou	0.9329	125	0.8786	154	0.7610	94	0.7336	137	0.8665	101	0.3475	249	0.8260	105	0.8314	73
Putian	1.0000	1	0.8551	180	0.8612	12	0.8257	106	0.8052	154	0.2528	273	0.8539	26	0.2907	249
Quanzhou	0.9632	86	0.8720	161	0.8472	23	0.8433	59	0.8749	94	0.1849	283	0.4294	224	0.8298	78
Yangjiang	0.9987	19	0.8206	206	0.6070	141	0.7394	136	0.9306	43	0.5208	184	0.8156	113	0.4029	202
Erdos	0.4577	267	0.9814	15	0.4541	206	1.0000	1	0.2083	282	0.9190	3	0.8281	95	0.4164	200
Fuzhou	0.8929	160	0.9112	96	0.4871	191	0.4267	236	0.7747	165	0.4468	211	0.8282	94	0.6604	131
Xuqian	0.9007	158	0.8462	188	0.5439	164	0.6274	160	0.8619	107	0.5385	179	0.8276	97	0.7476	111
Huangshi	0.9446	113	0.9040	109	0.8250	84	0.8206	109	0.9060	64	0.3521	245	0.8817	8	0.5804	155
Longyan	0.8670	173	0.8936	133	0.7299	102	0.8372	75	0.5969	215	0.4689	205	0.4917	196	0.6794	125
Nanping	0.8133	198	0.8897	141	0.8254	82	0.7413	135	0.4909	246	0.8296	80	0.6338	153	0.3715	214
Jiaxing	0.9513	105	0.9038	110	0.8546	15	0.8509	43	0.7507	176	0.8339	66	0.4503	212	0.3319	228
Guangyuan	1.0000	1	0.8153	211	0.3795	237	0.3694	263	0.6837	196	0.8325	73	0.8312	75	0.8530	40
Dandong	0.9630	87	0.6719	250	0.7063	114	0.8113	114	0.5915	217	0.8673	24	0.5818	170	0.5425	165
Qitaihe	0.8734	170	0.5788	265	0.5097	177	0.4673	218	0.5669	224	0.8276	95	0.9256	2	0.8470	52

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Lishui	0.9685	80	0.8697	167	0.7191	109	0.8143	113	0.5797	219	0.5731	168	0.3091	258	0.7059	122
Zhongwei	0.9180	138	1.0000	1	0.5010	183	0.4596	223	0.3512	265	0.8430	45	0.6823	141	0.8483	50
Chaozhou	0.9986	21	0.8627	172	0.8290	62	0.5134	204	0.7746	166	0.4152	223	0.4835	198	0.7399	112
Taizhou	0.9825	54	0.6218	261	0.6846	116	0.8459	52	0.7548	173	0.5071	191	0.8319	71	0.5723	157
Mudanjiang	1.0000	1	0.3483	283	0.6392	135	0.7680	123	0.3452	267	0.6540	148	0.8452	40	0.8295	80
Tai'an	0.9851	51	0.9443	49	0.5868	147	0.8288	96	0.8447	129	0.5503	175	0.6497	148	0.5632	159
Lijiang	0.9192	137	0.9591	30	0.4517	208	0.3560	266	0.3153	271	0.8741	19	0.4273	227	0.8209	96
Tonghua	0.9052	152	0.9241	80	0.5801	150	0.7890	117	0.5520	230	0.8278	94	0.7292	130	0.3214	230
Shijiazhuang	0.9865	47	0.9446	48	0.8303	57	0.8176	110	0.8773	91	0.7179	130	0.5516	182	0.8252	90
Zhongshan	0.6680	234	0.9070	104	0.8971	4	0.8675	32	0.7643	169	0.6639	145	0.3205	255	0.6084	146
Mianyang	0.9823	57	0.9186	86	0.5051	181	0.5260	197	0.8511	118	0.6414	153	0.8155	114	0.4443	195
Linxin	0.9095	147	0.9399	57	0.5938	143	0.5831	177	0.8767	92	0.5966	159	0.6359	152	0.7900	103
Shaoguan	0.7975	206	0.8178	208	0.6410	134	0.6208	162	0.6505	209	0.8262	104	0.8438	43	0.2397	268
Yichun	0.8393	186	0.4683	273	0.8425	34	0.4118	242	0.2630	277	0.7300	128	1.0000	1	0.8837	19
Yangquan	0.3488	277	0.8393	190	0.8259	77	0.7777	121	0.8693	97	0.8298	79	0.8293	86	0.4716	188
Yichun	0.9903	35	0.9315	69	0.3792	238	0.4536	226	0.8866	79	0.4507	209	0.4638	206	0.8638	31
Rizhao	0.9896	41	0.9385	62	0.6710	121	0.8317	87	0.9230	50	0.2466	274	0.8465	37	0.3483	220
Zhengzhou	0.7563	217	0.9586	31	0.8428	33	0.8496	47	0.5826	218	0.7036	132	0.3533	243	0.8303	76

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Xining	0.9764	71	0.7384	238	0.8297	61	0.7622	129	0.8747	95	0.8256	107	0.5368	186	0.8490	49
Fushun	0.4876	263	0.7414	237	0.7262	107	0.8448	57	0.6925	192	0.8591	29	0.8391	49	0.3811	209
Lanzhou	0.9747	73	0.7798	227	0.8286	63	0.8272	100	0.8613	108	0.8578	31	0.8284	93	0.8279	85
Xuancheng	0.8439	184	0.8535	183	0.5291	168	0.5836	176	0.7797	163	0.2144	279	0.7224	132	0.8784	20
Laiwu	0.9805	61	0.9428	53	0.7379	101	0.8278	99	0.9107	59	0.2763	266	0.8677	15	0.5899	150
Jinhua	0.9825	54	0.8901	139	0.8399	39	0.8433	58	0.9975	2	0.8430	44	0.2772	264	0.4467	193
Xuzhou	0.9922	32	0.9150	90	0.5899	145	0.8305	92	0.7436	178	0.5147	188	0.8451	41	0.5237	172
Haozhou	0.9984	22	0.9012	118	0.2830	266	0.2945	275	0.8334	140	0.3632	240	0.8366	59	0.8297	79
Liu'an	0.7842	208	0.8746	159	0.2800	267	0.3246	270	0.9663	20	0.7207	129	0.5865	169	0.8276	87
Anqing	0.9698	79	0.8961	128	0.4467	211	0.4750	217	0.9734	15	0.3513	247	0.8066	115	0.6136	144
Xiangtan	0.9665	82	0.8785	155	0.4834	193	0.8305	91	0.9026	67	0.4876	200	0.4546	209	0.8426	58
Changzhi	0.7036	228	0.9257	79	0.6464	130	0.6958	145	0.8270	144	0.8348	62	0.4308	222	0.6703	128
Fuxin	0.8601	176	0.5782	266	0.7552	96	0.6064	167	0.6681	206	0.8401	52	0.3576	241	0.7002	123
Baotou	0.5499	254	0.8562	177	0.7455	97	0.9190	6	0.3827	259	0.8665	25	0.8355	61	0.2615	262
Yulin	0.9708	78	0.8406	189	0.4870	192	0.8690	31	0.3978	254	0.8404	50	0.2587	269	0.7919	102
Jingmen	0.9241	134	0.8558	179	0.5582	157	0.7334	138	0.8260	145	0.4471	210	0.8307	78	0.3018	241
Leshan	0.9554	96	0.8177	209	0.5091	178	0.6167	164	0.8596	109	0.8266	100	0.8354	62	0.5196	173
Laibin	0.7471	220	0.8247	202	0.3571	245	0.4316	234	0.6849	195	0.5184	186	0.7914	119	0.8499	47

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Handan	0.9552	97	0.9752	19	0.5921	144	0.5831	178	0.7935	160	0.6096	155	0.7078	136	0.8513	46
Zhangzhou	0.9490	109	0.8903	138	0.8319	50	0.7991	115	0.9590	23	0.4193	219	0.4492	213	0.3044	240
Wuzhong	0.7761	210	0.9005	119	0.4094	227	0.4754	215	0.3958	255	0.8278	93	0.4991	194	0.7890	104
Dezhou	0.9914	33	0.9497	44	0.4778	201	0.7656	127	0.9131	56	0.6788	139	0.5179	188	0.6058	148
Jiuquan	0.6590	236	0.9436	51	0.5537	158	0.8380	73	0.1750	284	0.8602	28	0.8302	81	0.2482	266
Suizhou	0.9990	17	0.6127	262	0.5629	153	0.5398	191	0.8484	122	0.6716	142	0.7973	118	0.3128	237
Luohe	0.9998	13	0.9503	38	0.5157	172	0.5945	172	0.5624	227	0.5398	178	0.8218	111	0.2831	254
Yiyang	0.8914	164	0.8253	201	0.4081	229	0.4608	221	0.9588	24	0.5109	190	0.3863	235	0.8342	70
Yulin	0.8929	160	0.9910	10	0.3522	247	0.3850	254	0.9200	52	0.3952	230	0.7841	120	0.4783	185
Deyang	0.9999	12	0.8999	125	0.5153	174	0.6975	144	0.8649	104	0.5876	162	0.3656	239	0.5418	166
Ankang	0.9044	154	0.8578	175	0.3990	232	0.4122	241	0.5204	238	0.1750	284	0.7656	122	0.9090	9
Binzhou	0.8389	187	0.9114	95	0.6747	120	0.8364	80	0.9637	21	0.2654	270	0.5652	176	0.5293	170
Wenzhou	0.9902	39	0.8830	147	0.8454	26	0.7671	124	0.8568	113	0.3353	251	0.4347	219	0.4196	198
Loudi	0.9852	50	0.8089	215	0.4277	219	0.5205	199	0.9236	48	0.5801	165	0.1750	284	0.8214	95
Tangshan	0.7544	219	0.9481	45	0.8275	67	0.8631	38	0.9253	47	0.8288	84	0.5961	164	0.3858	208
Hohhot	0.4497	269	0.8121	212	0.8041	87	0.8765	25	0.5346	234	0.9112	5	0.5659	175	0.5691	158
Huludao	0.5980	247	0.8564	176	0.5842	148	0.5329	195	0.8497	119	0.8259	105	0.4591	208	0.8456	53
Songyuan	0.8928	162	0.9579	32	0.3882	235	0.8374	74	0.5292	235	0.8284	88	0.2952	262	0.2150	274

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Wulanchabu	0.7550	218	0.9848	14	0.2663	275	0.6913	146	0.3026	274	0.7314	127	0.6120	158	0.6465	138
Jiamusi	0.8208	195	0.7030	245	0.5283	169	0.5610	182	0.3634	261	0.8295	82	0.6060	161	0.3883	207
Qingyuan	0.8880	166	0.8381	191	0.5643	152	0.5149	201	0.7529	174	0.3847	235	0.8483	33	0.2927	248
Suining	0.9903	35	0.9329	68	0.2706	273	0.4050	247	0.8472	125	0.3151	259	0.8716	12	0.5594	160
Baishan	0.6756	232	0.6709	252	0.4918	186	0.8318	86	0.3598	263	0.7957	112	0.8543	25	0.5388	167
Yueyang	0.9318	126	0.5978	264	0.4028	231	0.7726	122	0.9473	31	0.6476	152	0.4284	225	0.4969	178
Heihe	0.9346	122	0.9001	121	0.4525	207	0.4073	244	0.2286	280	0.8469	39	0.6459	149	0.3401	226
Anshan	0.3561	276	0.8709	163	0.8085	86	0.8576	40	0.9482	29	0.8719	22	0.4852	197	0.2149	275
Jiaozuo	0.6237	242	0.8730	160	0.7202	108	0.8268	101	0.7377	179	0.6534	149	0.5428	184	0.3014	242
Nanchong	0.8167	197	0.8357	192	0.3350	254	0.3800	260	0.8883	78	0.4167	221	0.7331	129	0.8373	64
Weifang	0.9998	13	0.9315	69	0.8761	9	0.8261	105	0.9198	53	0.4310	216	0.4090	230	0.3745	211
Jining	0.9142	140	0.9358	65	0.5147	175	0.7528	130	0.8353	137	0.4080	224	0.6561	145	0.6129	145
Qiqihar	0.7356	221	0.6870	248	0.3431	251	0.4201	238	0.5209	237	0.8158	109	0.8305	79	0.8286	81
Guyuan	0.9124	142	0.6520	258	0.2518	277	0.2690	278	0.4851	247	0.6874	137	0.7652	123	0.9146	7
Jinchang	0.3313	278	0.6532	257	0.6547	128	0.8330	84	0.3054	273	0.8606	27	0.8448	42	0.4937	179
Tongliao	0.8539	180	0.9944	8	0.3673	243	0.8366	79	0.3080	272	0.8219	108	0.5539	180	0.1938	280
Bayannaoer	0.6652	235	0.9396	58	0.4448	212	0.8285	97	0.2377	279	0.8405	49	0.8271	100	0.1902	281
Jixi	0.9036	155	0.4475	276	0.4706	202	0.5445	189	0.3876	258	0.8333	69	0.8270	101	0.4552	192

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Xiaogan	0.7219	226	0.9500	40	0.4791	200	0.4576	224	0.8960	71	0.4620	208	0.8416	46	0.3926	206
Fuyang	0.9997	16	0.9001	121	0.8307	54	0.2562	279	0.6443	210	0.1904	282	0.5927	167	0.8280	83
Jiayuguan	0.5459	257	0.3484	282	0.8457	25	0.8827	16	0.3475	266	0.8894	9	0.9081	4	0.6452	139
Luzhou	0.9026	157	0.4263	279	0.4058	230	0.4793	214	0.9821	10	0.3619	241	0.8426	44	0.8279	84
Binzhou	0.5489	255	0.9024	115	0.4344	214	0.6406	157	0.8460	128	0.5893	161	0.2061	278	0.7558	109
Meishan	1.0000	1	0.7839	225	0.3543	246	0.5151	200	0.9539	26	0.3465	250	0.7483	126	0.6607	130
Panzhihua	0.3026	281	0.3659	281	0.8301	59	0.8460	50	0.5766	221	0.7986	110	0.8749	10	0.6541	135
Xinxiang	0.9766	70	0.9000	123	0.7064	113	0.5529	186	0.8411	133	0.3908	233	0.3771	237	0.4192	199
Ningde	0.9532	100	0.8698	166	0.8273	69	0.7669	126	0.8400	134	0.3932	231	0.4822	201	0.1803	283
Weinan	1.0000	1	0.8318	195	0.3686	241	0.4532	227	0.9987	1	0.8349	61	0.3263	252	0.7971	100
Heyuan	0.4556	268	0.8939	132	0.4834	193	0.4047	248	0.7951	159	0.2678	268	0.4458	214	0.8557	36
Xuchang	0.9883	43	0.9697	22	0.5219	171	0.7785	120	0.6824	198	0.4710	203	0.3365	245	0.3928	205
Luoyang	0.6432	240	0.9857	13	0.8298	60	0.8257	107	0.9835	9	0.4261	218	0.4508	211	0.2636	260
Siping	0.9226	136	0.7673	230	0.4323	216	0.6412	156	0.8024	155	0.8281	91	0.5071	191	0.1878	282
Hanzhong	0.5847	249	0.9028	114	0.3972	234	0.4608	222	0.5496	232	0.7481	125	0.4833	199	0.7549	110
Sanming	0.8541	179	0.4113	280	0.8313	53	0.8390	69	0.4936	245	0.6641	144	0.6635	144	0.2659	259
Jincheng	0.7948	207	0.9500	40	0.6578	127	0.7896	116	0.8009	156	0.8314	76	0.3221	254	0.1963	279
Zhangjiakou	0.4756	266	0.9198	84	0.4421	213	0.5333	194	0.5084	241	0.8295	81	0.6026	162	0.5524	162

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Tieling	0.7088	227	1.0000	1	0.4817	197	0.6044	168	0.8004	157	0.7377	126	0.3278	250	0.3551	217
Yancheng	0.8053	199	0.7761	229	0.5060	180	0.8263	104	0.9595	22	0.4721	202	0.5391	185	0.3650	216
Zigong	0.9085	148	0.7646	232	0.4471	210	0.6490	155	0.8343	139	0.3225	254	0.9151	3	0.4030	201
Yongzhou	0.8345	191	0.8104	214	0.2758	270	0.3997	251	0.8595	110	0.4276	217	0.2785	263	0.8358	66
Hegang	0.8839	168	0.5331	268	0.4125	225	0.5264	196	0.3621	262	0.8729	20	0.8833	7	0.4903	180
Ya'an	0.5554	253	0.6711	251	0.4908	188	0.4873	210	0.4470	249	0.5354	180	0.5588	178	0.8345	69
Pingdingshan	0.9572	93	0.8999	125	0.4833	196	0.5594	183	0.8586	111	0.7755	120	0.3273	251	0.2674	257
Jingzhou	0.4408	270	0.9017	117	0.5810	149	0.4177	240	0.9719	16	0.4331	214	0.8356	60	0.3533	218
Xianning	0.6156	244	0.9093	100	0.5972	142	0.6219	161	0.8777	90	0.3619	242	0.7412	127	0.2516	265
Shuangyashan	0.6903	229	0.5110	269	0.5033	182	0.6531	154	0.3372	268	0.8329	71	0.8384	53	0.3737	212
Xinyang	0.9883	43	0.9691	23	0.2587	276	0.4435	229	0.9222	51	0.4457	212	0.5573	179	0.2898	250
Yan'an	0.8014	202	0.8919	136	0.4795	199	0.8419	64	0.3363	269	0.7548	123	0.2417	272	0.3519	219
Shangluo	0.3188	279	0.9474	46	0.4113	226	0.3926	253	0.5175	240	0.5132	189	0.7372	128	0.8237	92
Hengyang	0.8249	193	0.6286	259	0.4183	223	0.5338	193	0.9401	38	0.4039	226	0.5053	193	0.5353	168
Suihua	1.0000	1	1.0000	1	0.3348	255	0.3773	262	0.5991	214	0.5064	192	0.8296	83	0.3457	224
Suzhou	0.6491	239	0.8606	173	0.3436	250	0.3407	267	0.8679	99	0.2614	272	0.8327	67	0.4821	183
Kaifeng	1.0000	1	0.7541	234	0.5481	161	0.5218	198	0.7681	168	0.4027	227	0.5944	166	0.5766	156
Baoding	0.8991	159	0.9650	26	0.6665	123	0.4564	225	0.9142	55	0.3186	256	0.3946	234	0.8320	72

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Changde	0.9801	63	0.9031	113	0.4129	224	0.6906	147	0.9086	61	0.4312	215	0.3364	246	0.1750	284
Zhangye	0.7263	224	0.8704	164	0.4962	185	0.4954	208	0.2456	278	0.8492	36	0.5055	192	0.2291	271
Chengde	0.2044	283	0.8666	170	0.4891	190	0.6403	158	0.4217	253	0.7923	113	0.8290	87	0.3475	221
Yunfu	0.8000	203	0.8185	207	0.8496	18	0.4452	228	0.9437	37	0.2844	264	0.2728	265	0.4686	189
Ziyang	0.9934	31	0.9036	111	0.2324	280	0.5421	190	0.8755	93	0.3047	261	0.6176	155	0.2093	276
Liaocheng	0.9841	53	0.9462	47	0.5123	176	0.7063	143	0.8643	105	0.4191	220	0.4429	216	0.3965	204
Jieyang	0.9988	18	0.7595	233	0.7732	93	0.4796	213	0.5623	228	0.2377	275	0.6401	151	0.2668	258
Guang’an	0.7626	215	0.9282	75	0.2450	279	0.4636	219	0.8377	135	0.2704	267	0.5770	172	0.8234	93
Shangrao	0.3088	280	0.9032	112	0.4833	195	0.3800	259	0.9079	62	0.2277	278	0.5675	174	0.5934	149
Nanyang	0.7268	223	0.8538	182	0.3398	252	0.4424	230	0.9943	5	0.5178	187	0.8323	68	0.5239	171
Anyang	0.8598	177	0.9771	17	0.6367	136	0.5865	174	0.7974	158	0.4346	213	0.4195	229	0.2962	244
Pingliang	0.7234	225	0.8002	221	0.3040	262	0.2995	274	0.7316	180	0.6619	146	0.5606	177	0.5039	176
Bazhong	0.9581	91	0.8241	203	0.1987	283	0.2342	281	0.8936	73	0.2322	277	0.3313	248	0.8657	29
Wuwei	0.8374	188	0.9909	11	0.3141	259	0.3800	261	0.3157	270	0.8320	74	0.5531	181	0.2623	261
Huaihua	0.4047	273	0.8301	196	0.3502	248	0.4182	239	0.6743	203	0.6005	158	0.2020	279	0.8187	97
Wuzhou	0.7837	209	0.6261	260	0.4679	203	0.5970	170	0.8482	123	0.3827	236	0.2476	271	0.5554	161
Lvliang	0.8201	196	0.9093	100	0.4914	187	0.5759	180	0.6706	205	0.5290	182	0.1854	283	0.6342	142
Maoming	0.9600	88	0.8670	168	0.4255	220	0.6373	159	0.8650	103	0.3543	243	0.3584	240	0.2191	273

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Sanmenxia	0.4369	271	0.9268	78	0.8694	10	0.8324	85	0.7551	172	0.4652	207	0.3230	253	0.2886	252
Zunyi	0.9883	43	0.8872	144	0.3354	253	0.4622	220	0.8355	136	0.4026	228	0.3538	242	0.2954	245
Qingyang	0.9843	52	0.9022	116	0.2709	272	0.4864	211	0.4278	252	0.3778	238	0.3841	236	0.5009	177
Yibin	0.9132	141	0.8796	153	0.3675	242	0.5349	192	0.9815	11	0.3510	248	0.6695	142	0.3457	223
Heze	1.0000	1	0.8957	130	0.3981	233	0.4397	231	0.8257	146	0.4699	204	0.4349	218	0.4869	182
Hulunbuir	0.5086	261	0.9386	61	0.5301	167	0.8361	82	0.1869	283	0.7551	122	0.6209	154	0.3473	222
Jinzhong	0.8356	189	0.9650	26	0.6337	138	0.5507	187	0.7152	181	0.8334	68	0.3114	257	0.3192	231
Baoding	0.9118	144	0.8802	152	0.3209	258	0.3217	271	0.5200	239	0.5732	167	0.4929	195	0.2267	272
Yuxi	0.3769	274	0.8063	218	0.5605	156	0.8252	108	0.5466	233	0.6943	133	0.3987	232	0.2985	243
Qinzhou	0.9741	74	0.7479	236	0.4297	217	0.4297	235	0.9016	68	0.3219	255	0.2576	270	0.3757	210
Lasa	0.1750	284	0.1750	284	0.8284	64	0.8304	93	0.2154	281	0.7777	118	0.7579	124	0.3115	238
Cangzhou	0.9959	28	1.0000	1	0.5494	160	0.7289	140	0.9257	46	0.4677	206	0.2194	275	0.3411	225
Guigang	0.8016	201	0.4526	275	0.3228	257	0.3216	272	0.9441	35	0.3170	257	0.8266	104	0.7559	108
Tianshui	0.9524	103	0.8319	194	0.2690	274	0.2558	280	0.8461	127	0.2967	262	0.8257	106	0.6715	127
Shangqiu	0.9902	39	0.8662	171	0.3768	239	0.3802	258	0.7527	175	0.4026	229	0.3203	256	0.3657	215
Zhangjiajie	0.9731	76	0.8121	212	0.5004	184	0.4349	233	0.6545	208	0.8286	87	0.4697	204	0.2530	264
Langfang	0.9893	42	0.8766	157	0.8303	56	0.7671	125	0.8655	102	0.6094	156	0.3279	249	0.4759	187
Chaoyang	0.6299	241	0.7892	223	0.5060	179	0.5949	171	0.6345	211	0.6934	134	0.2156	276	0.3728	213

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Baicheng	0.9523	104	0.6648	255	0.4672	204	0.6090	166	0.3725	260	0.8824	14	0.4829	200	0.3176	232
Puyang	0.9533	99	0.6752	249	0.4492	209	0.5588	184	0.6772	200	0.3521	246	0.3013	260	0.4667	190
Hezhou	0.7680	212	0.7063	244	0.4239	221	0.3834	256	0.7072	186	0.3113	260	0.1919	280	0.7126	119
Baiyin	0.6139	245	0.4312	278	0.3855	236	0.4820	212	0.3900	257	0.8272	97	0.8321	70	0.4786	184
Shanwei	0.9962	27	0.8601	174	0.4280	218	0.4057	246	0.8431	130	0.2628	271	0.1876	281	0.3145	234
Shaoyang	0.6784	231	0.8156	210	0.2897	265	0.2886	276	0.9573	25	0.3167	258	0.2630	268	0.5878	151
Dingxi	0.8457	182	0.9065	105	0.1995	282	0.1750	284	0.5663	225	0.4725	201	0.2705	266	0.6438	140
Neijiang	0.9085	148	0.7361	240	0.2719	271	0.5116	206	0.8185	148	0.1989	281	0.6512	147	0.6672	129
Lincang	0.8018	200	0.9000	123	0.2778	269	0.3076	273	0.4353	251	0.2926	263	0.4275	226	0.2941	247
Chifeng	0.3678	275	0.8805	151	0.3296	256	0.6898	148	0.3015	275	0.6850	138	0.4695	205	0.2790	255
Anshun	0.7722	211	0.9273	77	0.3091	261	0.3400	268	0.8853	81	0.6487	151	0.6090	160	0.2897	251
Ganzhou	0.8345	191	0.4357	277	0.7561	95	0.3579	265	0.8095	153	0.4159	222	0.3489	244	0.1992	278
Baise	0.5630	251	0.6098	263	0.4337	215	0.4092	243	0.4728	248	0.4991	195	0.4737	203	0.5831	153
Zhumadian	0.9864	48	0.9206	82	0.3111	260	0.4012	249	0.8950	72	0.2818	265	0.4333	220	0.2846	253
Hechi	0.4208	272	0.8562	177	0.3688	240	0.2836	277	0.5001	243	0.3903	234	0.3985	233	0.5491	163
Qujing	0.6689	233	0.9045	108	0.3033	263	0.4750	216	0.7716	167	0.3530	244	0.3034	259	0.3135	236
Xingtai	0.9462	111	0.9060	106	0.5470	162	0.4009	250	0.8859	80	0.4919	196	0.4449	215	0.2951	246
Huanggang	0.9253	132	0.6984	246	0.3588	244	0.3844	255	0.9949	4	0.3231	253	0.7030	137	0.3066	239

(continued)

Table 5.3 (continued)

Cities	The comprehensive utilization of general industrial solid waste (%)		The rate of urban sewage treatment (%) replaced		The number of Internet broadband access subscribers (ten thousand families)/the total number of households at the end of the year (ten thousand yuan)		The GDP per capita (yuan/person)		Population density (the number of people/km^2)		The number of practitioners in water resources, environment and public facilities management in the city/Urban population at the end of the year)		The number of civilian vehicles/the length of urban road (km^2)		The expenditure of urban maintenance and construction/urban GDP	
	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank	Numerical value	Rank
Dazhou	0.9981	24	0.4887	271	0.2514	278	0.4070	245	0.9812	12	0.3913	232	0.2957	261	0.7211	115
Xinzhou	0.8593	178	0.9500	40	0.4084	228	0.3803	257	0.5012	242	0.7756	119	0.3359	247	0.4772	186
Yuncheng	0.6796	230	0.9200	83	0.5624	154	0.3942	252	0.9396	39	0.5434	176	0.2198	274	0.2735	256
Hengshui	0.9978	26	0.8034	220	0.6347	137	0.4361	232	0.9444	34	0.3724	239	0.4242	228	0.4374	196
Zhoukou	0.9600	88	0.8066	217	0.2799	268	0.3680	264	0.7120	184	0.2324	276	0.2107	277	0.3352	227
Liupanshui	0.5092	260	0.9866	12	0.2984	264	0.5465	188	0.9033	66	0.3827	237	0.3751	238	0.1994	277
Chongzuo	0.5905	248	0.5749	267	0.3446	249	0.5142	202	0.5515	231	0.4911	198	0.1863	282	0.5850	152
Zhaotong	0.4821	264	0.9170	87	0.1750	284	0.2235	282	0.8430	131	0.3258	252	0.2646	267	0.2352	270
Longnan	0.6230	243	0.9740	20	0.2279	281	0.1852	283	0.4393	250	0.1998	280	0.2222	273	0.8479	51

5.3.1 Comprehensive Ranking of the Health Condition of the Eco City (2013)

The top 10 of the total of 284 cities in the health index for 2013 are: Sanya, Xiamen, Zhuhai, Tongling, Xinyu, Huizhou, Zhoushan, Shenyang, Fuzhou and Dalian.

The top 10 of the total of 284 cities for green coverage rate of built-up urban areas in 2013 are: Zhuhai, Xinyu, Jiujiang, Jingdezhen, Benxi, Qinhuangdao, Fuzhou, Huzhou, Weihai and Shangrao.

The 25 cities with the number of good air quality days of which rank at the top of the 284 cities in 2013 are: Ji'an, Shantou, Meizhou, Yichun, Yichun, Dandong, Yangjiang, Heihe, Putian, Laibin, Songyuan, Qingyuan, Heyuan, Ya'an, Baoshan, Yunfu, Jieyang, Maoming, Hezhou, Qinzhou, Ganzhou, Anshun, Liupanshui, Shanwei and Zhaotong (in no particular order). The number of good air quality days in these 25 cities is 365 days, and accounts for 8.8 % of the total number of cities discussed.

The top 10 cities with regard to water consumption per capita in 2013 among the 284 cities (the index's calculation is based on the average, with a value greater than the average being negative, and a value less than the average being positive) are: Wuhu, Fuxin, Xiangtan, Putian, Huangshi, Huainan, Yichun, Bengbu, Jixi and Hegang.

The top 10 cities with regard to the amount of green area per capita in 2013 in the 284 cities are: Dongguan, Shenzhen, Guangzhou, Benxi, Zhoushan, Nanjing, Jiayuguan, Karamay, Urumqi and Xiamen.

There are 140 cities whose hazard-free treatment rate of household garbage in 2013 in the 284 cities ranked highly and they are: Zhuhai, Sanya, Huangshan, Xinyu, Tongling, Jingdezhen, Zhoushan, Shenyang, Haikou, Nanning, Weihai, Dalian, Hangzhou, Wuhan, Yantai, Ji'an, Jiujiang, Suzhou, Suozhou, Qingdao, Bengbu, Yanghzou, Huzhou, Panjing, Zhongwei, Zhenjiang, Dongying, Liuzhou, Chuzhou, Meizhou, Qinhuangdao, Lijiang, Nantong, Jiangmen, Fuzhou, Baoji, Zhanjiang, Liaoyuan, Hefei, Taizhou, Lianyungang, Pingxiang, Huaibei, Beihai, Zaozhuang, Yichun, Shaoxing, Shiyan, Wuxi, Lishui, Yingtan, Liaoning, Ezhou, Yichun, Zibo, Dandong, Ankang, Taiyuan, Yangjiang, Heihe, Qitaihe, Ningbo, Quzhou, Changsha, Suqian, Chengdu, Zhuzhou, Xuancheng, Chaozhou, Mudanjiang, Jiuquan, Haozhou, Tai'an, Laibin, Mianyang, Taizhou, Huangshi, Liu'an, Jiaxing, Linyi, Fushun, Yulin, Rizhao, Changzhi, Zhongshan, Handan, Xuzhou, Yiyang, Laiwu, Qingyuan, Jingmen, Jiayuguan, Dezhou, Deyang, Shangluo, Xiaogan, Loudi, Baoshan, Jinchang, Heyuan, Luohe, Xiangtan, Binzhou, Tieling, Bingzhou, Weifang, Zhangye, Wenzhou, Meishan, Yongzhou, Xianning, Jincheng, Xinxiang, Anshan, Jining, Lvliang, Yueyang, Shangrao, Yunfei, Baoding, Jingzhou, Luzhou, Ziyang, Yancheng, Changde, Zunyi, Liaocheng, Hengyang, Anyang, Heze, Hezhou, Hechi, Lasa, Wuzhou, Chaoyang, Baise, Ganzhou, Qujing, Xingtai and Liupanshui (in no particular order). The hazard-free treatment rate of urban household garbage in the 140 cities is 100 %, and this accounts for 49.3 % of the total number of discussed cities.

The top 10 cities ranked by their comprehensive energy consumption per unit of GDP in 2013 in the 284 cities (the index is a negative index, the ranking is from small to large) are: Taizhou, Taizhou, Beijing, Tianjin, Suzhou, Huangshan, Shenzhen (Both Huangshan and Shenzhen ranked the sixth place), Sanya, Zhuhai and Shanwei.

There are 11 cities whose comprehensive utility rate of general industrial solid waste in 2013 in the 284 cities ranked in first place. They are: Sanya, Tongchuan, Chizhou, Guangyuan, Putian, Mudanjiang, Suihua, Meishan, Weinan, Kaifeng and Heze. (in no particular order). The comprehensive utility rate of general industrial solid waste of the 11 cities is 100 %, accounted for 3.9 % of the total number of cities discussed.

The top 10 cities for the treatment rate of urban wastewater in 2013 (the index is adjusted for the concentrated treatment rate in the sewage treatment plant) in the 284 cities accross the country are: Panjin, Zhongwei, Liaoyang, Yingkou, Suihua, Tieling, Cangzhou, Tongliao, Yinchuan and Yulin, among which the first 7 cities ranked in first place and their urban wastewater treatment rate was 100 %.

The top 10 cities with regard to informationized infrastructure in 2013 (subscribers of Internet broadband access [ten thousand families)/the total number of urban households at the end of the year (families)] in the 284 cities are: Shenzhen, Dongguan, Guangzhou, Zhongshan, Zhuhai, Xiamen, Zhaoqing, Foshan, Weifang and Sanmenxia.

The top 10 cities ranked according to GDP per capita in 2013 in the 284 cities across the country are: Erdos, Dongying, Karamay, Daqing, Shenzhen, Baotou, Wuxi, Suzhou, Guangzhou and Dalian.

The top 10 cities ranked according to population density in 2013 in the 284 cities (the index's calculation is based on the average, with a value greater than the average being negative and a value less than the average being positive) are: Weinan, Jinhua, Weihai, Huanggang, Nanyang, Yingkou, Hangzhou, Huzhou, Luoyang and Luzhou.

The top 10 cities ranked according to the rate of popularization of ecological environmental protection knowledge and rules and regulations, and that of infrastructure readiness [water resources, environment and public facilities management practitioners in the city (ten thousand persons)/Urban population at the end of the year (ten thousand persons)] in 2013 in the 284 cities are: Sanya, Zhuhai, Eordos, Beijing, Hohhot, Panjin, Wuhai, Guangzhou, Jiayuguan and Shenyang.

The top 10 cities ranked according to public satisfaction with the urban ecological environment [the number of civilian vehicles/Urban road length (km)] in 2013 in the 284 cities (the index is a negative index and the ranking is from small to large) are: Yichun, Qitaihe, Zigong, Jiayuguan, Ezhou, Zhuhai, Hegang, Hhuangshi, Shizuishan and Panzhihua.

The top 10 cities ranked according to the effect of government investment and construction (expenditure of urban maintenance and construction/city GDP) in 2013 in the 284 cities are: Nanning, Kunming, Xi'an, Beijing, Tongchuan, Liuzhou, Guyuan, Datong, Ankang and Urumqi (Table 5.4).

Table 5.4 The max, min and average value of the 14 third grade indices of the health index in 284 cities in 2013

Cities	The green coverage rate of built-up area (%)	The number of days of good air quality (day)	Water consumption per capita (ton/person)	The green area per capita (m^2/person)	Hazard-free treatment rate of household garbage (%)	The comprehensive energy consumption of per unit of GDP (tons of standard coal/ten thousand yuan)	The comprehensive utilization of general industrial solid waste (%)	The rate of urban sewage treatment (%)	The average number of broadband Internet access	The GDP per capita (yuan/person)	Population density	The number of practitioners in water resources, environment and public facilities management in the city/urban population at the end of the year)	The number of civilian vehicles/the length of urban road	The expenditure of the urban maintenance and construction/urban GDP
Max	57.13	365.00	851.41	431.06	100.00	6.37	100.00	100.00	488.71	196,728.00	2616.23	1.27	2861.64	8.23
Min	3.08	38.00	1.55	0.10	18.76	0.08	1.86	0.08	9.93	9106.00	5.71	0.04	64.70	0.00
Average	39.40	292.98	41.13	19.48	93.21	1.06	82.03	82.99	52.93	47,006.60	435.32	0.21	686.80	1.25

5.3.2 The Assessment Ranking of the Health Status of the Urban Ecological Environment, Economy and Society (2013)

The evaluation criteria of the quality of the ecological environment mainly include: (1) the evaluation of ecological security; (2) an ecological risk assessment; (3) ecosystem health evaluation; (4) ecosystem stability evaluation; (5) evaluation of ecosystem service function and (6) evaluation of the ecological environmental bearing capacity (Table 5.5).

The following is an evaluation of the health of the urban ecological environment according to data collected in accordance with the following index, which is slightly thin, but reflects the health of urban ecological environment in differing degrees.

A healthy ecological environment is the fundamental basis for the sustainable development of human society. The top 10 cities ranked with regard to the quality of the ecological environment of the 284 cities studied in 2013 in China were: Xinyu, Huangshan, Weihai, Putian, Fuxin, Shaoguan, Fuzhou, Jiujiang and Panjin.

In the rankings of the quality of the ecological environment of the 284 cities above, are 119 cities whose health levels are very healthy, accounting for 41.9 % of all the cities ranked. There are 154 cities whose health level is healthy, accounting for 54.2 % of all the cities ranked and there are 10 cities whose health level is subhealthy, accounting for 3.5 % of the cities ranked. Finally, there is 1 city whose health level is unhealthy, accounting for 0.35 % of all the cities ranked.

The ecological economy refers to changing the manner of production and consumption by applying the principle of ecological economics and a system engineering method within the limit of the carrying capacity of the ecosystem, making full use of resource potentials, developing some economy-developed, ecology-efficient industries and establishing a culture of an appropriate system and a harmonious society as well as an environment with a healthy ecology and landscape. The ecological economy aims to integrate the rapid economic development and environmental protection, material civilization and spiritual civilization and promote a high degree of unity of natural ecology, human ecology and sustainable development of economy.

The top 10 cities ranked according to their ecological economic health in 2013 in the 284 cities in China were: Guangzhou, Shenzhen, Huizhou, Foshan, Tianjin, Hangzhou, Qingdao, Xiamen, Dongying and Wuhan.

When the 284 cities are ranked according to the ecological economy, there are 51 cities whose health level is very healthy, accounting for 18.0 % of all the cities ranked. There are 186 cities whose health level is healthy, accounting for 65.5 % of all the cities ranked. There are 44 cities whose health level is subhealthy, accounting for 15.5 % of all the cities ranked and there are 3 cities whose health level is unhealthy, accounting for 1.1 % of all the cities ranked.

Table 5.5 The Assessment Ranking of the Health Status of the Ecological Environment, Economy and Society in 2013 in 284 cities in China

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Zhuhai	0.8964	33	Very healthy	0.8874	13	Very healthy	0.8941	1	Very healthy
Sanya	0.8793	63	Very healthy	0.8584	46	Very healthy	0.8912	2	Very healthy
Xiamen	0.8738	71	Very healthy	0.8947	8	Very healthy	0.8412	15	Healthy
Tongling	0.9179	13	Very healthy	0.8252	66	Healthy	0.8650	4	Very healthy
Xinyu	0.9548	2	Very healthy	0.8475	54	Healthy	0.8052	34	Healthy
Huizhou	0.8382	147	Healthy	0.8995	6	Very healthy	0.8419	14	Healthy
Zhoushan	0.9050	22	Very healthy	0.8219	70	Healthy	0.8662	3	Very healthy
Shenyang	0.8363	152	Healthy	0.8764	26	Very healthy	0.8632	6	Very healthy
Fuzhou	0.9212	8	Very healthy	0.8646	41	Very healthy	0.7751	50	Healthy
Dalian	0.8960	34	Very healthy	0.8664	39	Very healthy	0.7906	42	Healthy
Haikou	0.8377	148	Healthy	0.8608	43	Very healthy	0.8497	11	Healthy
Jingdezhen	0.9658	1	Very healthy	0.8136	80	Healthy	0.7850	45	Healthy
Guangzhou	0.7810	223	Healthy	0.9067	1	Very healthy	0.8331	20	Healthy
Nanning	0.8822	56	Very healthy	0.8023	90	Healthy	0.8552	10	Very healthy
Wuhu	0.8926	44	Very healthy	0.8670	38	Very healthy	0.7725	51	Healthy
Huangshan	0.9479	3	Very healthy	0.7812	112	Healthy	0.8103	32	Healthy
Xi'an	0.7901	217	Healthy	0.8850	15	Very healthy	0.8303	23	Healthy
Suzhou	0.8583	103	Very healthy	0.8687	36	Very healthy	0.7806	48	Healthy
Yangzhou	0.8584	102	Very healthy	0.8738	30	Very healthy	0.7714	53	Healthy
Yantai	0.9133	17	Very healthy	0.8736	31	Very healthy	0.7212	86	Healthy
Qingdao	0.8799	59	Very healthy	0.8972	7	Very healthy	0.7247	82	Healthy
Weihai	0.9393	4	Very healthy	0.8912	11	Very healthy	0.6724	125	Healthy
Zhenjiang	0.8470	125	Healthy	0.8653	40	Very healthy	0.7817	47	Healthy

(continued)

Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Wuhan	0.7559	240	Healthy	0.8938	10	Very healthy	0.8309	22	Healthy
Bengbu	0.8812	57	Very healthy	0.8063	85	Healthy	0.8132	30	Healthy
Huzhou	0.8425	138	Healthy	0.8808	21	Very healthy	0.7634	56	Healthy
Changzhou	0.8392	144	Healthy	0.8749	28	Very healthy	0.7716	52	Healthy
Hangzhou	0.8271	164	Healthy	0.9040	3	Very healthy	0.7498	68	Healthy
Tongchuan	0.8801	58	Very healthy	0.7515	151	Healthy	0.8645	5	Very healthy
Karamay	0.8709	77	Very healthy	0.8236	69	Healthy	0.7900	43	Healthy
Jinan	0.7279	255	Healthy	0.8896	12	Very healthy	0.8448	13	Healthy
Huainan	0.8830	55	Very healthy	0.7602	142	Healthy	0.8455	12	Healthy
Chongqing	0.8260	167	Healthy	0.8195	72	Healthy	0.8235	27	Healthy
Hebi	0.8565	112	Very healthy	0.7819	110	Healthy	0.8326	21	Healthy
Tianjin	0.7495	245	Healthy	0.9006	5	Very healthy	0.7967	38	Healthy
Beijing	0.7967	205	Healthy	0.8502	51	Very healthy	0.8045	35	Healthy
Panjing	0.9208	10	Very healthy	0.8237	68	Healthy	0.7207	87	Healthy
Hefei	0.8920	45	Very healthy	0.8447	55	Healthy	0.7225	85	Healthy
Jiangmen	0.8778	65	Very healthy	0.8578	47	Very healthy	0.7185	89	Healthy
Qinhuangdao	0.8612	98	Very healthy	0.7736	124	Healthy	0.8265	26	Healthy
Dongying	0.7905	216	Healthy	0.8939	9	Very healthy	0.7463	70	Healthy
Urumqi	0.8391	146	Healthy	0.7667	135	Healthy	0.8390	18	Healthy
Foshan	0.8301	161	Healthy	0.9018	4	Very healthy	0.6944	106	Healthy
Shaoxing	0.8440	131	Healthy	0.8711	34	Very healthy	0.7145	93	Healthy
Harbin	0.7919	214	Healthy	0.8310	63	Healthy	0.8044	36	Healthy
Beihai	0.8412	141	Healthy	0.8622	42	Very healthy	0.7232	84	Healthy

(continued)

Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Kunming	0.8751	70	Very healthy	0.7702	130	Healthy	0.7939	40	Healthy
Nantong	0.8308	160	Healthy	0.8573	48	Very healthy	0.7359	77	Healthy
Shantou	0.8796	61	Very healthy	0.8409	57	Healthy	0.7031	101	Healthy
Jiujiang	0.9208	9	Very healthy	0.7614	139	Healthy	0.7536	64	Healthy
Suozhou	0.8646	91	Very healthy	0.7835	107	Healthy	0.7790	49	Healthy
Nanjing	0.7658	236	Healthy	0.8052	88	Healthy	0.8408	16	Healthy
Zaozhuang	0.7762	226	Healthy	0.8327	62	Healthy	0.7980	37	Healthy
Fangchenggang	0.8751	69	Very healthy	0.7347	169	Healthy	0.8178	29	Healthy
Lianyungang	0.8467	126	Healthy	0.7796	116	Healthy	0.7928	41	Healthy
Nanchang	0.8473	124	Healthy	0.8873	14	Very healthy	0.6714	127	Healthy
Changchun	0.7330	254	Healthy	0.8406	58	Healthy	0.8266	25	Healthy
Liaoyuan	0.8951	38	Very healthy	0.8249	67	Healthy	0.6966	104	Healthy
Wuxi	0.8258	169	Healthy	0.8807	22	Very healthy	0.6942	108	Healthy
Taizhou	0.8591	99	Very healthy	0.8794	24	Very healthy	0.6639	133	Healthy
Shizuishan	0.8753	68	Very healthy	0.7136	187	Healthy	0.8300	24	Healthy
Pingxiang	0.9106	18	Very healthy	0.7583	143	Healthy	0.7461	71	Healthy
Ezhou	0.8586	100	Very healthy	0.7637	137	Healthy	0.7863	44	Healthy
Liuzhou	0.8795	62	Very healthy	0.6832	213	Healthy	0.8556	8	Very healthy
Shenzhen	0.8566	110	Very healthy	0.9065	2	Very healthy	0.6259	154	Sub-healthy
Taiyuan	0.7932	212	Healthy	0.7448	160	Healthy	0.8559	7	Very healthy
Guilin	0.8320	157	Healthy	0.7949	98	Healthy	0.7596	58	Healthy
Xianyang	0.8542	115	Very healthy	0.7905	104	Healthy	0.7435	72	Healthy
Zhanjiang	0.8887	46	Very healthy	0.7925	100	Healthy	0.7076	99	Healthy

(continued)

Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Zibo	0.8258	168	Healthy	0.8339	61	Healthy	0.7179	90	Healthy
Chuzhou	0.8474	123	Healthy	0.7854	105	Healthy	0.7526	65	Healthy
Ningbo	0.8621	96	Very healthy	0.8308	64	Healthy	0.6870	118	Healthy
Huai'an	0.8044	195	Healthy	0.7711	129	Healthy	0.8060	33	Healthy
Liaoyang	0.9200	11	Very healthy	0.7781	117	Healthy	0.6896	115	Healthy
Baoji	0.8730	74	Very healthy	0.7567	146	Healthy	0.7560	61	Healthy
Huaibei	0.9191	12	Very healthy	0.7846	106	Healthy	0.6828	120	Healthy
Zhuzhou	0.8357	154	Healthy	0.8058	86	Healthy	0.7344	78	Healthy
Changsha	0.8058	192	Healthy	0.8846	16	Very healthy	0.6715	126	Healthy
Yingkou	0.8882	47	Very healthy	0.7980	95	Healthy	0.6934	110	Healthy
Shanghai	0.7732	231	Healthy	0.8806	23	Very healthy	0.7043	100	Healthy
Dongguan	0.7115	260	Healthy	0.8837	18	Very healthy	0.7557	63	Healthy
Datong	0.8734	73	Very healthy	0.6628	231	healthy	0.8554	9	Very healthy
Jingzhou	0.8791	64	Very healthy	0.7952	97	Healthy	0.7012	102	Healthy
Chizhou	0.8944	40	Very healthy	0.7713	128	Healthy	0.7118	95	Healthy
Zhaoqing	0.8185	181	Healthy	0.7982	94	Healthy	0.7499	67	Healthy
Jilin	0.8956	36	Very healthy	0.8179	74	Healthy	0.6528	139	Healthy
Chengdu	0.7777	225	Healthy	0.8701	35	Very healthy	0.6956	105	Healthy
Maanshan	0.8658	89	Very healthy	0.7358	166	Healthy	0.7658	55	Healthy
Xiangfan	0.8929	43	Very healthy	0.7929	99	Healthy	0.6699	129	Healthy
Yingtan	0.8951	37	Very healthy	0.8752	27	Very healthy	0.5724	184	Sub-healthy
Yinchuan	0.8227	173	Healthy	0.8148	78	Healthy	0.6975	103	Healthy
Ji'an	0.8672	84	Very healthy	0.7800	115	Healthy	0.6936	109	Healthy

(continued)

Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Yichang	0.8660	88	Very healthy	0.7229	177	Healthy	0.7583	60	Healthy
Meizhou	0.8681	82	Very healthy	0.7168	183	Healthy	0.7629	57	Healthy
Guiyang	0.8700	80	Very healthy	0.7553	148	Healthy	0.7123	94	Healthy
Wuhai	0.8476	122	Healthy	0.7761	120	Healthy	0.7089	97	Healthy
Daqing	0.8937	42	Very healthy	0.7087	190	Healthy	0.7375	74	Healthy
Benxi	0.9157	14	Very healthy	0.6480	239	Sub-healthy	0.7834	46	Healthy
Shiyan	0.8957	35	Very healthy	0.7038	195	Healthy	0.7368	76	Healthy
Quzhou	0.8376	149	Healthy	0.7915	103	Healthy	0.6881	116	Healthy
Putian	0.9346	5	Very healthy	0.8772	25	Very healthy	0.4997	232	Unhealthy
Quanzhou	0.9136	16	Very healthy	0.8742	29	Very healthy	0.5207	219	Sub-healthy
Yangjiang	0.8832	53	Very healthy	0.8148	77	Healthy	0.6148	165	Sub-healthy
Erdos	0.8999	26	Very healthy	0.7486	154	Healthy	0.6699	128	Healthy
Fuzhou	0.9011	23	Very healthy	0.7564	147	Healthy	0.6581	136	Healthy
Suqian	0.8071	190	Healthy	0.7765	119	Healthy	0.7203	88	Healthy
Huangshi	0.8578	106	Very healthy	0.8098	84	Healthy	0.6349	148	Sub-healthy
Longyan	0.9068	21	Very healthy	0.8419	56	Healthy	0.5517	198	Sub-healthy
Nanping	0.8777	66	Very healthy	0.8187	73	Healthy	0.5996	171	Sub-healthy
Jiaxing	0.8376	150	Healthy	0.8831	19	Very healthy	0.5599	191	Sub-healthy
Guangyuan	0.7867	218	Healthy	0.6876	207	Healthy	0.8234	28	Healthy
Dandong	0.9081	20	Very healthy	0.7353	167	Healthy	0.6566	137	Healthy
Qitaihe	0.8940	41	Very healthy	0.5860	267	Sub-healthy	0.8368	19	Healthy
Lishui	0.8947	39	Very healthy	0.8520	50	Very healthy	0.5344	210	Sub-healthy
Zhongwei	0.8333	156	Healthy	0.7083	191	Healthy	0.7472	69	Healthy

(continued)

Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Chaozhou	0.9146	15	Very healthy	0.7997	93	Healthy	0.5690	186	Sub-healthy
Taizhou	0.8104	188	Healthy	0.8126	82	Healthy	0.6489	141	Sub-healthy
Mudanjiang	0.8976	30	Very healthy	0.6635	230	Healthy	0.7332	79	Healthy
Tai'an	0.8008	199	Healthy	0.8481	53	Healthy	0.6134	166	Sub-healthy
Lijiang	0.8852	50	Very healthy	0.7247	173	Healthy	0.6682	130	Healthy
Tonghua	0.8536	116	Very healthy	0.7921	102	Healthy	0.6187	163	Sub-healthy
Shijianzhuang	0.6658	271	Healthy	0.8547	49	Very healthy	0.7161	92	Healthy
Zhongshan	0.8640	94	Very healthy	0.8378	60	Healthy	0.5543	195	Sub-healthy
Mianyang	0.8640	93	Very healthy	0.7470	159	Healthy	0.6555	138	Healthy
Linyi	0.7468	247	Healthy	0.8055	87	Healthy	0.6944	107	Healthy
Shaoguan	0.9254	7	Very healthy	0.7109	189	Healthy	0.6380	145	Sub-healthy
Yichun	0.8737	72	Very healthy	0.5969	265	Sub-healthy	0.8104	31	Healthy
Yangquan	0.8797	60	Very healthy	0.6656	227	Healthy	0.7261	81	Healthy
Yichun	0.8663	85	Very healthy	0.7675	132	Healthy	0.6222	160	Sub-healthy
Rizhao	0.8391	145	Healthy	0.8722	33	Very healthy	0.5247	217	Sub-healthy
Zhengzhou	0.7414	249	Healthy	0.8589	44	Very healthy	0.6244	156	Sub-healthy
Xining	0.7654	237	Healthy	0.7236	174	Healthy	0.7509	66	Healthy
Fushun	0.9006	24	Very healthy	0.6647	229	Healthy	0.6930	111	Healthy
Lanzhou	0.6203	277	Sub-healthy	0.7581	144	Healthy	0.8404	17	Healthy
Xuancheng	0.8586	101	Very healthy	0.7570	145	Healthy	0.6225	159	Sub-healthy
Laiwu	0.8466	127	Healthy	0.7759	122	Healthy	0.6112	167	Sub-healthy
Jinhua	0.7597	238	Healthy	0.8821	20	Very healthy	0.5699	185	Sub-healthy
Xuzhou	0.8173	183	Healthy	0.7725	125	Healthy	0.6394	144	Sub-healthy

(continued)

Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Haozhou	0.8188	179	Healthy	0.7231	175	Healthy	0.6922	113	Healthy
Liu'an	0.8240	171	Healthy	0.6763	216	Healthy	0.7371	75	Healthy
Anqing	0.8312	159	Healthy	0.7668	134	Healthy	0.6288	151	Sub-healthy
Xiangtan	0.8130	185	Healthy	0.7826	109	Healthy	0.6257	155	Sub-healthy
Changzhi	0.8581	105	Very healthy	0.7075	192	Healthy	0.6635	134	Healthy
Fuxin	0.9273	6	Very healthy	0.6685	222	Healthy	0.6362	146	Sub-healthy
Baotou	0.8723	75	Very healthy	0.7210	181	Healthy	0.6273	152	Sub-healthy
Yulin	0.7929	213	Healthy	0.8012	91	Healthy	0.6071	169	Sub-healthy
Jingmen	0.8764	67	Very healthy	0.7714	127	Healthy	0.5565	193	Sub-healthy
Leshan	0.7743	229	Healthy	0.6889	206	Healthy	0.7404	73	Healthy
Laibin	0.8416	140	Healthy	0.6541	237	Healthy	0.7164	91	Healthy
Handan	0.7063	265	Healthy	0.7471	157	Healthy	0.7299	80	Healthy
Zhangzhou	0.8684	81	Very healthy	0.8673	37	Very healthy	0.4477	250	Very unhealthy
Wuzhong	0.9081	19	Very healthy	0.6313	248	Sub-healthy	0.6743	122	Healthy
Dezhou	0.7164	257	Healthy	0.8210	71	Healthy	0.6321	150	Sub-healthy
Jiuquan	0.8573	109	Very healthy	0.7348	168	Healthy	0.5991	172	Sub-healthy
Suizhou	0.8581	104	Very healthy	0.7145	185	Healthy	0.6194	162	Sub-healthy
Luohe	0.8043	196	Healthy	0.8169	76	Healthy	0.5496	201	Sub-healthy
Yiyang	0.8480	121	Healthy	0.7217	180	Healthy	0.6153	164	Sub-healthy
Yulin	0.8423	139	Healthy	0.7480	155	Healthy	0.5893	175	Sub-healthy
Deyang	0.8565	111	Very healthy	0.7828	108	Healthy	0.5350	209	Sub-healthy
Ankang	0.8461	128	Healthy	0.7249	172	Healthy	0.6069	170	Sub-healthy
Binzhou	0.8435	133	Healthy	0.8121	83	Healthy	0.5043	229	Sub-healthy

(continued)

Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Wenzhou	0.8357	153	Healthy	0.8728	32	Very healthy	0.4425	252	Very unhealthy
Loudi	0.8495	120	Healthy	0.7471	156	Healthy	0.5653	189	Sub-healthy
Tangshan	0.7334	253	Healthy	0.7773	118	Healthy	0.6358	147	Sub-healthy
Hohhot	0.7760	227	Healthy	0.7135	188	Healthy	0.6673	131	Healthy
Huludao	0.8436	132	Healthy	0.6064	260	Sub-healthy	0.7241	83	Healthy
Songyuan	0.8972	32	Very healthy	0.8010	92	Healthy	0.4545	247	Unhealthy
Wulanchabu	0.8425	136	Healthy	0.6875	208	Healthy	0.6272	153	Sub-healthy
Jiamusi	0.8974	31	Very healthy	0.6791	214	Healthy	0.5835	179	Sub-healthy
Qingyuan	0.8999	27	Very healthy	0.7222	178	Healthy	0.5330	211	Sub-healthy
Suining	0.8079	189	Healthy	0.7286	170	Healthy	0.6085	168	Sub-healthy
Baishan	0.8394	142	Healthy	0.6253	251	Sub-healthy	0.6926	112	Healthy
Yueyang	0.8840	51	Very healthy	0.7015	197	Healthy	0.5666	187	Sub-healthy
Heihe	0.8151	184	Healthy	0.7512	152	Healthy	0.5727	183	Sub-healthy
Anshan	0.8989	28	Very healthy	0.6870	209	Healthy	0.5664	188	Sub-healthy
Jiaozuo	0.8549	113	Very healthy	0.7607	141	Healthy	0.5230	218	Sub-healthy
Nanchong	0.7947	209	Healthy	0.6601	233	Healthy	0.6850	119	Healthy
Weifang	0.7695	233	Healthy	0.8842	17	Very healthy	0.4563	246	Unhealthy
Jining	0.7068	264	Healthy	0.8173	75	Healthy	0.5866	176	Sub-healthy
Qiqihaer	0.7386	250	Healthy	0.6053	262	Sub-healthy	0.7946	39	Healthy
Guyuan	0.7552	241	Healthy	0.6235	252	Sub-healthy	0.7587	59	Healthy
Jinchang	0.8832	54	Very healthy	0.5795	271	Sub-healthy	0.6903	114	Healthy
Tongliao	0.8425	137	Healthy	0.7806	114	Healthy	0.5017	230	Sub-healthy
Bayinnaoer	0.8518	118	Very healthy	0.7020	196	Healthy	0.5811	180	Sub-healthy

(continued)

Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Jixi	0.8678	83	Very healthy	0.6055	261	Sub-healthy	0.6734	124	Healthy
Xiaogan	0.8345	155	Healthy	0.6961	204	Healthy	0.5984	173	Sub-healthy
Fuyang	0.7750	228	Healthy	0.7808	113	Healthy	0.5478	204	Sub-healthy
Jiayuguan	0.8575	107	Very healthy	0.5158	279	Sub-healthy	0.7676	54	Healthy
Luzhou	0.8661	87	Very healthy	0.5584	275	Sub-healthy	0.7080	98	Healthy
Binzhou	0.8524	117	Very healthy	0.7074	193	Healthy	0.5500	200	Sub-healthy
Meishan	0.8216	175	Healthy	0.6662	224	Healthy	0.6220	161	Sub-healthy
Panzhihua	0.8834	52	Very healthy	0.4965	282	Unhealthy	0.7559	62	Healthy
Xinxiang	0.8393	143	Healthy	0.8128	81	Healthy	0.4402	255	Very unhealthy
Ningde	0.8236	172	Healthy	0.8588	45	Very healthy	0.4007	270	Very unhealthy
Weinan	0.7429	248	Healthy	0.6661	225	Healthy	0.6874	117	Healthy
Heyuan	0.9003	25	Very healthy	0.6586	234	Healthy	0.5503	199	Sub-healthy
Xuchang	0.7958	206	Healthy	0.8495	52	Healthy	0.4283	260	Very unhealthy
Luoyang	0.7953	207	Healthy	0.8379	59	Healthy	0.4405	254	Very unhealthy
Siping	0.8197	177	Healthy	0.7267	171	Healthy	0.5371	206	Sub-healthy
Hanzhong	0.7858	219	Healthy	0.6499	238	Sub-healthy	0.6509	140	Healthy
Sanming	0.8986	29	Very healthy	0.6678	223	Healthy	0.5274	213	Sub-healthy
Jincheng	0.8179	182	Healthy	0.7687	131	Healthy	0.4850	237	Unhealthy
Zhangjiajie	0.8186	180	Healthy	0.6228	253	Sub-healthy	0.6462	143	Sub-healthy
Tieling	0.8719	76	Very healthy	0.7007	198	Healthy	0.5062	228	Sub-healthy
Yancheng	0.7918	215	Healthy	0.7611	140	Healthy	0.5088	225	Sub-healthy
Zigong	0.8223	174	Healthy	0.6734	218	Healthy	0.5756	182	Sub-healthy
Yongzhou	0.8616	97	Very healthy	0.6652	228	Healthy	0.5485	203	Sub-healthy

(continued)

Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Hegang	0.7816	222	Healthy	0.5829	270	Sub-healthy	0.7102	96	Healthy
Ya'an	0.8508	119	Very healthy	0.6019	264	Sub-healthy	0.6233	157	Sub-healthy
Pingdingshan	0.7977	204	Healthy	0.7549	149	Healthy	0.4969	235	Unhealthy
Jingzhou	0.7993	203	Healthy	0.6739	217	Healthy	0.5838	178	Sub-healthy
Xianning	0.8432	134	Healthy	0.7170	182	Healthy	0.4942	236	Unhealthy
Shuangyashan	0.8574	108	Very healthy	0.5676	272	Sub-healthy	0.6472	142	Sub-healthy
Xinyang	0.7993	202	Healthy	0.7617	138	Healthy	0.4800	238	Unhealthy
Yan'an	0.8032	198	Healthy	0.7924	101	Healthy	0.4382	257	Very unhealthy
Shangluo	0.7350	252	Healthy	0.6357	245	Sub-healthy	0.6739	123	Healthy
Hengyang	0.8641	92	Very healthy	0.6616	232	Healthy	0.5274	214	Sub-healthy
Suihua	0.6826	267	Healthy	0.7722	126	Healthy	0.5644	190	Sub-healthy
Suzhou	0.8268	165	Healthy	0.6560	236	Healthy	0.5597	192	Sub-healthy
Kaifeng	0.7159	258	Healthy	0.7530	150	Healthy	0.5489	202	Sub-healthy
Baoding	0.6721	269	Healthy	0.7761	121	Healthy	0.5550	194	Sub-healthy
Changde	0.8366	151	Healthy	0.7975	96	Healthy	0.3737	277	Very unhealthy
Zhangye	0.8661	86	Very healthy	0.6577	235	Healthy	0.4997	233	Unhealthy
Chengde	0.7934	210	Healthy	0.5919	266	Sub-healthy	0.6328	149	Sub-healthy
Yunfu	0.8651	90	Very healthy	0.7374	163	Healthy	0.4021	267	Very unhealthy
Ziyang	0.8276	163	Healthy	0.7444	162	Healthy	0.4270	261	Very unhealthy
Liaocheng	0.7089	262	Healthy	0.8033	89	Healthy	0.4640	243	Unhealthy
Jieyang	0.8063	191	Healthy	0.7815	111	Healthy	0.3996	271	Very unhealthy
Guang'an	0.7995	201	Healthy	0.6208	254	Sub-healthy	0.5850	177	Sub-healthy
Shangrao	0.8705	79	Very healthy	0.6296	249	Sub-healthy	0.5074	227	Sub-healthy

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Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Nanyang	0.6301	276	Sub-healthy	0.6864	210	Healthy	0.6616	135	Healthy
Anyang	0.7845	221	Healthy	0.7674	133	Healthy	0.4248	263	Very unhealthy
Pingliang	0.8199	176	Healthy	0.5851	268	Sub-healthy	0.5911	174	Sub-healthy
Bazhong	0.8262	166	Healthy	0.6432	242	Sub-healthy	0.5181	221	Sub-healthy
Wuwei	0.7486	246	Healthy	0.6970	202	Healthy	0.5258	216	Sub-healthy
Huaihua	0.8106	187	Healthy	0.6069	259	Sub-healthy	0.5538	196	Sub-healthy
Wuzhou	0.8864	49	Very healthy	0.6422	243	Sub-healthy	0.4405	253	Very unhealthy
Lvliang	0.8054	193	Healthy	0.6770	215	Healthy	0.4717	241	Unhealthy
Miaoming	0.7998	200	Healthy	0.7739	123	Healthy	0.3660	280	Very unhealthy
Sanmenxia	0.7680	234	Healthy	0.7656	136	Healthy	0.3985	273	Very unhealthy
Zunyi	0.8427	135	Healthy	0.6984	200	Healthy	0.3991	272	Very unhealthy
Qingyang	0.7550	242	Healthy	0.7471	158	Healthy	0.4216	264	Very unhealthy
Yibin	0.7206	256	Healthy	0.6974	201	Healthy	0.5080	226	Sub-healthy
Heze	0.6805	268	Healthy	0.7361	165	Healthy	0.5001	231	Sub-healthy
Hulunbeir	0.6579	272	Healthy	0.7217	179	Healthy	0.5357	208	Sub-healthy
Jinzhong	0.7112	261	Healthy	0.6994	199	Healthy	0.5107	223	Sub-healthy
Baoshan	0.8190	178	Healthy	0.6728	219	Healthy	0.4398	256	Very unhealthy
Yuxi	0.8130	186	Healthy	0.6451	241	Sub-healthy	0.4721	240	Unhealthy
Qinzhou	0.8284	162	Healthy	0.7138	186	Healthy	0.3767	276	Very unhealthy
Lasa	0.8635	95	Very healthy	0.5027	281	Sub-healthy	0.5757	181	Sub-healthy
Cangzhou	0.6695	270	Healthy	0.8138	79	Healthy	0.4011	269	Very unhealthy
Guigang	0.7932	211	Healthy	0.4784	283	Unhealthy	0.6643	132	Healthy
Tianshui	0.5762	281	Sub-healthy	0.6838	211	Healthy	0.6228	158	Sub-healthy

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Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Shangqiu	0.7535	243	Healthy	0.7365	164	Healthy	0.4018	268	Very unhealthy
Zhangjiejia	0.5965	279	Sub-healthy	0.7448	161	Healthy	0.5308	212	Sub-healthy
Langfang	0.5154	283	Sub-healthy	0.8271	65	Healthy	0.5105	224	Sub-healthy
Chaoyang	0.8449	129	Healthy	0.6142	255	Sub-healthy	0.4480	249	Very unhealthy
Baicheng	0.6148	278	Sub-healthy	0.7165	184	Healthy	0.5421	205	Sub-healthy
Puyang	0.7949	208	Healthy	0.6926	205	Healthy	0.4038	266	Very unhealthy
Hezhou	0.8868	48	Very healthy	0.5832	269	Sub-healthy	0.4355	258	Very unhealthy
Baiyin	0.7583	239	Healthy	0.4635	284	Unhealthy	0.6804	121	Healthy
Shanwei	0.8034	197	Healthy	0.7509	153	Healthy	0.3138	283	Very unhealthy
Shaoyang	0.8046	194	Healthy	0.6291	250	Sub-healthy	0.4460	251	Very unhealthy
Dingxi	0.7496	244	Healthy	0.6474	240	Sub-healthy	0.4726	239	Unhealthy
Neijiang	0.7149	259	Healthy	0.6080	257	Sub-healthy	0.5370	207	Sub-healthy
Lincang	0.8248	170	Healthy	0.6836	212	Healthy	0.3478	281	Very unhealthy
Chifeng	0.8705	78	Very healthy	0.5451	276	Sub-healthy	0.4602	244	Unhealthy
Anshun	0.6915	266	Healthy	0.6075	258	Sub-healthy	0.5528	197	Sub-healthy
Ganzhou	0.8548	114	Very healthy	0.6315	247	Sub-healthy	0.3702	278	Very unhealthy
Baise	0.8444	130	Healthy	0.5037	280	Sub-healthy	0.5140	222	Sub-healthy
Zhumadian	0.7723	232	Healthy	0.6687	221	Healthy	0.3894	274	Very unhealthy
Hechi	0.7853	220	Healthy	0.6022	263	Sub-healthy	0.4514	248	Unhealthy
Qujing	0.8314	158	Healthy	0.6384	244	Sub-healthy	0.3681	279	Very unhealthy
Xingtai	0.6448	274	Sub-healthy	0.7073	194	Healthy	0.4581	245	Unhealthy
Huanggang	0.6380	275	Sub-healthy	0.6693	220	Healthy	0.4993	234	Unhealthy
Dazhou	0.7677	235	Healthy	0.5276	278	Sub-healthy	0.5206	220	Sub-healthy

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Table 5.5 (continued)

City	Ecological environment			Ecological economy			Ecological society		
	Health index	Rank	Grade	Health index	Rank	Grade	Health index	Rank	Grade
Xinzhou	0.5862	280	Sub-healthy	0.6657	226	Healthy	0.5267	215	Sub-healthy
Yuncheng	0.7789	224	Healthy	0.6090	256	Sub-healthy	0.4050	265	Very unhealthy
Hengshui	0.5533	282	Sub-healthy	0.7230	176	Healthy	0.4646	242	Unhealthy
Zhoukou	0.7379	251	Healthy	0.6970	203	Healthy	0.3047	284	Very unhealthy
Liupanshui	0.7737	230	Healthy	0.5596	274	Sub-healthy	0.3775	275	Very unhealthy
Chongzuo	0.7085	263	Healthy	0.5317	277	Sub-healthy	0.4339	259	Very unhealthy
Zhaotong	0.6522	273	Healthy	0.5676	273	Sub-healthy	0.3320	282	Very unhealthy
Longnan	0.4519	284	Unhealthy	0.6337	246	Sub-healthy	0.4249	262	Very unhealthy

An ecological society is a healthy and sustainable society with a harmonious coexistence between man and man, and man and nature, ensuring that life becomes increasingly secure, healthier and more dignified from generation to the next. In this sense, the evaluation system of ecological society is very complex.

The top 10 cities ranked according to the ecological social health index in 2013 in the 284 cities in China are: Zhuhai, Sanya, Zhoushan, Tongling, Tongchuan, Shenyang, Taiyuan, Datong, Nanning and Liuzhou.

In the ecological social ranking of the 284 cities in 2013 in China, there are 10 cities whose health level is very healthy, accounting for 3.5 % of all the cities ranked. There are 130 cities whose health level is healthy, accounting for 45.8 % of all the cities ranked. There are 91 cities whose health level is subhealthy, accounting for 32.0 % of all the cities ranked. There are 17 cities whose health level is unhealthy, accounting for 6.0 % of all the cities ranked and there are 36 cities whose health level is very unhealthy, accounting for 12.7 % of all the cities ranked.

5.4 Further Discussion

5.4.1 The Calculation Principle of the Construction Focus, Difficulty of Construction and Comprehensive Degree of Construction

In the third grade indicator of the health indices of the eco city, the construction focus, the difficulty of construction and the comprehensive degree of the construction are auxiliary decision making parameters, but quantitative must be objective, appropriate and scientific, removing subjectivity.

Suppose $A_i(t)$ is the rank of the i index of the city A in the year t, calling

$$\lambda A_i(t+1) = \frac{A_i(t)}{\sum_{j=1}^{n} A_j(t)} \quad i = 1, 2, \ldots, N$$

the construction focus of the i index of the city A at the year $t+1$, N here is the number of cities, n is the number of indices.

If $\lambda A_i(t+1) > \lambda A_j(t+1)$, it shows the construction of the i index is better than the j index in the year $t+1$.This is because in the year t, the rank of the i in the rankings of the whole country is worse than that of the j index. So in the year $t+1$, the construction of the i index is better than the j index. This can narrow the gap across the whole country, enabling the ecological construction to become synchronous with the development of the country.

Using $\max_i(t)$ and $\min_i(t)$ to indicate the max and the min of the i index in the year t respectively, $\alpha A_i(t)$ is the value of the i index of the city A in the year t, making

$$\mu A_i(t) = \begin{cases} \frac{\max_i(t)+1}{\alpha A_i(t)+1} & \text{Index } i \text{ positive.} \\ \frac{\alpha A_i(t)+1}{\min_i(t)+1} & \text{Index } i \text{ negative} \end{cases}$$

calling

$$\gamma A_i(t+1) = \frac{\mu A_i(t)}{\sum_{j=1}^{n} \mu A_i(t)}$$

the construction difficulty $(i = 1, 2, \ldots, N)$ of the i index of the city A in the year $t + 1$.

If $\gamma A_i(t+1) > \gamma A_j(t+1)$, it shows that the i index is further than the j index from the optimum value in the country in the year t. So in year $t + 1$, the construction of the i index is prior to the j index. Calling

$$vA_i(t+1) = \frac{\lambda A_i(t)\mu A_i(t)}{\sum_{j=1}^{n} \lambda A_j(t)\mu A_j(t)}$$

the comprehensive degree $(i = 1, 2, \ldots, N)$ of the i index of city A in the year $t + 1$.

If $vA_i(t+1) > vA_j(t+1)$,it shows that in the year $t + 1$,the construction of the i index occurs theoretically prior to the j index.

Thus, it is easy to see that it is an ongoing task for us to define the construction focus, the construction difficulty and the comprehensive degree of the construction, so as to help guide the ecological construction.

5.4.2 *The Results of the Annual Construction Focus of the Eco City*

It can be seen from the earlier definition that the greater extent to which urban construction focuses on an index, the closer it is to the top of the rankings, which means that in the following year the city should focus on the construction of the index. For example, in 2013, the top 4 indices of the construction focus of Zhuhai are water consumption per capita (0.3056), urban wastewater treatment rate (0.1736), the number of days of good air quality (0.1724) and the comprehensive utilization rate of general industrial solid waste (0.1510) respectively. This is the order of construction that Zhuhai needs to consider focusing on in the following year in order to make it a more outstanding eco city.

According to the earlier definition, we calculated the construction focus of 14 indices of health indicators during 2013 in the 284 eco cities and the results are presented in Table 5.6. The construction focusing degree rankings of 14 indices of health indicators of the eco city in 2013, are also listed in Table 5.6.

Table 5.6 The construction focusing degrees of 14 indices of ecological health indicators of 284 cities in 2013

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Zhuhai	0.0012	13	0.1724	3	0.3056	1	0.0178	7	0.0012	13	0.0119	9
Sanya	0.0242	10	0.1454	3	0.2202	2	0.0253	9	0.0011	12	0.0095	11
Xiamen	0.0775	6	0.0852	5	0.1893	1	0.0086	13	0.1317	3	0.0138	10
Tongling	0.0189	11	0.1230	4	0.1050	5	0.0161	12	0.0009	14	0.1391	3
Xinyu	0.0023	13	0.1153	4	0.0228	12	0.0434	7	0.0011	14	0.2226	1
Huizhou	0.1725	1	0.1192	3	0.0702	5	0.0395	11	0.1696	2	0.0629	7
Zhoushan	0.2000	2	0.1503	3	0.0238	9	0.0052	13	0.0010	14	0.0819	5
Shenyang	0.0739	6	0.2282	1	0.0975	4	0.0246	12	0.0009	14	0.1297	2
Fuzhou	0.0570	8	0.0729	6	0.0285	12	0.0662	7	0.1340	3	0.0184	14
Dalian	0.0265	11	0.1584	1	0.0673	7	0.0327	10	0.0009	14	0.0602	8
Haikou	0.0574	8	0.1836	1	0.1385	2	0.0320	10	0.0008	14	0.0148	12
Jingdezhen	0.0037	13	0.0240	12	0.0425	11	0.0453	9	0.0009	14	0.0536	8
Guanghzou	0.0824	5	0.1553	4	0.1751	2	0.0022	13	0.1759	1	0.0110	10
Nanning	0.0675	6	0.1614	2	0.0404	9	0.0157	12	0.0008	13	0.0527	8
Wuhu	0.1126	4	0.1172	3	0.0008	14	0.0632	9	0.1434	1	0.0386	11
Huangshan	0.0130	11	0.0276	10	0.0665	6	0.0104	12	0.0009	14	0.0052	13
Xi'an	0.0615	7	0.2087	1	0.0421	10	0.0514	9	0.1129	3	0.0327	12
Suzhou	0.0716	6	0.1710	2	0.1264	3	0.0295	10	0.0008	14	0.0025	13
Yanghzou	0.0438	9	0.1936	1	0.0135	13	0.0791	6	0.0008	14	0.0269	12

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Yantai	0.0485	10	0.1024	4	0.0701	5	0.0674	8	0.0009	14	0.0530	9
Qingdao	0.0296	12	0.2011	1	0.0429	8	0.0305	11	0.0010	14	0.0362	9
Weihai	0.0096	12	0.0965	4	0.0675	6	0.0504	8	0.0011	14	0.0868	5
Zhenjiang	0.0647	5	0.2036	1	0.0483	8	0.0362	11	0.0009	14	0.0406	10
Wuhan	0.1488	2	0.1947	1	0.1421	3	0.0429	8	0.0007	14	0.0681	6
Bengbu	0.1450	2	0.1339	3	0.0063	13	0.0951	6	0.0008	14	0.0468	9
Huzhou	0.0070	12	0.2233	1	0.0269	11	0.0678	8	0.0009	14	0.1025	3
Changzhou	0.0434	10	0.1692	1	0.0580	7	0.0399	11	0.0986	4	0.0538	8
Hanghzou	0.1330	3	0.2354	1	0.1187	4	0.0211	10	0.0010	14	0.0287	8
Tongchuan	0.0277	10	0.0797	7	0.0784	8	0.0399	9	0.1561	2	0.1601	1
Karamay	0.0412	7	0.0446	6	0.1839	2	0.0055	13	0.1105	4	0.1709	3
Jinan	0.1264	3	0.2014	1	0.0289	10	0.0433	8	0.1415	2	0.0780	5
Huainan	0.0932	7	0.1088	3	0.0036	14	0.0460	10	0.1022	4	0.0735	9
Chongqing	0.0631	9	0.1664	1	0.0262	12	0.0671	8	0.0993	3	0.0785	7
Hebi	0.1022	4	0.0934	5	0.0180	14	0.0585	9	0.1131	1	0.1093	2
Tianjin	0.1619	2	0.1765	1	0.0660	7	0.0353	10	0.1213	3	0.0013	14
Beijing	0.0087	11	0.1891	1	0.1326	3	0.0145	9	0.1094	7	0.0036	12
Panjing	0.1282	3	0.0597	7	0.0411	10	0.0524	9	0.0008	13	0.1960	1
Hefei	0.0665	8	0.1374	1	0.0269	13	0.0456	11	0.0007	14	0.0344	12

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Jiangmen	0.0437	8	0.1724	1	0.0305	12	0.0330	10	0.0008	14	0.0322	11
Qinhuangdao	0.0046	13	0.1899	2	0.0085	12	0.0569	8	0.0008	14	0.1053	4
Dongying	0.0543	7	0.2194	1	0.0259	11	0.0251	12	0.0008	14	0.1182	4
Urumqi	0.1151	3	0.0915	7	0.0877	8	0.0049	14	0.1184	2	0.1375	1
Foshan	0.1000	5	0.1414	1	0.1057	4	0.0318	11	0.0955	6	0.0204	12
Shaoxing	0.0856	6	0.1607	1	0.0623	9	0.0587	10	0.0007	14	0.0644	8
Harbin	0.1275	2	0.1253	3	0.0098	14	0.0563	10	0.1291	1	0.0760	5
Beihai	0.1257	4	0.1554	1	0.0290	11	0.0704	7	0.0007	14	0.0725	6
Kunming	0.1010	5	0.0682	7	0.0446	9	0.0266	12	0.1413	2	0.1066	4
Nantong	0.0570	8	0.1674	1	0.0377	10	0.1004	5	0.0007	14	0.0135	12
Shantou	0.0646	5	0.0007	14	0.0270	11	0.0490	7	0.1825	2	0.0099	13
Jiujiang	0.0021	13	0.0615	9	0.0971	4	0.0923	5	0.0007	14	0.0649	8
Shuozhou	0.0384	11	0.1061	4	0.0827	7	0.0857	6	0.0006	14	0.1145	3
Nanjing	0.0257	9	0.1616	2	0.1424	3	0.0038	14	0.1424	3	0.0526	7
Zaozhuang	0.0912	4	0.1733	1	0.0515	10	0.0678	6	0.0007	14	0.1336	2
Fangchenggang	0.1609	2	0.0203	12	0.0076	14	0.0792	6	0.1229	4	0.1026	5
Lianyungang	0.0956	3	0.1463	2	0.0748	6	0.0189	13	0.0007	14	0.0488	10
Nanchang	0.0507	8	0.1612	1	0.0674	7	0.0445	11	0.0980	3	0.0313	14
Changchun	0.1744	1	0.1482	3	0.0185	13	0.0645	7	0.1559	2	0.0236	11

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Liaoyuan	0.1103	2	0.0938	6	0.0291	12	0.0627	8	0.0007	14	0.1044	4
Wuxi	0.0471	8	0.1790	1	0.0877	6	0.0193	12	0.0007	14	0.0435	10
Taizhou	0.0313	12	0.1465	1	0.0590	10	0.1122	4	0.0007	14	0.0029	13
Shizuishan	0.0903	5	0.0772	7	0.0838	6	0.0065	13	0.1171	4	0.1670	1
Pingxiang	0.0778	6	0.0240	12	0.0670	8	0.0816	5	0.0006	14	0.1518	1
Erzhou	0.1519	1	0.1074	4	0.0134	12	0.0519	9	0.0006	14	0.1300	3
Liuzhou	0.0618	7	0.0952	5	0.1113	4	0.0399	11	0.0006	14	0.1506	2
Shenzhen	0.0194	9	0.0870	6	0.1853	1	0.0013	13	0.1124	5	0.0040	11
Tiayuan	0.0985	5	0.1732	1	0.0773	6	0.0271	10	0.0007	14	0.1388	3
Guilin	0.0455	12	0.0555	9	0.0529	10	0.1158	2	0.1343	1	0.0693	7
Xianyang	0.0737	8	0.0865	5	0.0410	12	0.1175	1	0.1125	2	0.0421	11
Zhanjiang	0.0762	8	0.0250	12	0.0968	5	0.1336	1	0.0006	14	0.0194	13
Zibo	0.0287	10	0.1915	1	0.0449	9	0.0206	13	0.0007	14	0.1686	2
Chuzhou	0.1033	5	0.1002	6	0.1051	4	0.0894	7	0.0006	14	0.0368	12
Ningbo	0.1278	3	0.1246	4	0.0658	7	0.0439	10	0.0006	14	0.0562	8
Huai'an	0.0719	5	0.1143	3	0.0157	13	0.0702	6	0.1514	1	0.0586	10
Liaoyang	0.0884	4	0.0669	6	0.0461	8	0.0430	9	0.0008	13	0.1952	2
Baoji	0.0821	6	0.0890	4	0.0775	8	0.0764	9	0.0006	14	0.0597	10
Huaibei	0.0219	11	0.0857	7	0.0459	9	0.0459	9	0.0007	14	0.1049	3

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Zhuhzou	0.0642	9	0.1523	1	0.0088	13	0.0680	6	0.0006	14	0.0648	7
Changsha	0.1191	3	0.1699	1	0.0676	7	0.0656	8	0.0007	14	0.0615	9
Yingkou	0.1034	5	0.0491	8	0.0265	11	0.0491	8	0.1460	2	0.1647	1
Shanghai	0.1107	5	0.1259	4	0.1321	2	0.0073	13	0.1265	3	0.0203	10
Dongguan	0.0127	11	0.1379	3	0.1894	1	0.0007	14	0.1821	2	0.0288	8
Datong	0.0278	13	0.0731	8	0.0354	11	0.0611	9	0.1216	2	0.1183	3
Jingzhou	0.0523	9	0.0439	13	0.0096	14	0.0754	5	0.1316	1	0.0866	4
Chizhou	0.0699	9	0.0382	11	0.0817	8	0.0899	6	0.0846	7	0.1046	4
Zhaoqing	0.1398	2	0.1292	3	0.0364	10	0.0664	7	0.0963	5	0.0299	12
Jilin	0.0125	14	0.0900	5	0.0179	13	0.0531	9	0.1199	3	0.0900	5
Chengdu	0.0932	5	0.1765	1	0.0449	10	0.0529	6	0.0007	14	0.0469	9
Maanshan	0.0264	13	0.1216	3	0.0523	8	0.0282	12	0.1039	4	0.1450	1
Xiangfan	0.0148	14	0.0866	5	0.0330	12	0.0929	4	0.0849	7	0.0946	3
Yingtan	0.0898	6	0.0375	11	0.0978	2	0.0924	4	0.0007	14	0.0228	13
Yinchuan	0.0634	8	0.1233	3	0.0417	10	0.0131	12	0.1330	2	0.1398	1
Ji'an	0.0126	11	0.0006	13	0.1538	1	0.1382	3	0.0006	13	0.0126	11
Yichang	0.0563	10	0.0863	5	0.0316	12	0.0568	9	0.1153	2	0.1147	3
Meizhou	0.0353	10	0.0006	13	0.1306	3	0.1405	2	0.0006	13	0.0763	7
Guiyang	0.0273	11	0.1116	3	0.0535	10	0.0105	14	0.1105	4	0.1273	2

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Wuhai	0.0801	6	0.1122	5	0.0609	7	0.0160	10	0.1519	1	0.1449	4
Daqing	0.0152	11	0.0419	10	0.0894	6	0.0085	12	0.1368	3	0.1143	4
Benxi	0.0032	13	0.0393	9	0.1289	4	0.0026	14	0.0921	5	0.1798	2
Shiyan	0.0329	10	0.0834	8	0.0282	11	0.0852	6	0.0006	14	0.1052	4
Quzhou	0.0593	9	0.1214	2	0.0599	8	0.0752	5	0.0005	14	0.1137	3
Putian	0.0131	9	0.0007	13	0.0029	12	0.1284	4	0.1123	5	0.0124	10
Quanzhou	0.0450	10	0.0244	13	0.0695	6	0.0817	5	0.0977	4	0.0334	12
Yangjiang	0.1218	3	0.0006	13	0.0964	6	0.1112	5	0.0006	13	0.0241	11
Erdos	0.0381	10	0.0698	7	0.0546	9	0.0094	11	0.1133	5	0.0874	6
Fuzhou	0.0041	13	0.0186	11	0.1060	5	0.1089	4	0.0006	14	0.0140	12
Suqian	0.0454	12	0.1307	1	0.1003	3	0.0537	10	0.0006	14	0.0244	13
Huangshi	0.1583	1	0.0834	5	0.0030	13	0.0792	6	0.0006	14	0.1396	3
Longyan	0.0372	13	0.0232	14	0.0458	11	0.1014	4	0.0836	6	0.0485	10
Nanping	0.0054	14	0.0128	13	0.1106	3	0.1170	2	0.0771	6	0.0634	10
Jiaxing	0.0551	8	0.1647	1	0.0170	12	0.0654	7	0.0007	14	0.0470	9
Guangyuan	0.1001	4	0.0311	12	0.0889	6	0.0853	8	0.1173	2	0.0830	9
Dandong	0.1054	4	0.0006	13	0.0393	11	0.0820	7	0.0006	13	0.1224	3
Qitaihe	0.0990	5	0.0827	8	0.0290	10	0.0237	12	0.0005	14	0.1316	2
Lishui	0.0254	12	0.0376	11	0.0856	6	0.1209	3	0.0006	14	0.0150	13

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Zhongwei	0.1126	4	0.0495	10	0.1221	3	0.0570	9	0.0005	13	0.1351	1
Chaozhou	0.0214	11	0.0190	12	0.0678	8	0.1082	4	0.0006	14	0.0945	7
Taizhou	0.0756	7	0.1369	2	0.0733	8	0.0974	5	0.0006	13	0.0006	13
Mudanjiang	0.1091	3	0.0716	8	0.0657	9	0.0370	11	0.0006	13	0.0845	5
Tai’an	0.0248	13	0.1404	1	0.1086	2	0.0879	5	0.0006	14	0.0749	9
Lijiang	0.0662	9	0.0303	11	0.0842	6	0.0826	7	0.0005	14	0.0924	5
Tonghua	0.1093	1	0.0444	12	0.0590	10	0.0787	6	0.0819	5	0.0855	4
Shijiazhuang	0.0333	10	0.1655	1	0.0164	14	0.0830	5	0.1480	2	0.1123	3
Zhongshan	0.0785	7	0.1243	3	0.0773	8	0.0315	10	0.0006	14	0.0142	12
Mianyang	0.1050	1	0.0690	9	0.0705	8	0.0844	6	0.0005	14	0.1035	2
Linxin	0.0534	11	0.1535	1	0.0742	8	0.0787	7	0.0006	14	0.0602	9
Shaoguan	0.0087	14	0.0260	12	0.0327	11	0.0587	9	0.0868	6	0.1062	3
Yichun	0.1603	2	0.0006	12	0.0041	11	0.0176	9	0.0006	12	0.1381	5
Yangquan	0.0556	8	0.0624	7	0.0079	14	0.0483	10	0.1201	3	0.1207	2
Yichun	0.0319	10	0.0006	13	0.1375	2	0.1317	3	0.0006	13	0.0638	7
Rizhao	0.0420	9	0.1667	2	0.0620	6	0.0748	5	0.0007	14	0.0185	13
Zhengzhou	0.1116	6	0.1444	1	0.0070	14	0.0499	8	0.1218	3	0.0301	10
Xining	0.1013	5	0.1153	3	0.0341	11	0.0476	9	0.1201	2	0.1321	1
Fushun	0.0541	9	0.0716	7	0.0755	6	0.0293	11	0.0006	14	0.1246	3

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Lanzhou	0.1296	3	0.0897	5	0.0441	10	0.0378	12	0.1485	1	0.1411	2
Xuancheng	0.0575	11	0.0702	8	0.0992	2	0.0595	10	0.0005	14	0.0493	12
Laiwu	0.0241	10	0.1765	3	0.0170	11	0.0149	12	0.0007	14	0.1970	1
Jinhua	0.1124	3	0.1385	2	0.0923	6	0.1037	5	0.0891	7	0.0331	9
Xuzhou	0.0366	11	0.1516	2	0.0507	10	0.0531	8	0.0006	14	0.1540	1
Haozhou	0.0713	6	0.0606	8	0.1309	3	0.1318	2	0.0005	14	0.0238	12
Liu’an	0.1007	5	0.0441	10	0.1151	3	0.1096	4	0.0005	14	0.0223	12
Anqing	0.0554	10	0.0902	5	0.0796	7	0.0984	4	0.0815	6	0.0376	13
Xiangtan	0.0763	7	0.1464	1	0.0017	13	0.0735	8	0.0006	14	0.1051	5
Changzhi	0.0127	13	0.1088	4	0.0477	10	0.0891	5	0.0005	14	0.1374	1
Fuxin	0.0450	10	0.0439	11	0.0010	14	0.0434	12	0.0760	7	0.1049	4
Baotou	0.0391	10	0.0936	6	0.0483	9	0.0175	12	0.0987	5	0.1162	4
Yulin	0.0779	8	0.0593	9	0.1121	2	0.0944	4	0.0944	4	0.0576	10
Jingmen	0.0781	6	0.0732	8	0.0371	13	0.0910	3	0.0005	14	0.0865	5
Leshan	0.1032	3	0.0636	10	0.0752	6	0.0653	9	0.1101	2	0.1135	1
Laibin	0.1072	2	0.0004	13	0.0905	6	0.0944	5	0.0004	13	0.0711	10
Handan	0.0072	13	0.1557	1	0.0889	4	0.0878	6	0.0006	14	0.1436	2
Zhanghzou	0.0536	10	0.0138	13	0.1076	5	0.1166	2	0.0827	6	0.0387	11
Wuzhong	0.0650	8	0.0456	11	0.0212	14	0.0320	13	0.0731	7	0.1236	1

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Dezhou	0.0331	10	0.1577	1	0.1023	4	0.0949	5	0.0006	14	0.0766	8
Jiuquan	0.1138	4	0.0835	6	0.0546	8	0.0546	8	0.0005	14	0.1083	5
Suizhou	0.0234	13	0.0909	5	0.0797	6	0.0371	12	0.0959	4	0.0426	11
Luohe	0.0887	8	0.1368	1	0.0112	12	0.0892	7	0.0005	14	0.0513	10
Yiyang	0.0871	8	0.0535	10	0.0900	6	0.0980	4	0.0005	14	0.0393	11
Yulin	0.1082	5	0.0152	12	0.1058	6	0.1157	3	0.0005	14	0.0579	9
Deyang	0.0772	8	0.0741	9	0.0853	5	0.0945	2	0.0005	14	0.0930	3
Ankang	0.0589	9	0.0225	12	0.1191	2	0.0944	6	0.0004	14	0.0508	11
Binzhou	0.0210	12	0.1311	2	0.0641	8	0.0630	9	0.0006	14	0.0851	6
Wenzhou	0.1185	4	0.1243	3	0.0201	11	0.0869	6	0.0006	14	0.0069	13
Loudi	0.0777	8	0.0589	9	0.0902	6	0.1085	2	0.0005	14	0.0492	10
Tangshan	0.0584	7	0.1475	1	0.0139	14	0.0584	7	0.1164	4	0.1378	2
Hohhot	0.1266	2	0.1157	3	0.0236	11	0.0170	12	0.0770	8	0.0897	6
Huludao	0.0852	6	0.0523	10	0.0290	13	0.0554	9	0.1068	3	0.1217	1
Songyuan	0.0373	11	0.0005	14	0.0591	9	0.0863	6	0.0911	5	0.0654	8
Wulanchabu	0.0743	6	0.0167	13	0.1076	3	0.0668	8	0.0718	7	0.0997	4
Jiamusi	0.0442	10	0.0318	13	0.0263	14	0.0373	12	0.0963	3	0.0723	9
Qingyan	0.0626	11	0.0005	13	0.0641	10	0.0993	3	0.0005	13	0.0885	6
Suining	0.1178	3	0.0514	10	0.0940	5	0.0394	11	0.0917	6	0.0651	8

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Baishan	0.1279	1	0.0367	11	0.0202	12	0.0738	8	0.0005	14	0.1189	3
Yueyang	0.0665	8	0.0706	7	0.0266	12	0.0936	4	0.0005	14	0.0629	10
Heihe	0.1142	2	0.0004	13	0.1098	4	0.1124	3	0.0004	13	0.0433	11
Anshan	0.1060	5	0.0563	8	0.0658	7	0.0390	10	0.0006	14	0.1255	3
Jiaozuo	0.0674	9	0.0789	5	0.0432	14	0.0613	11	0.0798	4	0.0679	8
Nanchong	0.0455	12	0.0689	9	0.0790	7	0.0826	5	0.0959	3	0.0661	10
Weifang	0.0745	7	0.1560	1	0.0768	6	0.0733	8	0.0006	14	0.0833	5
Jining	0.1148	2	0.1342	1	0.0577	11	0.0751	5	0.0005	14	0.0552	12
Qiqihar	0.0788	7	0.0320	14	0.0546	9	0.0505	10	0.1137	1	0.0698	8
Guyuan	0.1085	3	0.0420	12	0.1005	5	0.0685	8	0.0809	7	0.0116	13
Jinchang	0.1163	5	0.0709	7	0.0349	10	0.0220	11	0.0005	14	0.1228	4
Tongliao	0.0068	13	0.0459	11	0.0655	9	0.0709	8	0.1145	3	0.0827	5
Bayannur	0.0849	6	0.0382	12	0.0789	7	0.0637	9	0.0751	8	0.1027	3
Jixi	0.0645	9	0.0477	10	0.0041	14	0.0413	12	0.1118	3	0.0754	7
Xiaogan	0.0129	13	0.0760	9	0.1157	2	0.1185	1	0.0005	14	0.0927	8
Fuyang	0.1041	3	0.0535	10	0.1016	4	0.1012	5	0.0811	7	0.0597	9
Jiayuguan	0.1175	5	0.0623	8	0.1158	6	0.0038	12	0.0005	14	0.1546	1
Luzhou	0.0735	8	0.0853	6	0.0510	10	0.0720	9	0.0005	14	0.1009	5
Bingzhou	0.0352	13	0.0775	6	0.0837	5	0.0913	4	0.0005	14	0.0380	12

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Meishan	0.0929	7	0.0707	9	0.0956	6	0.1005	4	0.0004	13	0.1045	3
Panzhihua	0.0808	6	0.0467	10	0.0780	7	0.0265	12	0.0847	5	0.1314	3
Xinxiang	0.0590	10	0.1038	3	0.0526	12	0.0861	6	0.0005	14	0.0615	8
Ningde	0.0385	11	0.0147	13	0.1209	2	0.1200	3	0.1008	5	0.0050	14
Weinan	0.0874	7	0.0677	10	0.0849	8	0.1083	1	0.1079	2	0.1017	4
Heyuan	0.0174	12	0.0005	13	0.0754	8	0.1215	4	0.0005	13	0.0322	10
Xuchang	0.0772	9	0.0866	6	0.0969	2	0.0835	7	0.0826	8	0.0314	12
Luoyang	0.1037	4	0.0903	7	0.0390	11	0.0694	8	0.1184	2	0.0476	10
Siping	0.1005	2	0.0324	14	0.0753	7	0.0789	5	0.0749	8	0.0545	11
Hanzhong	0.0758	8	0.0253	14	0.0903	4	0.0985	1	0.0922	3	0.0658	10
Sanming	0.0457	10	0.0196	14	0.0365	11	0.1019	4	0.0795	7	0.0895	5
Jincheng	0.0140	13	0.1258	3	0.0634	7	0.0589	9	0.0005	14	0.1108	4
Zhangjiakou	0.0421	12	0.0760	7	0.0515	11	0.0675	8	0.0981	3	0.0912	4
Tieling	0.0764	9	0.0236	12	0.0856	6	0.0801	7	0.0005	13	0.1124	2
Yancheng	0.0629	10	0.1006	3	0.1011	2	0.1006	3	0.0005	14	0.0116	12
Zigong	0.0672	8	0.0801	7	0.0594	11	0.0494	13	0.0880	4	0.0988	2
Yongzhou	0.0943	5	0.0167	13	0.0701	9	0.1039	4	0.0004	14	0.0543	10
Hegang	0.0433	10	0.0605	9	0.0048	13	0.0219	11	0.1314	1	0.1067	5
Ya'an	0.0412	12	0.0004	14	0.0629	11	0.0724	9	0.1028	4	0.0633	10

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Pingdingshan	0.0596	9	0.0940	3	0.0435	13	0.0915	4	0.0869	5	0.0716	8
Jingzhou	0.0799	8	0.1005	4	0.0812	7	0.1088	3	0.0005	14	0.0399	11
Xianning	0.1013	4	0.0520	11	0.0917	5	0.0529	10	0.0005	14	0.0758	6
Shuangyashan	0.0208	14	0.0384	10	0.0530	9	0.0384	10	0.1126	3	0.1020	4
Xinyang	0.0328	10	0.0715	9	0.1239	2	0.0970	5	0.0934	7	0.0059	14
Yan’an	0.0624	9	0.0502	11	0.0940	3	0.0770	8	0.0932	4	0.0219	14
Shangluo	0.1182	1	0.0268	11	0.1153	4	0.1157	3	0.0004	14	0.0147	13
Hengyang	0.1070	2	0.0360	12	0.0537	10	0.0963	5	0.0004	14	0.0439	11
Suihua	0.1093	2	0.0435	10	0.1093	2	0.1101	1	0.1037	4	0.0364	11
Suzhou	0.0786	7	0.0406	11	0.0886	6	0.0937	4	0.0642	10	0.0344	13
Kaifeng	0.0914	4	0.0876	5	0.0643	12	0.0755	7	0.1110	1	0.0230	13
Baoding	0.0628	9	0.1283	1	0.1040	4	0.1017	6	0.0005	14	0.0756	7
Changde	0.0241	13	0.0966	5	0.0787	7	0.0946	6	0.0005	14	0.0521	10
Zhangye	0.1061	3	0.0344	12	0.0615	10	0.0374	11	0.0004	14	0.0989	4
Chengde	0.0465	12	0.0807	5	0.0628	9	0.0485	11	0.0962	3	0.0791	6
Yunfu	0.0708	10	0.0005	13	0.0923	7	0.1129	3	0.0005	13	0.0782	9
Ziyang	0.0732	7	0.0390	12	0.1165	3	0.1113	5	0.0004	14	0.0546	9
Liaocheng	0.0069	13	0.1367	1	0.0954	6	0.1101	2	0.0005	14	0.0782	8
Jieyang	0.1120	2	0.0004	14	0.0755	9	0.0818	8	0.0856	7	0.0281	12

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Guang'an	0.0847	6	0.0158	14	0.1001	2	0.0928	5	0.0756	9	0.0972	4
Shangrao	0.0048	13	0.0124	12	0.1203	5	0.1280	3	0.0005	14	0.0134	11
Nanyang	0.1104	1	0.0789	7	0.0917	4	0.0789	7	0.1065	2	0.0080	13
Anyang	0.0722	9	0.1068	1	0.0598	11	0.0979	3	0.0004	14	0.0868	6
Pingliang	0.0885	4	0.0202	14	0.0940	3	0.0647	9	0.0528	12	0.0795	7
Bazhong	0.0779	8	0.0235	13	0.0980	4	0.0980	4	0.0675	9	0.0621	10
Wuwei	0.1066	1	0.0260	13	0.0795	7	0.0901	6	0.0599	11	0.0708	8
Huaihua	0.0878	4	0.0156	14	0.0762	8	0.0849	6	0.0776	7	0.0439	12
Wuzhou	0.0752	6	0.0204	13	0.0633	11	0.0752	6	0.0004	14	0.0718	9
Lvliang	0.0631	10	0.0515	12	0.1080	2	0.1057	3	0.0004	14	0.1042	4
Maoming	0.1015	2	0.0004	14	0.0945	4	0.0909	6	0.0783	8	0.0464	11
Sanmenxia	0.0206	13	0.0902	5	0.0872	6	0.0843	8	0.0986	4	0.0621	10
Zunyi	0.0451	11	0.0335	12	0.1013	3	0.1071	1	0.0004	14	0.0877	8
Qingyang	0.0983	4	0.0226	13	0.1031	1	0.1002	3	0.0769	9	0.0244	12
Yibin	0.0964	1	0.0597	10	0.0946	3	0.0738	8	0.0957	2	0.0783	7
Heze	0.0487	12	0.1141	1	0.1112	2	0.1004	3	0.0004	13	0.0650	9
Hulunbuir	0.1101	2	0.0200	14	0.0866	6	0.0784	7	0.1062	3	0.0690	8
Jinzhong	0.0864	5	0.0778	7	0.0748	8	0.0782	6	0.0992	2	0.1037	1
Baoshan	0.0904	5	0.0004	14	0.0847	7	0.0926	3	0.0563	11	0.0664	9

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Yuxi	0.0848	6	0.0097	14	0.0643	10	0.0755	8	0.0938	2	0.0755	8
Qinzhou	0.1011	3	0.0004	14	0.0725	9	0.0689	10	0.0892	6	0.0302	11
Lasa	0.1013	6	0.0449	9	0.1022	5	0.0158	13	0.0005	14	0.0253	12
Cangzhou	0.0891	6	0.1088	2	0.1052	4	0.1072	3	0.0746	9	0.0794	8
Guigang	0.1030	1	0.0351	13	0.0502	10	0.0963	5	0.0616	9	0.0970	4
Tianshui	0.0929	5	0.0279	14	0.0827	7	0.0906	6	0.1073	1	0.0423	11
Shangqiu	0.0376	13	0.0640	9	0.0991	1	0.0987	2	0.0886	5	0.0398	12
Zhangjiajie	0.0695	9	0.0796	7	0.0615	11	0.0635	10	0.1133	1	0.0225	14
Langfang	0.0152	14	0.1253	2	0.0871	5	0.0590	9	0.1295	1	0.0889	4
Chaoyang	0.0980	3	0.0165	13	0.0611	11	0.0896	5	0.0004	14	0.1007	2
Baicheng	0.1045	2	0.0329	13	0.0825	6	0.0751	9	0.1084	1	0.0410	11
Puyang	0.0653	11	0.0686	8	0.0617	12	0.0823	4	0.0798	5	0.0516	13
Hezhou	0.0156	12	0.0004	13	0.0782	9	0.0790	8	0.0004	13	0.0986	5
Baiyin	0.0997	4	0.0398	11	0.0072	14	0.0516	10	0.1016	2	0.1016	2
Shanwei	0.0362	11	0.0004	14	0.0896	7	0.1139	2	0.1065	4	0.0033	13
Shaoyang	0.0830	6	0.0449	12	0.0721	9	0.0954	2	0.0675	10	0.0424	13
Dingxi	0.0951	5	0.0194	14	0.0975	2	0.0975	2	0.0598	10	0.0484	11
Neijiang	0.0739	7	0.0525	10	0.0787	6	0.0711	8	0.0929	3	0.0891	4
Lincang	0.0673	10	0.0166	14	0.0935	2	0.0928	3	0.0621	11	0.0290	13

(continued)

Table 5.6 (continued)

The name of the city	The green coverage of the built-up area (%)		Good air quality days (day)		Water consumption per capita (tons/person)		The green area per capita (m^2/person)		The rate of Hazard-free treatment household garbage (%)		Comprehensive energy consumption of per unit of GDP (tons of standard coal/yuan)	
	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Rankings	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Chifeng	0.0694	7	0.0419	13	0.0334	14	0.0595	9	0.0672	8	0.1029	1
Anshun	0.1059	1	0.0004	14	0.0882	7	0.0499	11	0.1003	4	0.1029	2
Ganzhou	0.0790	8	0.0004	13	0.0926	6	0.0972	5	0.0004	13	0.0170	12
Baise	0.0790	7	0.0273	13	0.0693	11	0.0920	3	0.0004	14	0.0959	1
Zhumadian	0.0499	11	0.0680	10	0.0915	5	0.0966	1	0.0771	9	0.0926	4
Hechi	0.0958	4	0.0196	13	0.0890	5	0.0994	1	0.0004	14	0.0410	12
Qujing	0.0858	8	0.0096	13	0.0921	4	0.0962	2	0.0004	14	0.0773	10
Xingtai	0.0863	5	0.1134	1	0.0791	8	0.0843	7	0.0004	14	0.0911	4
Huanggang	0.0908	4	0.0588	10	0.0915	3	0.0975	1	0.0954	2	0.0404	13
Dazhou	0.0939	5	0.0265	12	0.0838	10	0.0906	6	0.0874	8	0.0964	3
Xinzhou	0.0887	2	0.0621	11	0.0803	8	0.0883	3	0.0934	1	0.0846	5
Yuncheng	0.0705	8	0.0666	10	0.0854	6	0.0903	4	0.0687	9	0.0999	1
Hengshui	0.0402	12	0.1056	1	0.0984	3	0.0872	5	0.1014	2	0.0744	9
Zhoukou	0.0579	12	0.0707	9	0.0919	1	0.0906	4	0.0698	10	0.0238	14
Liupanshui	0.1059	3	0.0004	13	0.0896	9	0.1079	2	0.0004	13	0.1082	1
Chongzuo	0.0720	9	0.0164	14	0.0855	4	0.0807	5	0.0878	2	0.0695	10
Zhaotong	0.0851	8	0.0003	14	0.0899	4	0.0903	3	0.0883	5	0.0559	11
Longnan	0.0947	1	0.0200	12	0.0947	1	0.0947	1	0.0930	7	0.0427	11

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Zhuhai	0.1510	4	0.1736	2	0.0059	11	0.0131	8	0.1165	5	0.0024	12	0.0071	10	0.0202	6
Sanya	0.0011	12	0.2360	1	0.0306	8	0.0537	6	0.0927	5	0.0011	12	0.1128	4	0.0464	7
Xiamen	0.0990	4	0.0757	7	0.0052	14	0.0301	9	0.1893	1	0.0129	11	0.0723	8	0.0095	12
Tongling	0.1788	1	0.1703	2	0.0549	7	0.0227	10	0.0785	6	0.0520	8	0.0274	9	0.0123	13
Xinyu	0.1495	3	0.0274	10	0.1027	5	0.0468	6	0.0308	9	0.1712	2	0.0274	10	0.0365	8
Huizhou	0.0782	4	0.0154	13	0.0139	14	0.0563	9	0.0629	7	0.0651	6	0.0344	12	0.0402	10
Zhoushan	0.0238	9	0.2632	1	0.0332	8	0.0352	7	0.1098	4	0.0176	11	0.0166	12	0.0383	6
Shenyang	0.1222	3	0.0379	9	0.0672	7	0.0284	11	0.0540	8	0.0095	13	0.0928	5	0.0331	10
Fuzhou	0.0938	4	0.1558	1	0.0293	11	0.0461	10	0.0251	13	0.0854	5	0.1365	2	0.0511	9
Dalian	0.1327	3	0.1487	2	0.0575	9	0.0088	13	0.0159	12	0.0761	6	0.0965	5	0.1177	4
Haikou	0.0967	6	0.1148	3	0.0230	11	0.1090	4	0.0992	5	0.0090	13	0.0541	9	0.0672	7
Jingdezhen	0.0665	7	0.2209	1	0.0813	5	0.1238	3	0.0693	6	0.0980	4	0.0444	10	0.1257	2
Guanghzou	0.0751	6	0.0677	7	0.0022	13	0.0066	11	0.1560	3	0.0059	12	0.0383	9	0.0464	8
Nanning	0.0906	5	0.1993	1	0.0404	9	0.1227	3	0.0568	7	0.0395	11	0.1112	4	0.0008	13
Wuhu	0.0447	10	0.0925	5	0.0810	6	0.0640	8	0.0740	7	0.1342	2	0.0139	13	0.0200	12
Huangshan	0.1848	2	0.0812	5	0.1200	4	0.1425	3	0.1917	1	0.0492	8	0.0492	8	0.0579	7
Xi'an	0.0740	5	0.0701	6	0.0171	13	0.0607	8	0.1176	2	0.0397	11	0.1090	4	0.0023	14
Suzhou	0.0539	7	0.1904	1	0.0118	11	0.0067	12	0.1205	5	0.0362	9	0.1264	3	0.0522	8

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Yanghzou	0.0564	8	0.1313	2	0.0749	7	0.0354	11	0.0985	4	0.1187	3	0.0379	10	0.0892	5
Yantai	0.1662	1	0.0305	12	0.0701	5	0.0323	11	0.0153	13	0.0701	5	0.1644	2	0.1087	3
Qingdao	0.1020	5	0.0496	7	0.0362	9	0.0267	13	0.1087	4	0.1296	3	0.0658	6	0.1401	2
Weihai	0.1297	3	0.0632	7	0.0461	9	0.0279	11	0.0032	13	0.0429	10	0.1672	2	0.2079	1
Zhenjiang	0.0500	7	0.1760	2	0.0587	6	0.0198	13	0.1035	4	0.0457	9	0.0302	12	0.1217	3
Wuhan	0.0777	5	0.0540	7	0.0096	13	0.0215	12	0.1392	4	0.0415	9	0.0281	11	0.0311	10
Bengbu	0.0269	10	0.0602	8	0.1307	4	0.1466	1	0.0650	7	0.1165	5	0.0166	11	0.0095	12
Huzhou	0.0738	7	0.0843	6	0.0313	10	0.0530	9	0.0070	12	0.0877	4	0.1486	2	0.0860	5
Changzhou	0.0378	12	0.1294	2	0.0287	13	0.0154	14	0.1133	3	0.0524	9	0.0643	6	0.0958	5
Hanghzou	0.1110	5	0.0316	7	0.0105	12	0.0172	11	0.0067	13	0.0220	9	0.1981	2	0.0651	6
Tongchuan	0.0007	14	0.0905	6	0.1047	4	0.1020	5	0.1155	3	0.0277	10	0.0135	12	0.0034	13
Karamay	0.1036	5	0.0412	7	0.0144	12	0.0021	14	0.1894	1	0.0323	10	0.0220	11	0.0384	9
Jinan	0.0332	9	0.0744	6	0.0289	10	0.0282	12	0.0996	4	0.0664	7	0.0260	13	0.0238	14
Huainan	0.0986	5	0.1363	1	0.0789	8	0.0974	6	0.1094	2	0.0275	11	0.0102	13	0.0143	12
Chongqing	0.1228	2	0.0490	10	0.0893	4	0.0879	5	0.0094	14	0.0879	5	0.0376	11	0.0154	13
Hebi	0.0623	8	0.1071	3	0.0443	12	0.0836	6	0.0770	7	0.0464	11	0.0525	10	0.0322	13
Tianjin	0.0200	11	0.0899	5	0.0553	8	0.0087	13	0.1093	4	0.0200	11	0.0546	9	0.0799	6

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Beijing	0.1246	5	0.1442	2	0.0174	8	0.0145	9	0.1101	6	0.0029	13	0.1254	4	0.0029	13
Panjing	0.1089	5	0.0008	13	0.0798	6	0.0153	11	0.0597	7	0.0048	12	0.1113	4	0.1411	2
Hefei	0.0919	4	0.1180	3	0.0874	5	0.0471	10	0.0627	9	0.1262	2	0.0680	7	0.0874	5
Jiangmen	0.1205	3	0.1180	4	0.0429	9	0.0982	5	0.0107	13	0.1592	2	0.0446	7	0.0932	6
Qinhuangdao	0.1937	1	0.0300	10	0.0607	7	0.1153	3	0.0246	11	0.0753	6	0.0930	5	0.0415	9
Dongying	0.0397	9	0.0510	8	0.0389	10	0.0016	13	0.1304	2	0.0923	5	0.1287	3	0.0737	6
Urumqi	0.0926	6	0.1123	4	0.0148	12	0.0290	11	0.1063	5	0.0526	9	0.0318	10	0.0055	13
Foshan	0.0790	7	0.0338	10	0.0051	14	0.0108	13	0.1268	3	0.0490	9	0.1382	2	0.0624	8
Shaoxing	0.0906	5	0.1047	3	0.0297	12	0.0262	13	0.0311	11	0.0729	7	0.1189	2	0.0934	4
Harbin	0.0640	7	0.0585	8	0.0717	6	0.0520	11	0.1100	4	0.0208	13	0.0416	12	0.0574	9
Beihai	0.0131	13	0.1333	3	0.0456	10	0.0767	5	0.0249	12	0.0497	8	0.1540	2	0.0490	9
Kunming	0.1623	1	0.0229	13	0.0316	11	0.0558	8	0.0818	6	0.0403	10	0.1159	3	0.0012	14
Nantong	0.0434	9	0.1061	4	0.0848	6	0.0321	11	0.1332	2	0.1303	3	0.0826	7	0.0107	13
Shantou	0.0490	7	0.0604	6	0.0327	10	0.1470	3	0.1875	1	0.1378	4	0.0391	9	0.0128	12
Jiujiang	0.1763	1	0.0123	12	0.0786	7	0.1183	2	0.0848	6	0.1162	3	0.0437	11	0.0513	10
Shuozhou	0.1025	5	0.0096	13	0.1331	1	0.0408	10	0.1277	2	0.0354	12	0.0785	8	0.0444	9
Nanjing	0.0892	6	0.1642	1	0.0192	10	0.0096	13	0.1219	5	0.0411	8	0.0122	12	0.0141	11

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Zaozhuang	0.0085	13	0.0463	12	0.0638	8	0.0671	7	0.1107	3	0.0808	5	0.0469	11	0.0580	9
Fangchenggang	0.0184	13	0.1710	1	0.0475	7	0.0443	8	0.1412	3	0.0266	10	0.0215	11	0.0361	9
Lianyungang	0.0637	9	0.1606	1	0.0715	8	0.0923	5	0.0728	7	0.0930	4	0.0332	11	0.0280	12
Nanchang	0.0452	10	0.0688	6	0.0327	13	0.0375	12	0.0806	5	0.0486	9	0.0924	4	0.1411	2
Changchun	0.0160	14	0.1412	4	0.0709	5	0.0307	9	0.0256	10	0.0217	12	0.0403	8	0.0684	6
Liaoyuan	0.0594	9	0.0192	13	0.1123	1	0.0502	11	0.0991	5	0.0925	7	0.0581	10	0.1083	3
Wuxi	0.1013	4	0.0934	5	0.0264	11	0.0050	13	0.1455	2	0.0642	7	0.0464	9	0.1405	3
Taizhou	0.0605	9	0.0999	5	0.0328	11	0.0641	8	0.0649	7	0.1144	3	0.0787	6	0.1319	2
Shizuishan	0.1266	3	0.0297	10	0.0766	8	0.0398	9	0.1361	2	0.0196	12	0.0053	14	0.0244	11
Pingxiang	0.0595	10	0.1252	2	0.0670	8	0.0835	4	0.0209	13	0.1170	3	0.0696	7	0.0544	11
Erzhou	0.0933	6	0.1318	2	0.0757	7	0.0403	10	0.0702	8	0.1013	5	0.0031	13	0.0293	11
Liuzhou	0.0766	6	0.1750	1	0.0450	10	0.0573	8	0.1190	3	0.0167	12	0.0470	9	0.0039	13
Shenzhen	0.1371	4	0.0187	10	0.0007	14	0.0033	12	0.1632	3	0.0214	8	0.0662	7	0.1799	2
Tiayuan	0.1626	2	0.1236	4	0.0106	12	0.0535	8	0.0278	9	0.0106	12	0.0773	6	0.0185	11
Guilin	0.0883	5	0.0471	11	0.0661	8	0.0894	4	0.1068	3	0.0286	13	0.0873	6	0.0132	14
Xianyang	0.0504	9	0.1109	4	0.0837	7	0.0843	6	0.0227	13	0.0460	10	0.1120	3	0.0166	14
Zhanjiang	0.0412	11	0.0793	7	0.0993	4	0.1267	2	0.0481	10	0.1074	3	0.0836	6	0.0630	9

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Zibo	0.0744	6	0.0265	11	0.0545	7	0.0243	12	0.0928	4	0.0493	8	0.0825	5	0.1406	3
Chuzhou	0.0483	8	0.0405	10	0.1196	2	0.1262	1	0.0380	11	0.1093	3	0.0465	9	0.0362	13
Ningbo	0.1007	5	0.1517	1	0.0129	13	0.0136	12	0.0452	9	0.0407	11	0.1427	2	0.0736	6
Huai'an	0.0389	11	0.1410	2	0.0963	4	0.0684	7	0.0313	12	0.0667	9	0.0081	14	0.0673	8
Liaoyang	0.1660	3	0.0008	13	0.0769	5	0.0553	7	0.0215	11	0.0138	12	0.0231	10	0.2022	1
Baoji	0.1436	1	0.0379	12	0.0839	5	0.0810	7	0.1017	2	0.0936	3	0.0511	11	0.0218	13
Huaibei	0.0891	5	0.0877	6	0.0836	8	0.1199	2	0.1008	4	0.1844	1	0.0151	12	0.0144	13
Zhuhzou	0.1026	3	0.1517	2	0.0573	11	0.0617	10	0.0283	12	0.0969	4	0.0648	7	0.0780	5
Changsha	0.1171	4	0.0167	12	0.0368	11	0.0094	13	0.0388	10	0.0742	6	0.1271	2	0.0957	5
Yingkou	0.1124	3	0.0006	14	0.0665	7	0.0401	10	0.0039	13	0.0239	12	0.1014	6	0.1124	3
Shanghai	0.0435	9	0.0915	6	0.0175	11	0.0152	12	0.1446	1	0.0073	13	0.0706	8	0.0870	7
Dongguan	0.1365	4	0.0234	9	0.0013	13	0.0328	7	0.0950	6	0.1319	5	0.0181	10	0.0094	12
Datong	0.0791	6	0.1379	1	0.0763	7	0.1118	4	0.0812	5	0.0316	12	0.0403	10	0.0044	14
Jingzhou	0.0675	8	0.1299	2	0.0478	11	0.0720	6	0.0478	11	0.0681	7	0.1181	3	0.0495	10
Chizhou	0.0006	14	0.0541	10	0.1016	5	0.1052	3	0.1110	2	0.1322	1	0.0065	13	0.0200	12
Zhaoqing	0.1521	1	0.0323	11	0.0041	14	0.0816	6	0.0587	8	0.1169	4	0.0470	9	0.0094	13
Jilin	0.1157	4	0.0334	12	0.0704	7	0.0388	10	0.1288	2	0.0358	11	0.0537	8	0.1401	1

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Chengdu	0.0231	12	0.1216	4	0.0502	8	0.0370	11	0.1262	3	0.0231	12	0.1527	2	0.0509	7
Maanshan	0.1304	2	0.0969	6	0.0611	7	0.0417	9	0.0352	10	0.1016	5	0.0294	11	0.0264	13
Xiangfan	0.0330	12	0.0855	6	0.1168	2	0.0536	10	0.0496	11	0.0661	8	0.0581	9	0.1305	1
Yingtan	0.0891	7	0.0422	10	0.0616	9	0.0683	8	0.0328	12	0.0904	5	0.0958	3	0.1788	1
Yinchuan	0.1033	6	0.0051	14	0.0457	9	0.0342	11	0.1102	4	0.0120	13	0.1079	5	0.0674	7
Ji'an	0.0451	9	0.0613	8	0.0980	6	0.1424	2	0.1094	4	0.0986	5	0.0877	7	0.0391	10
Yichang	0.1373	1	0.0525	11	0.0676	6	0.0247	13	0.1056	4	0.0627	8	0.0209	14	0.0676	6
Meizhou	0.0202	11	0.1266	4	0.1092	5	0.1555	1	0.0376	9	0.1023	6	0.0491	8	0.0156	12
Guiyang	0.1384	1	0.0826	6	0.0256	12	0.0651	8	0.0110	13	0.0576	9	0.0808	7	0.0983	5
Wuhai	0.1519	1	0.0462	9	0.0109	12	0.0077	13	0.0487	8	0.0045	14	0.0147	11	0.1494	3
Daqing	0.0511	9	0.1666	1	0.0681	7	0.0024	14	0.1435	2	0.0973	5	0.0079	13	0.0571	8
Benxi	0.1817	1	0.0522	7	0.0464	8	0.0284	10	0.1334	3	0.0077	12	0.0180	11	0.0863	6
Shiyan	0.1557	1	0.0852	6	0.0429	9	0.1063	3	0.1328	2	0.1005	5	0.0182	13	0.0229	12
Quzhou	0.0686	7	0.0846	4	0.0516	12	0.0752	5	0.0555	11	0.1367	1	0.0577	10	0.0401	13
Putian	0.0007	13	0.1313	3	0.0088	11	0.0773	7	0.1123	5	0.1991	1	0.0190	8	0.1816	2
Quanzhou	0.0553	8	0.1035	3	0.0148	14	0.0379	11	0.0605	7	0.1820	1	0.1441	2	0.0502	9
Yangjiang	0.0117	12	0.1273	1	0.0871	7	0.0841	8	0.0266	10	0.1137	4	0.0698	9	0.1248	2

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Erdos	0.1567	2	0.0088	12	0.1209	3	0.0006	14	0.1655	1	0.0018	13	0.0558	8	0.1174	4
Fuzhou	0.0932	7	0.0559	9	0.1112	3	0.1374	1	0.0961	6	0.1229	2	0.0547	10	0.0763	8
Suqian	0.0875	7	0.1042	2	0.0909	5	0.0886	6	0.0593	9	0.0992	4	0.0537	10	0.0615	8
Huangshi	0.0683	7	0.0659	8	0.0508	10	0.0659	8	0.0387	11	0.1480	2	0.0048	12	0.0937	4
Longyan	0.0933	5	0.0717	7	0.0550	9	0.0405	12	0.1160	1	0.1106	2	0.1057	3	0.0674	8
Nanping	0.0973	5	0.0693	8	0.0403	11	0.0663	9	0.1209	1	0.0393	12	0.0752	7	0.1052	4
Jiaxing	0.0715	6	0.0749	5	0.0102	13	0.0293	11	0.1198	4	0.0449	10	0.1443	3	0.1552	2
Guangyuan	0.0005	14	0.0952	5	0.1069	3	0.1186	1	0.0884	7	0.0329	11	0.0338	10	0.0180	13
Dandong	0.0495	10	0.1424	1	0.0649	8	0.0649	8	0.1236	2	0.0137	12	0.0968	5	0.0940	6
Qitaihe	0.0895	7	0.1395	1	0.0932	6	0.1148	4	0.1180	3	0.0500	9	0.0011	13	0.0274	11
Lishui	0.0463	10	0.0966	5	0.0630	9	0.0654	8	0.1267	2	0.0972	4	0.1492	1	0.0706	7
Zhongwei	0.0690	8	0.0005	13	0.0915	6	0.1116	5	0.1326	2	0.0225	12	0.0705	7	0.0250	11
Chaozhou	0.0125	13	0.1023	5	0.0369	10	0.1213	2	0.0987	6	0.1326	1	0.1177	3	0.0666	9
Taizhou	0.0309	11	0.1495	1	0.0664	9	0.0298	12	0.0991	4	0.1094	3	0.0407	10	0.0899	6
Mudanjiang	0.0006	13	0.1660	1	0.0792	6	0.0721	7	0.1566	2	0.0868	4	0.0235	12	0.0469	10
Tai’an	0.0301	11	0.0289	12	0.0867	7	0.0566	10	0.0761	8	0.1032	3	0.0873	6	0.0938	4
Lijiang	0.0703	8	0.0154	12	0.1068	4	0.1366	2	0.1391	1	0.0098	13	0.1165	3	0.0493	10

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Tonghua	0.0695	7	0.0366	14	0.0686	8	0.0535	11	0.1052	2	0.0430	13	0.0595	9	0.1052	2
Shijiazhuang	0.0275	13	0.0281	12	0.0333	10	0.0643	7	0.0532	8	0.0760	6	0.1064	4	0.0526	9
Zhongshan	0.1447	2	0.0643	9	0.0025	13	0.0198	11	0.1045	4	0.0897	6	0.1577	1	0.0903	5
Mianyang	0.0294	13	0.0443	12	0.0932	5	0.1014	3	0.0608	10	0.0788	7	0.0587	11	0.1004	4
Linxin	0.0827	5	0.0321	13	0.0804	6	0.0996	2	0.0517	12	0.0894	3	0.0855	4	0.0579	10
Shaoguan	0.1052	5	0.1062	3	0.0684	8	0.0827	7	0.1067	2	0.0531	10	0.0219	13	0.1368	1
Yichun	0.1088	6	0.1597	3	0.0199	8	0.1416	4	0.1621	1	0.0749	7	0.0006	12	0.0111	10
Yangquan	0.1453	1	0.0997	4	0.0404	13	0.0635	6	0.0509	9	0.0414	12	0.0451	11	0.0986	5
Yichun	0.0203	11	0.0400	9	0.1381	1	0.1311	4	0.0458	8	0.1212	5	0.1195	6	0.0180	12
Rizhao	0.0292	11	0.0442	8	0.0862	4	0.0620	6	0.0356	10	0.1952	1	0.0264	12	0.1567	3
Zhengzhou	0.1165	5	0.0166	13	0.0177	12	0.0252	11	0.1170	4	0.0709	7	0.1304	2	0.0408	9
Xining	0.0341	11	0.1143	4	0.0293	13	0.0620	7	0.0456	10	0.0514	8	0.0893	6	0.0235	14
Fushun	0.1483	1	0.1336	2	0.0603	8	0.0321	10	0.1082	5	0.0163	13	0.0276	12	0.1178	4
Lanzhou	0.0383	11	0.1191	4	0.0331	13	0.0525	7	0.0567	6	0.0163	14	0.0488	8	0.0446	9
Xuancheng	0.0936	3	0.0931	4	0.0855	6	0.0895	5	0.0829	7	0.1419	1	0.0671	9	0.0102	13
Laiwu	0.0432	7	0.0376	9	0.0716	5	0.0702	6	0.0418	8	0.1885	2	0.0106	13	0.1063	4
Jinhua	0.0293	11	0.0755	8	0.0212	13	0.0315	10	0.0011	14	0.0239	12	0.1434	1	0.1048	4

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Xuzhou	0.0189	13	0.0531	8	0.0855	6	0.0543	7	0.1050	4	0.1109	3	0.0242	12	0.1015	5
Haozhou	0.0107	13	0.0572	9	0.1289	4	0.1333	1	0.0679	7	0.1163	5	0.0286	11	0.0383	10
Liu'an	0.0966	6	0.0738	8	0.1240	2	0.1253	1	0.0093	13	0.0599	9	0.0785	7	0.0404	11
Anqing	0.0381	12	0.0617	9	0.1017	3	0.1046	2	0.0072	14	0.1191	1	0.0554	10	0.0694	8
Xiangtan	0.0464	10	0.0876	6	0.1091	4	0.0514	9	0.0379	11	0.1131	3	0.1181	2	0.0328	12
Changzhi	0.1210	2	0.0419	11	0.0690	8	0.0769	6	0.0764	7	0.0329	12	0.1178	3	0.0679	9
Fuxin	0.0910	5	0.1375	1	0.0496	9	0.0863	6	0.1065	3	0.0269	13	0.1245	2	0.0636	8
Baotou	0.1306	3	0.0910	7	0.0499	8	0.0031	14	0.1332	2	0.0129	13	0.0314	11	0.1347	1
Yulin	0.0338	12	0.0818	7	0.0831	6	0.0134	14	0.1100	3	0.0216	13	0.1165	1	0.0442	11
Jingmen	0.0662	11	0.0885	4	0.0776	7	0.0682	10	0.0717	9	0.1038	2	0.0386	12	0.1191	1
Leshan	0.0413	13	0.0899	4	0.0765	5	0.0705	8	0.0469	11	0.0430	12	0.0267	14	0.0744	7
Laibin	0.0966	4	0.0887	7	0.1076	1	0.1028	3	0.0856	8	0.0817	9	0.0523	11	0.0206	12
Handan	0.0536	10	0.0105	12	0.0795	8	0.0983	3	0.0883	5	0.0856	7	0.0751	9	0.0254	11
Zhanghzou	0.0578	9	0.0732	7	0.0265	12	0.0610	8	0.0122	14	0.1161	3	0.1129	4	0.1273	1
Wuzhong	0.0948	5	0.0537	9	0.1024	3	0.0970	4	0.1151	2	0.0420	12	0.0875	6	0.0469	10
Dezhou	0.0189	13	0.0251	12	0.1149	2	0.0726	9	0.0320	11	0.0794	7	0.1074	3	0.0846	6
Jiuquan	0.1172	3	0.0253	12	0.0785	7	0.0363	11	0.1411	1	0.0139	13	0.0402	10	0.1321	2

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Suizhou	0.0086	14	0.1330	1	0.0777	7	0.0970	3	0.0619	9	0.0721	8	0.0599	10	0.1203	2
Luohe	0.0069	13	0.0203	11	0.0919	5	0.0919	5	0.1213	3	0.0951	4	0.0593	9	0.1357	2
Yiyang	0.0777	9	0.0952	5	0.1084	2	0.1046	3	0.0114	13	0.0900	6	0.1113	1	0.0331	12
Yulin	0.0759	8	0.0047	13	0.1172	2	0.1205	1	0.0247	11	0.1091	4	0.0569	10	0.0878	7
Deyang	0.0061	13	0.0639	11	0.0889	4	0.0736	10	0.0531	12	0.0828	7	0.1221	1	0.0848	6
Ankang	0.0692	8	0.0787	7	0.1043	5	0.1083	3	0.1070	4	0.1276	1	0.0548	10	0.0040	13
Binzhou	0.1061	3	0.0539	10	0.0681	7	0.0454	11	0.0119	13	0.1532	1	0.0999	4	0.0965	5
Wenzhou	0.0224	10	0.0846	7	0.0150	12	0.0713	8	0.0650	9	0.1444	1	0.1260	2	0.1139	5
Loudi	0.0241	12	0.1037	4	0.1056	3	0.0960	5	0.0232	13	0.0796	7	0.1370	1	0.0458	11
Tangshan	0.1174	3	0.0241	12	0.0359	10	0.0204	13	0.0252	11	0.0450	9	0.0879	6	0.1115	5
Hohhot	0.1271	1	0.1001	5	0.0411	10	0.0118	13	0.1105	4	0.0024	14	0.0827	7	0.0746	9
Huludao	0.1085	2	0.0773	7	0.0650	8	0.0857	5	0.0523	10	0.0461	12	0.0914	4	0.0233	14
Songyuan	0.0785	7	0.0155	13	0.1139	3	0.0359	12	0.1139	3	0.0427	10	0.1270	2	0.1328	1
Wulanchabu	0.0909	5	0.0058	14	0.1147	1	0.0609	10	0.1143	2	0.0530	12	0.0659	9	0.0576	11
Jiamusi	0.0898	5	0.1129	2	0.0778	7	0.0838	6	0.1202	1	0.0378	11	0.0742	8	0.0953	4
Qingyan	0.0812	8	0.0934	5	0.0743	9	0.0983	4	0.0851	7	0.1149	2	0.0161	12	0.1213	1
Suining	0.0160	13	0.0312	12	0.1252	1	0.1133	4	0.0573	9	0.1188	2	0.0055	14	0.0734	7

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Baishan	0.1091	5	0.1185	4	0.0874	6	0.0404	10	0.1236	2	0.0527	9	0.0118	13	0.0785	7
Yueyang	0.0644	9	0.1350	1	0.1181	2	0.0624	11	0.0158	13	0.0777	6	0.1150	3	0.0910	5
Heihe	0.0544	9	0.0540	10	0.0924	7	0.1089	5	0.1249	1	0.0174	12	0.0665	8	0.1008	6
Anshan	0.1539	1	0.0909	6	0.0480	9	0.0223	11	0.0162	12	0.0123	13	0.1099	4	0.1534	2
Jiaozuo	0.1067	1	0.0705	7	0.0476	12	0.0445	13	0.0789	5	0.0657	10	0.0811	3	0.1067	1
Nanchong	0.0794	6	0.0774	8	0.1023	2	0.1048	1	0.0314	13	0.0890	4	0.0520	11	0.0258	14
Weifang	0.0077	12	0.0408	10	0.0053	13	0.0621	9	0.0313	11	0.1277	3	0.1359	2	0.1247	4
Jining	0.0678	8	0.0315	13	0.0848	4	0.0630	10	0.0664	9	0.1085	3	0.0703	6	0.0703	6
Qiqihar	0.0907	6	0.1018	3	0.1030	2	0.0977	4	0.0973	5	0.0447	11	0.0324	13	0.0332	12
Guyuan	0.0568	9	0.1033	4	0.1109	2	0.1113	1	0.0989	6	0.0548	10	0.0492	11	0.0028	14
Jinchang	0.1387	1	0.1282	3	0.0639	8	0.0419	9	0.1362	2	0.0135	13	0.0210	12	0.0893	6
Tongliao	0.0818	6	0.0036	14	0.1105	4	0.0359	12	0.1236	2	0.0491	10	0.0818	6	0.1273	1
Bayannur	0.0997	4	0.0246	13	0.0900	5	0.0412	11	0.1184	2	0.0208	14	0.0424	10	0.1193	1
Jixi	0.0704	8	0.1254	1	0.0918	4	0.0859	6	0.1172	2	0.0313	13	0.0459	11	0.0872	5
Xiaogan	0.1080	3	0.0191	12	0.0956	7	0.1071	4	0.0339	10	0.0994	5	0.0220	11	0.0985	6
Fuyang	0.0066	14	0.0498	11	0.0222	13	0.1148	2	0.0864	6	0.1160	1	0.0687	8	0.0342	12
Jiayuguan	0.1404	4	0.1541	2	0.0137	9	0.0087	10	0.1454	3	0.0049	11	0.0022	13	0.0760	7

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Luzhou	0.0769	7	0.1367	1	0.1127	3	0.1049	4	0.0049	13	0.1181	2	0.0216	12	0.0412	11
Bingzhou	0.1213	2	0.0547	10	0.1018	3	0.0747	8	0.0609	9	0.0766	7	0.1322	1	0.0518	11
Meishan	0.0004	13	0.1000	5	0.1094	2	0.0889	8	0.0116	12	0.1112	1	0.0560	11	0.0578	10
Panzhihua	0.1352	1	0.1352	1	0.0284	11	0.0241	13	0.1064	4	0.0529	9	0.0048	14	0.0650	8
Xinxiang	0.0344	13	0.0605	9	0.0556	11	0.0915	5	0.0654	7	0.1146	2	0.1166	1	0.0979	4
Ningde	0.0458	10	0.0760	7	0.0316	12	0.0577	9	0.0614	8	0.1058	4	0.0921	6	0.1296	1
Weinan	0.0004	13	0.0800	9	0.0989	5	0.0931	6	0.0004	13	0.0250	12	0.1034	3	0.0410	11
Heyuan	0.1329	1	0.0654	9	0.0957	6	0.1230	3	0.0788	7	0.1329	1	0.1061	5	0.0178	11
Xuchang	0.0193	13	0.0099	14	0.0768	10	0.0539	11	0.0889	5	0.0911	4	0.1100	1	0.0920	3
Luoyang	0.1141	3	0.0062	13	0.0285	12	0.0509	9	0.0043	14	0.1037	4	0.1003	6	0.1236	1
Siping	0.0545	11	0.0921	3	0.0865	4	0.0625	9	0.0621	10	0.0364	13	0.0765	6	0.1129	1
Hanzhong	0.0926	2	0.0424	12	0.0870	5	0.0825	7	0.0862	6	0.0465	11	0.0740	9	0.0409	13
Sanming	0.0818	6	0.1279	1	0.0242	13	0.0315	12	0.1119	3	0.0658	8	0.0658	8	0.1183	2
Jincheng	0.1033	5	0.0200	12	0.0634	7	0.0579	10	0.0779	6	0.0379	11	0.1268	2	0.1393	1
Zhangjiakou	0.1087	1	0.0343	13	0.0871	5	0.0793	6	0.0985	2	0.0331	14	0.0662	9	0.0662	9
Tieling	0.1050	3	0.0005	13	0.0912	5	0.0777	8	0.0727	10	0.0583	11	0.1157	1	0.1004	4
Yancheng	0.0927	7	0.1067	1	0.0838	9	0.0484	11	0.0102	13	0.0941	6	0.0862	8	0.1006	3

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Zigong	0.0614	10	0.0963	3	0.0872	5	0.0643	9	0.0577	12	0.1054	1	0.0012	14	0.0834	6
Yongzhou	0.0797	8	0.0893	7	0.1127	1	0.1048	3	0.0459	11	0.0906	6	0.1098	2	0.0275	12
Hegang	0.0800	8	0.1276	2	0.1071	4	0.0933	6	0.1248	3	0.0095	12	0.0033	14	0.0857	7
Ya’an	0.1053	1	0.1045	2	0.0783	6	0.0874	5	0.1037	3	0.0749	7	0.0741	8	0.0287	13
Pingdingshan	0.0385	14	0.0517	10	0.0811	6	0.0757	7	0.0459	12	0.0497	11	0.1039	2	0.1064	1
Jingzhou	0.1239	1	0.0537	10	0.0684	9	0.1101	2	0.0073	13	0.0982	6	0.0275	12	0.1000	5
Xianning	0.1114	2	0.0456	12	0.0648	8	0.0735	7	0.0411	13	0.1105	3	0.0580	9	0.1209	1
Shuangyashan	0.1011	5	0.1188	1	0.0804	7	0.0680	8	0.1183	2	0.0313	12	0.0234	13	0.0936	6
Xinyang	0.0196	12	0.0105	13	0.1257	1	0.1043	4	0.0232	11	0.0966	6	0.0815	8	0.1139	3
Yan’an	0.0818	6	0.0551	10	0.0806	7	0.0259	13	0.1090	2	0.0498	12	0.1102	1	0.0887	5
Shangluo	0.1169	2	0.0193	12	0.0947	7	0.1060	5	0.1006	6	0.0792	8	0.0536	9	0.0386	10
Hengyang	0.0857	6	0.1150	1	0.0990	4	0.0857	6	0.0169	13	0.1003	3	0.0857	6	0.0746	9
Suihua	0.0004	13	0.0004	13	0.1010	6	0.1037	4	0.0847	8	0.0760	9	0.0329	12	0.0887	7
Suzhou	0.0925	5	0.0670	9	0.0967	3	0.1033	2	0.0383	12	0.1053	1	0.0259	14	0.0708	8
Kaifeng	0.0004	14	0.0977	2	0.0672	10	0.0826	6	0.0701	8	0.0947	3	0.0693	9	0.0651	11
Baoding	0.0729	8	0.0119	13	0.0564	10	0.1031	5	0.0252	12	0.1173	2	0.1072	3	0.0330	11
Changde	0.0304	11	0.0546	9	0.1082	3	0.0710	8	0.0295	12	0.1038	4	0.1188	2	0.1371	1

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density ($population/km^2$)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Zhangye	0.0951	5	0.0696	9	0.0785	8	0.0883	6	0.1180	1	0.0153	13	0.0815	7	0.1150	2
Chengde	0.1125	1	0.0676	8	0.0755	7	0.0628	9	0.1006	2	0.0449	13	0.0346	14	0.0878	4
Yunfu	0.0928	6	0.0946	5	0.0082	12	0.1042	4	0.0169	11	0.1207	2	0.1211	1	0.0864	8
Ziyang	0.0134	13	0.0481	10	0.1213	1	0.0823	6	0.0403	11	0.1130	4	0.0671	8	0.1195	2
Liaocheng	0.0261	11	0.0231	12	0.0865	7	0.0703	9	0.0516	10	0.1082	3	0.1062	4	0.1003	5
Jieyang	0.0076	13	0.0978	4	0.0390	11	0.0894	6	0.0957	5	0.1154	1	0.0634	10	0.1083	3
Guang’an	0.0789	8	0.0275	13	0.1023	1	0.0803	7	0.0495	11	0.0979	3	0.0631	10	0.0341	12
Shangrao	0.1337	1	0.0535	9	0.0931	6	0.1237	4	0.0296	10	0.1328	2	0.0831	7	0.0712	8
Nanyang	0.0889	6	0.0726	10	0.1005	3	0.0917	4	0.0020	14	0.0746	9	0.0271	12	0.0682	11
Anyang	0.0756	7	0.0073	13	0.0581	12	0.0744	8	0.0675	10	0.0910	5	0.0979	3	0.1043	2
Pingliang	0.0813	5	0.0799	6	0.0947	2	0.0990	1	0.0651	8	0.0528	12	0.0640	10	0.0636	11
Bazhong	0.0351	11	0.0783	7	0.1092	1	0.1084	2	0.0282	12	0.1069	3	0.0957	6	0.0112	14
Wuwei	0.0708	8	0.0041	14	0.0976	5	0.0983	3	0.1017	2	0.0279	12	0.0682	10	0.0983	3
Huaihua	0.0990	2	0.0711	10	0.0900	3	0.0867	5	0.0736	9	0.0573	11	0.1012	1	0.0352	13
Wuzhou	0.0888	4	0.1105	2	0.0862	5	0.0722	8	0.0523	12	0.1003	3	0.1151	1	0.0684	10
Lvliang	0.0754	6	0.0384	13	0.0719	7	0.0692	9	0.0788	5	0.0700	8	0.1088	1	0.0546	11
Maoming	0.0346	13	0.0661	9	0.0866	7	0.0626	10	0.0405	12	0.0956	3	0.0945	4	0.1074	1

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Sanmenxia	0.1137	1	0.0327	12	0.0042	14	0.0357	11	0.0721	9	0.0868	7	0.1061	2	0.1057	3
Zunyi	0.0178	13	0.0596	9	0.1046	2	0.0910	7	0.0562	10	0.0943	6	0.1001	5	0.1013	3
Qingyang	0.0192	14	0.0429	11	0.1006	2	0.0780	8	0.0932	5	0.0880	6	0.0872	7	0.0654	10
Yibin	0.0523	13	0.0568	11	0.0898	5	0.0712	9	0.0041	14	0.0920	4	0.0527	12	0.0827	6
Heze	0.0004	13	0.0541	11	0.0970	4	0.0962	5	0.0608	10	0.0850	7	0.0908	6	0.0758	8
Hulunbuir	0.1023	4	0.0239	13	0.0654	9	0.0321	12	0.1109	1	0.0478	11	0.0603	10	0.0870	5
Jinzhong	0.0710	9	0.0098	14	0.0519	12	0.0703	10	0.0680	11	0.0256	13	0.0966	3	0.0868	4
Baoshan	0.0517	13	0.0545	12	0.0926	3	0.0972	2	0.0858	6	0.0599	10	0.0700	8	0.0976	1
Yuxi	0.1024	1	0.0814	7	0.0583	11	0.0403	13	0.0870	4	0.0497	12	0.0867	5	0.0908	3
Qinzhou	0.0302	11	0.0962	4	0.0884	7	0.0958	5	0.0277	13	0.1039	2	0.1100	1	0.0856	8
Lasa	0.1357	1	0.1357	1	0.0306	11	0.0444	10	0.1343	3	0.0564	8	0.0592	7	0.1137	4
Cangzhou	0.0113	13	0.0004	14	0.0645	10	0.0564	11	0.0185	12	0.0830	7	0.1108	1	0.0907	5
Guigang	0.0742	8	0.1015	2	0.0948	6	0.1004	3	0.0129	14	0.0948	6	0.0384	12	0.0399	11
Tianshui	0.0389	13	0.0733	8	0.1035	3	0.1057	2	0.0480	9	0.0989	4	0.0400	12	0.0480	9
Shangqiu	0.0141	14	0.0618	11	0.0864	6	0.0933	3	0.0633	10	0.0828	7	0.0926	4	0.0778	8
Zhangjiajie	0.0305	13	0.0852	4	0.0740	8	0.0936	3	0.0836	5	0.0350	12	0.0820	6	0.1061	2
Langfang	0.0194	13	0.0724	7	0.0258	12	0.0576	10	0.0470	11	0.0719	8	0.1147	3	0.0862	6

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Chaoyang	0.0927	4	0.0857	6	0.0688	9	0.0657	10	0.0811	8	0.0515	12	0.1061	1	0.0819	7
Baicheng	0.0403	12	0.0987	4	0.0790	7	0.0643	10	0.1007	3	0.0054	14	0.0774	8	0.0898	5
Puyang	0.0357	14	0.0899	2	0.0754	6	0.0664	10	0.0722	7	0.0888	3	0.0938	1	0.0686	8
Hezhou	0.0868	7	0.0999	4	0.0905	6	0.1048	3	0.0761	10	0.1064	2	0.1146	1	0.0487	11
Baiyin	0.0929	6	0.1054	1	0.0895	7	0.0804	8	0.0974	5	0.0368	12	0.0265	13	0.0697	9
Shanwei	0.0111	12	0.0715	9	0.0896	7	0.1012	5	0.0535	10	0.1114	3	0.1155	1	0.0962	6
Shaoyang	0.0816	7	0.0742	8	0.0936	4	0.0975	1	0.0088	14	0.0911	5	0.0947	3	0.0533	11
Dingxi	0.0629	9	0.0363	13	0.0975	2	0.0982	1	0.0778	7	0.0695	8	0.0919	6	0.0484	11
Neijiang	0.0511	11	0.0828	5	0.0935	2	0.0711	8	0.0511	11	0.0970	1	0.0507	13	0.0445	14
Lincang	0.0690	9	0.0424	12	0.0928	3	0.0942	1	0.0866	6	0.0907	5	0.0780	8	0.0852	7
Chifeng	0.1010	2	0.0555	10	0.0940	4	0.0544	11	0.1010	2	0.0507	12	0.0753	6	0.0937	5
Anshun	0.0798	8	0.0291	13	0.0988	5	0.1014	3	0.0306	12	0.0571	10	0.0605	9	0.0950	6
Ganzhou	0.0790	8	0.1146	2	0.0393	11	0.1096	3	0.0633	10	0.0918	7	0.1009	4	0.1150	1
Baise	0.0902	4	0.0945	2	0.0772	8	0.0873	6	0.0891	5	0.0700	10	0.0729	9	0.0550	12
Zhumadian	0.0174	14	0.0297	12	0.0941	3	0.0901	7	0.0260	13	0.0959	2	0.0796	8	0.0915	5
Hechi	0.0969	3	0.0630	10	0.0855	7	0.0986	2	0.0865	6	0.0833	8	0.0830	9	0.0580	11
Qujing	0.0862	7	0.0400	12	0.0973	1	0.0799	9	0.0618	11	0.0903	5	0.0958	3	0.0873	6

(continued)

Table 5.6 (continued)

The name of the city	Comprehensive utilization rate of general industrial solid waste (%)		The rate of urban sewage treatment (%)		Internet broadband access subscribers (ten thousand families)/the total number of urban households at the end of a year		Per capita GDP (yuan/per person)		Population density (population/km^2)		Water resources, environment and public facilities management practitioners in the city/urban population at the end of the year		The number of civilian vehicles/urban road length (km)		Expenditure of urban maintenance and construction/city GDP	
	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking	The numerical value	Ranking
Xingtai	0.0443	11	0.0423	12	0.0647	10	0.0998	2	0.0319	13	0.0783	9	0.0859	6	0.0982	3
Huanggang	0.0459	12	0.0856	7	0.0849	8	0.0888	5	0.0014	14	0.0881	6	0.0477	11	0.0832	9
Dazhou	0.0087	13	0.0983	2	0.1008	1	0.0888	7	0.0044	14	0.0841	9	0.0946	4	0.0417	11
Xinzhou	0.0598	12	0.0134	14	0.0766	9	0.0863	4	0.0813	7	0.0400	13	0.0829	6	0.0625	10
Yuncheng	0.0815	7	0.0294	13	0.0546	12	0.0893	5	0.0138	14	0.0623	11	0.0971	2	0.0907	3
Hengshui	0.0098	14	0.0826	8	0.0515	11	0.0872	5	0.0128	13	0.0898	4	0.0856	7	0.0736	10
Zhoukou	0.0291	13	0.0717	8	0.0886	5	0.0873	6	0.0608	11	0.0912	3	0.0916	2	0.0750	7
Liupanshui	0.0991	6	0.0046	12	0.1006	5	0.0716	10	0.0252	11	0.0903	8	0.0907	7	0.1056	4
Chongzuo	0.0797	7	0.0859	3	0.0801	6	0.0650	11	0.0743	8	0.0637	12	0.0907	1	0.0489	13
Zhaotong	0.0848	9	0.0279	13	0.0912	1	0.0906	2	0.0421	12	0.0810	10	0.0858	7	0.0867	6
Longnan	0.0810	10	0.0067	14	0.0937	5	0.0943	4	0.0833	9	0.0933	6	0.0910	8	0.0170	13

Note The greater the numerical value of the construction focusing degree of an index is, the more necessary it becomes that the index should be focused on in the construction. The closer the rank of the construction focusing degree of an index is to the top, the more priority should be given to the index

From Table 5.6, it can be seen that the top 4 of the 14 indices of the construction focusing degree of Beijing in 2013 are the number of days of good air quality, urban wastewater treatment rate, water consumption per capita and the number of civilian vehicles/the total length of urban road.

The top 4 of the 14 indices of the construction focusing degree of Tianjin in 2013 are the number of days of good air quality, green coverage of the built-up area, the hazard-free treatment rate of household garbage and population density.

The top 4 of the 14 indices of the construction focusing degree of Shanghai in 2013 are population density, the hazard-free treatment rate of household garbage, water consumption per capita and the number of days of good air quality.

The top 4 of the 14 indices of the construction focusing degree of Guangzhou in 2013 are the hazard-free treatment rate of household garbage, water consumption per capita, population density and the number of days of good air quality.

The construction focusing degrees of other cities are shown in Table 5.6.

5.4.3 Results of the Annual Construction Difficulty and Comprehensive Degree of Construction of the Eco City

Here we omit the calculation results of the annual construction difficulty and integrated degree of the eco city. These can be found in reference [2].

5.5 Conclusion and Discussion

The ecological health evaluation of Chinese cities in 2013 achieved two new breakthroughs on the basis of previous work. Firstly, the scope of the evaluation was larger than that of previous works with the number of cities evaluated being increased from 115 or 116 to 284, more than double the previous amount. Due to the expansion of the sample size of the data collected, the evaluation more accurately reflects the reality of China. Secondly, the number of evaluation indices changed from the original 13, to 14. The adjustment of the evaluation indices is based on previous work, and the newly adjusted indices make data collection easier, while at the same time that data can better reflect the core of the problems we are focusing on.

In 2013, in the health assessment of the ecological construction of the 284 cities around the country, there are 11 cities whose health level is overall very healthy, accounting for 3.9 % of the total number of cities, and those 11 cities are: Sanya, Xiamen, Zhuhai, Tongling, Xinyu, Huizhou, Zhoushan, Shenyang, Fuzhou, Dalian and Haikou. There are 225 cities whose health level is healthy, accounting for 79.2 % of the total number and there are 48 cities whose health level is subhealthy, accounting for 16.9 % of the total number of cities. These data further show the imbalance in eco city construction in China between eastern regions and western regions, and coastal areas and inland areas.

Looking at the secondary indicators in 2013, then the cities whose ecological environment health level is more than healthy accounted for 96.1 % of the 284 cities. Cities whose ecological economic health level is more than healthy accounted for 83.5 %, while cities whose ecological social health level is more than healthy accounted for 49.3 %. These data show that in eco city construction in China, the ecological environment is in better condition than the ecological economy, and the ecological economy itself is superior to the ecological society. In 2013, in the 284 cities throughout China, the cities whose ecological social health level is not very healthy accounted for 12.7 % (a total of 36 cities), which shows that in eco city construction in China, the indicators of the ecological society have somewhat lagged behind. According to the four third-grade indicators of the ecological society (population density, rate of popularity of ecological environmental protection knowledge and regulations and that of the infrastructure in good condition, the rate of public satisfaction with the urban ecological environment, government investment and the construction effect), we suggest that in the process of eco city construction, we should give the social service function of the city—such as solving the problem of urban road congestion etc.—a higher profile.

In the health evaluation of ecological construction in the 284 cities around the country in 2013, four municipalities directly under control of the central government and the vast majority of first-tier cities all dropped out of the top 10, even taking into account the evaluation model's error. It also shows that eco city construction in China has entered the crucial stage. In the 25 cities in which the number of good air quality days in a year is the full 365, there isn't a single city belonging to the 4 municipalities directly under central government control, nor is there a city belonging to the 28 provincial capital cities, indicating that the management of air pollution is still a challenging task in the long-term.

In the 284 Chinese cities studied in 2013, there are 140 cities in which the hazard-free treatment rate of urban household garbage has reached 100 %, compared to 2011 when there were only 42 cities in which the hazard-free treatment rate of urban household garbage reached 100 % and 2012 when there were only 47 cities in which the hazard-free treatment rate of urban household garbage reached 100 %. The data reflect the fact that China has made positive efforts in household garbage disposal.

The ecological construction the 284 cities was surveyed and we provide strong data supporting the aspect of the construction focusing degree, the construction difficulty and comprehensive degrees, and indicating the direction of travel for policymakers.

In conclusion, the construction of ecological civilization is an inevitable stage in the development of human civilization, and the construction of eco cities is the key battleground in the construction of ecological civilization. We have made a quantitative analysis and evaluation of the state of the ecological health of Chinese eco cities through the establishment of the model, in order to theoretical support for government decisions.

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Part II
Development Pattern of Chinese-Style Eco City Construction

Chapter 6
Evaluation Report on the Construction of Environmentally Friendly Cities

Guohua Chang, Qing Zhang and Xiaoni Shi

Abstract The report evaluated and analyzed the construction of the environment-friendly features of Chinese cities in 2013, ranking the top 100 cities and briefly analyzing the proportion of cities entering the top 100 in different regions. The report also pointed out that the best way to the sustainable development of Chinese urbanization was to establish sensible scientific plans conducive to improving the construction of eco cities and to building a new way of thinking with eco cities in harmony with man and nature, based on their ecological carrying capacity, and upholding resource-saving and environmentally-friendly principles.

Keywords Environmentally friendly cities · Evaluation · Health index · Ecological carrying capacity

6.1 Introduction

The city is a geographical area with the largest human population and economic activity. It is not only the core area of social-economic development, but also the engine of future economic growth. The maintenance of the normal running of cities requires a large amount of natural resources and energy, which is currently impossible without emitting waste into the environment [1].

If the amount of natural resources and energy required and the level of emission goes beyond the carrying capacity of nature, then it will cause damage to the ecological environment. The ecological environment is an important resource and the carrier for the development of the city. As such it is a vital part of the sustainable development of the city. Therefore, an unsustainable ecological environment is bound to affect the

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sustainability of urban development, and also directly affect the sustainability and potential of social-economic development.

Over the past ten years, while the rapid development of cities in China has played a significant role in promoting economic and social development, the process of urbanization in China over the past decade has focused more on increases in scale and quantity, as the key features. With economic development as the central aim, export-oriented industrialization as the central power, land as the main component, large scale expansion as the means of development and a large amount of material capital investment as the driving element, the traditional extensive mode of urbanization will lead to a series of problems, such as excessive land urbanization, urban sprawl, large increases in resource and energy consumption, excessive concentration of space, an imbalance in the economic structure, a large number of motor vehicles in use, traffic congestion and serious environmental pollution and ecological damage etc. [2, 3]. Urbanization in China has entered a period of rapid development. For a nation or a country, urbanization only happens once and with the end of the urbanization process, the layout of towns and major infrastructure is determined. Once it is determined, it is very hard to change [4]. Therefore, transforming the process of urban development and steering it in a more sustainable, healthy and environment-friendly direction is crucial to both the health and sustainability of the city, and even the whole of society, which is one of the big challenges facing China today.

The environment-friendly city is a mode of eco city development and its central tenets are to be centered on the harmony between man and nature, adopt a unified way of thinking in order to integrate economic development, social behavior, the political system, technology and culture of the city into an organic unified framework of scientific development against a background of the principles and objectives of environment-friendly construction and embed it into every aspect of the economic and social development of the city. This will result in placing the production, life and consumption of the city within the carrying capacity of the ecological environment, adopting the patterns of production, life and consumption which are conducive to the protection of the ecological environment, founding natural and harmonious relations and interaction in the urban-environment, and promoting the comprehensive, coordinated and sustainable development of economy, society and environment of the city with the ideas and methods of ecological and environmental protection. Therefore, the construction of the environmentally-friendly eco city is of great importance to the transformation of the development model from the traditional one to a healthier and more sustainable form of development, and to the realization of harmonious development between man and nature, and the promotion of the comprehensive coordinated development of the economy, society and environment of the city [5].

The report selected five indicators of environmentally friendly features to evaluate the environmentally-friendly features of cities at the prefecture-level or above in China, and put forward some suggestions for the future construction of cities, aiming at providing a reference for the construction of environment friendly cities in China.

6.2 Research Methodology

6.2.1 Design of the Evaluation Index System

This book selected the index system for the evaluation of environment friendly features, based on the basic requirements of eco city construction and the principles of an environmentally friendly city. The index system consists of five specific indices, including industrial sulfur dioxide emissions per unit GDP (kg/10 thousand Yuan), private cars/civilian cars (%), ammonia nitrogen emissions per unit GDP (kg/10 thousand Yuan) (replaced temporarily by fertilizer use per unit of cultivated land (fold scalar) (tons/hectares), the utility rate of the main form of clean energy (%) and the operating cost of major pollution control and treatment facilities (10 thousand Yuan)/urban GDP (10 thousand Yuan) [replaced temporarily by the expenditure of agriculture, forestry and water affairs (10 thousand Yuan)/urban GDP (10 thousand Yuan) (%)].

Since the evaluation range was 284 cities at the prefecture-level, some indices are missing as there were insufficient data released by the national authoritative department. The missing indices were replaced with other related or similar indices. For example, there were only a few cities whose ammonia nitrogen emissions and running costs of the main pollution treatment and governance facilities were released by Ministry of Environmental Protection which mainly focused on more important cities in China. When the number of cities considered by the Ministry of Environmental Protection is increased in the future, we will replace them again. The names of the environmentally friendly characteristic indices of the city are shown in Table 6.1.

Table 6.1 Environmentally friendly characteristic index of cities in China

The first grade index	No.	The second grade index	Property	Weight
Environmentally friendly characteristic index	1[a]	Industrial sulfur dioxide emissions per unit GDP (kg/10 thousand Yuan)	Inverse	0.24
	2	Private cars/civilian cars (%)	Inverse	0.24
	3	Ammonia nitrogen emissions per unit GDP (kg/10 thousand Yuan) [fertilizer use per unit of cultivated land (fold scalar) (tons/hectares)]	Inverse	0.18
	4	The utility rate of major clean energy (%)	Positive	0.24
	5	The operating cost of major pollution control and treatment facilities (10 thousand Yuan)/city GDP (10 thousand Yuan) [the expenditure of agriculture, forestry, water affairs (10 thousand Yuan)/urban GDP (10 thousand Yuan) (%)]	Positive	0.1

Note [a]If a city caused major pollution incidents, its evaluation result would be deducted 5–10 points

6.2.2 Index Description, Data Sources and Treatment Methods

The significance and the data source of the characteristic indices of the environmentally friendly city are described as follows.

Industrial sulfur dioxide emissions per unit GDP (kg/10 thousand Yuan) refers to the ratio of the total amount of sulfur dioxide emitted into the atmosphere in the process of production and fuel combustion processes in factories by some industrial business compared to the total annual regional GDP. The calculation formula is:

Industrial sulfur dioxide emissions per unit GDP (kg/10 thousand Yuan) = Total annual industrial sulfur dioxide emissions (kg)/Annual urban GDP (10 thousand Yuan).

Sources: *Environmental Protection Departments, Environmental Bulletins, The Statistical Yearbook of Chinese Cities*.

Private cars/civilian cars refers to the ratio of private cars to civilian cars in the city in that year.

Private car ownership in Chinese cities is growing rapidly and is not only a problem of personal consumption, but is also a big problem for the healthy development of the city. The development of private transportation is good for individual convenience but it severely restricts the city's sustainable development. The rapid growth of private car ownership not only causes traffic jams, land tenure, energy consumption and traffic accidents but also causes many environmental problems such as smog and greenhouse gases caused by exhaust gas emissions. This results in economic losses totaling hundreds of millions of yuan each year. This also seriously affects people's work and daily lives, and hampers the normal running of urban functions [6, 7]. In an average city, the energy consumption of cars per capita over 100 km is 12 times as much as that of the bus [8]. Both in terms of energy and resources, and also environmental aspects, developing public transportation and constructing an environmentally friendly mode of transportation is obligatory in the process of eco city construction both at home and abroad.

Data source: *China Statistical Yearbook of Regional Economy*.

Fertilizer use per unit of cultivated land (fold scalar) (tons/hectares) refers to the amount of fertilizers used on the regional arable land unit within a single year. The amount of fertilizer used is calculated in a fold scalar way. Fold scalar refers to the amount of nitrogen, phosphate and potash fertilizers present after being reduced according to one hundred percent of the components of nitrogen, phosphorus pentoxide, and potassium oxide they contain respectively. Compound fertilizer is calculated according to its main ingredients. The calculation formula is:

Fertilizer use per unit of arable land (tons/hectares) = Fertilizer use (ton)/Arable land area (hectares).

Data source: *China Statistical Yearbook of Regional Economy*. Because the common arable land area of some cities was not listed in the Yearbook but the corresponding crop planting area data was complete, this data was used to replace the former values.

The utility rate of major clean energy (%) refers to the ratio of the total supply of natural gas, artificial coal gas, liquefied petroleum gas and electricity folded after the million tons of standard coal, to the comprehensive energy consumption of the city. The calculation formula is:

The utility rate of major clean energy (%) = [amount of natural gas supply (10 thousand tons standard coal) + total artificial coal gas supply (10 thousand tons standard coal) + total liquefied petroleum gas (10 thousand tons standard coal) + electricity consumption of the whole society (10 thousand tons standard coal)]/total annual urban integrated energy consumption (10 thousand tons standard coal).

Total annual urban integrated energy consumption (10 thousand tons standard coal) = Comprehensive energy consumption per unit of GDP (tons standard coal/10 thousand Yuan) × Urban GDP (100 million Yuan).

These coefficients of energy are quoted from *China Energy Statistical Yearbook of 2013* [9].

The expenditure of Agriculture, Forestry and Water Affairs (Yuan)/city GDP (million) refers to the ratio of the expenditure of Agriculture, Forestry and Water Affairs of the city in the current year to annual regional GDP.

Data source: China Statistical Yearbook of Regional Economy.

The above processing methods of index data can be seen in the "Methodology and Modeling" section of the book *Health Evaluation Report on the Eco Cities in China* edited by Zhao Tinggang and Liu Haitao et al. The weightings of the indicators are shown in Table 6.1. Because some data were missing, in order to ensure the validity of data processing, the processing method used is replaced by the mean values of the corresponding indices of all the evaluated cities.

6.3 Results and Findings

6.3.1 The Evaluation Results of the Environmentally Friendly Characteristics of Chinese Cities

Based on the evaluation index system of urban environmentally friendly characteristics, five characteristic indicators were ranked respectively and their environmentally friendly characteristic indices were calculated, and thus the ranking of the top 100 Chinese cities in 2013 and that of their individual characteristic index was obtained (Table 6.2). From Table 6.2, it can be seen that in terms of the environmentally friendly characteristic index, the top 10 cities were Lhasa, Sanya, Qiqihar, Xining, Shanghai, Zhoushan, Changsha, Yichun, Loudi, and Fushun. Lhasa's industrial sulfur dioxide emissions per unit of GDP ranked seventh among the 284 prefecture-level cities, which shows that sulfur dioxide emissions in this city are very low and that Lhasa should continue to maintain its low emissions into the future. In the construction of the environmentally friendly city, municipal government should increase investment in agriculture, forestry and water conservancy,

Table 6.2 Evaluation results of environmentally friendly characteristics of Chinese cities in 2013

City Name	The environmentally friendly characteristic index (5 index results)		The rankings of the individual items of the characteristic index				
	Points	Ranking	Industrial sulfur dioxide emissions per unit of GDP	Private car ownership/civilian car ownership	Fertilizer use (fold scalar) per unit of arable land	The use rate of major clean energy	The expenditure of agriculture, forestry, water affairs/urban GDP
Lhasa	0.833061	1	7	22	137	98	106
Sanya	0.815111	2	1	69	280	15	63
Qiqihar	0.814804	3	8	71	8	88	26
Xining	0.806534	4	246	32	19	57	105
Shanghai	0.80156	5	17	30	68	13	252
Zhoushan	0.796486	6	66	37	33	102	21
Changsha	0.79602	7	6	25	72	161	265
Yichun	0.795877	8	241	19	3	135	30
Loudi	0.794968	9	257	6	36	70	156
Fushun	0.79179	10	190	29	61	81	154
Baiyin	0.790002	11	118	42	16	38	36
Beijing	0.788287	12	5	111	138	6	181
Zhangjiajie	0.784053	13	232	5	60	137	56
Zhuzhou	0.783962	14	113	15	78	85	233
Huangshan	0.782276	15	15	21	219	71	43
Lanzhou	0.778462	16	196	20	44	62	242
Xinyu	0.775744	17	238	28	35	101	231
Nanchang	0.775631	18	44	36	62	50	247
Hengyang	0.775171	19	192	14	51	130	162
Guyuan	0.774716	20	251	55	17	51	2

(continued)

Table 6.2 (continued)

City Name	The environmentally friendly characteristic index (5 index results)		The rankings of the individual items of the characteristic index				
	Points	Ranking	Industrial sulfur dioxide emissions per unit of GDP	Private car ownership/civilian car ownership	Fertilizer use (fold scalar) per unit of arable land	The use rate of major clean energy	The expenditure of agriculture, forestry, water affairs/urban GDP
Fuzhou	0.773729	21	110	24	81	155	38
Xiangtan	0.772448	22	161	12	112	108	219
Shenzhen	0.772176	23	2	113	221	5	281
Chongqing	0.766438	24	193	49	65	43	122
Qinzhou	0.76586	25	114	1	265	67	136
Ningbo	0.760059	26	97	41	103	74	223
Luzhou	0.759949	27	180	38	139	53	65
Liaocheng	0.755379	28	3	239	191	105	199
Binzhou	0.754978	29	121	11	86	177	129
Benbu	0.753715	30	82	23	252	40	119
Yiyang	0.752743	31	205	10	79	187	108
Zhongwei	0.751232	32	272	157	98	4	11
Yueyang	0.750631	33	124	16	64	168	172
Karamay	0.750224	34	209	31	1	141	284
Fuxin	0.750001	35	277	59	76	110	32
Haikou	0.746855	36	4	153	283	14	209
Hegang	0.746695	37	203	139	26	59	92
Tianshui	0.746427	38	108	172	32	99	16
Changde	0.746299	39	78	8	53	210	142
Shuangyashan	0.744222	40	158	155	13	100	112

(continued)

Table 6.2 (continued)

City Name	The environmentally friendly characteristic index (5 index results)		The rankings of the individual items of the characteristic index				
	Points	Ranking	Industrial sulfur dioxide emissions per unit of GDP	Private car ownership/civilian car ownership	Fertilizer use (fold scalar) per unit of arable land	The use rate of major clean energy	The expenditure of agriculture, forestry, water affairs/urban GDP
Huaihua	0.743762	41	175	4	21	236	80
Jingzhou	0.742972	42	164	26	202	127	73
Changzhou	0.742682	43	18	94	95	31	261
Shaoyang	0.74254	44	60	13	54	243	41
Urumqi	0.742112	45	167	93	2	28	249
Yongzhou	0.739698	46	102	9	58	242	48
Wuxi	0.739492	47	27	56	115	89	272
Jinchang	0.739122	48	284	144	110	20	96
Shanwei	0.739037	49	89	2	181	166	144
Benxi	0.738776	50	225	33	37	160	222
Jingdezhen	0.73728	51	198	163	34	45	123
Zhuhai	0.736916	52	56	95	90	8	270
Jixi	0.735619	53	188	255	4	82	101
Guiyang	0.73419	54	168	97	41	77	188
Hangzhou	0.733435	55	25	108	67	24	274
Yangquan	0.733354	56	275	80	30	11	246
Suzhou	0.73326	57	48	112	94	12	264
Daqing	0.732787	58	32	46	12	139	275
Tongchuan	0.729232	59	215	47	206	25	60
Dandong	0.728975	60	151	219	105	87	94

(continued)

Table 6.2 (continued)

City Name	The environmentally friendly characteristic index (5 index results)		The rankings of the individual items of the characteristic index				
	Points	Ranking	Industrial sulfur dioxide emissions per unit of GDP	Private car ownership/civilian car ownership	Fertilizer use (fold scalar) per unit of arable land	The use rate of major clean energy	The expenditure of agriculture, forestry, water affairs/urban GDP
Yingtan	0.72698	61	170	34	28	222	176
Huainan	0.726041	62	247	27	268	42	170
Jiujiang	0.725988	63	224	48	70	169	85
Quzhou	0.724661	64	197	128	83	121	126
Suihua	0.7244	65	40	17	24	282	24
Taizhou	0.724096	66	81	130	145	2	179
Chuzhou	0.721888	67	83	39	220	133	33
Jiamusi	0.721673	68	77	72	7	196	15
Pingxiang	0.721022	69	270	58	59	143	158
Zhenjiang	0.72033	70	116	129	74	61	251
Wenzhou	0.720317	71	21	249	96	72	198
Shaoxing	0.720164	72	67	152	80	44	255
Nanjing	0.719706	73	58	147	87	41	268
Taizhou	0.719154	74	57	236	102	63	171
Huludao	0.718301	75	260	89	97	152	87
Qitaihe	0.717322	76	237	271	11	79	75
Dalian	0.716762	77	53	51	132	119	248
Jiaxing	0.716426	78	119	88	75	124	235
Harbin	0.716412	79	51	85	50	150	193
Dongguan	0.715448	80	105	191	14	7	280

(continued)

Table 6.2 (continued)

City Name	The environmentally friendly characteristic index (5 index results)		The rankings of the individual items of the characteristic index				
	Points	Ranking	Industrial sulfur dioxide emissions per unit of GDP	Private car ownership/civilian car ownership	Fertilizer use (fold scalar) per unit of arable land	The use rate of major clean energy	The expenditure of agriculture, forestry, water affairs/urban GDP
Fuyang	0.714404	81	85	44	183	147	40
Datong	0.714168	82	273	243	49	75	137
Xinyang	0.713582	83	112	127	164	76	90
Chengdu	0.711491	84	12	221	125	55	257
Taiyuan	0.710971	85	182	164	42	36	267
Maanshan	0.710773	86	211	45	180	96	201
Nanning	0.710217	87	38	79	168	80	202
Shangqiu	0.709898	88	122	57	259	68	88
Chongzuo	0.708784	89	45	3	150	272	71
Guangzhou	0.708576	90	9	84	261	27	278
Ezhou	0.708295	91	221	7	281	65	221
Heyuan	0.708129	92	69	160	128	129	76
Tianjing	0.708007	93	65	185	133	3	254
Yinchuan	0.707833	94	242	162	200	1	143
Heihe	0.707461	95	231	74	6	216	5
Ji’an	0.707281	96	156	52	27	223	27
Qingdao	0.706762	97	22	106	142	97	271
Wuhai	0.706127	98	280	242	111	10	184
Hefei	0.705834	99	23	43	241	116	232
Pingliang	0.705151	100	258	50	57	220	12

reduce the amount of fertilizer use and increase the use of clean energy. Industrial sulfur dioxide emissions per unit of GDP in Sanya was the lowest and the individual index of industrial sulfur dioxide emissions per unit of GDP in Sanya ranked first. Its utility rate of clean energy also ranked close to the top but its chemical fertilizer application per unit of arable land is higher, thereby decreasing its ranking. Therefore, Sanya needs to reduce the amount of chemical fertilizer used in agricultural production and apply organic fertilizer in the future. This would be more conducive to improving the quality of urban water and the soil environment. Meanwhile, Sanya needs to strengthen the construction of its urban public transport system and make reasonable efforts to control the number of private cars. The five characteristic indicators of Qiqihar ranked third overall and it needs to strengthen its use of clean energy. Xining needs to control sulfur dioxide emissions per unit of GDP. Shanghai has done a good job in controlling sulfur dioxide emissions and using clean energy, so in the future it should strengthen its investment in environmental protection. Zhoushan did an excellent job in the construction of the environmentally friendly city. It should enhance the use of clean energy in the future, control sulfur dioxide emissions, and continue to control private car ownership. Changsha did an outstanding job in reducing sulfur dioxide emissions and controlling private car ownership, and it should strengthen the use of clean energy and increase investment in future environmental protection. Yichun showed outstanding performance in controlling private car ownership and fertilizer use on farms. To continue such a performance, it should further reduce sulfur dioxide emissions and promote the use of clean energy. Loudi and Fushun need to strengthen their use of clean energy.

In the indices of industrial sulfur dioxide emissions per unit of GDP in China, Zhangjiajie, Xinyu, Guyuan, Yiyang, Zhongwei, Karamay, Fuxin, Hegang, Jinchang, Benxi, Yangquan, Tongchuan, Huainan, Jiujiang, Pingxiang, Huludao, Qitaihe, Datong, Maanshan, Ezhou, Yinchuan, Heihe, Wuhai and Pingliang ranked lower than 200th, so the municipal government of these cities need to strengthen control of sulfur dioxide emissions in future.

Among the indices of civil car ownership in China, the proportion of private car ownership in Liaocheng, Jixi, Dandong, Wenzhou, Taizhou, Qitaihe, Datong, Chengdu and Wuhai is very high. Therefore, these cities have to steer the development of private car ownership effectively and strengthen the construction of urban public transport systems in order to prevent urban congestion or further deterioration in the future.

In terms of fertilizer use per unit of arable land in the environmentally friendly characteristic indices, Huangshan, Shenzhen, Qinzhou, Bengbu, Haikou, Jingzhou, Tongchuan, Huainan, Chuzhou, Shangqiu, Guangzhou, Ezhou, Yinchuan and Hefei ranked at the bottom. In order to protect the quality of both urban water and soil, those cities need to control farmland fertilizer use and use more organic fertilizer where possible in order to promote ecological agriculture. In terms of the indices of major clean energy use, Changde, Huaihua, Shaoyang, Yongzhou, Yingtan, Suihua, Chongzuo, Heihe, Ji’an and Pingliang ranked at the bottom and they need to work harder.

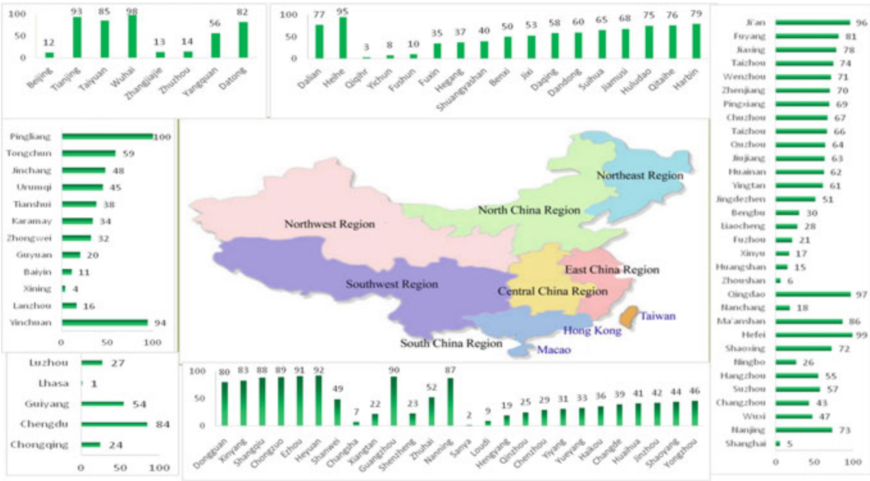

Fig. 6.1 Environmentally friendly characteristic index of the top 100 cities in China in 2013

As far as investment in agriculture, forestry and water affairs is concerned, Shenzhen, Karamay, Changzhou, Wuxi, Zhuhai, Hangzhou, Suzhou, Daqing, Zhenjiang, Shaoxing, Nanjing, Dongguan, Chengdu, Taiyuan, Guangzhou, Tianjin and Qingdao ranked below 250th. These cities should increase their future investment in agriculture, forestry and water affairs in order to improve their urban ecological environments and their carrying capacities.

In accordance with the specific administrative areas of these cities, we put the top 100 environmentally friendly cities in 2013 on a map of Chinese administrative regions (Fig. 6.1). It can be seen from the figure that there were only three cities from northern China in the top 20 in 2013, while the other northern cities in the top 100 ranked from 50th to 100th. In the northeast region there were seven cities in the top 50, while the remaining cities ranked lower than 50th. Across the various Chinese regions, the number of the cities in the top 100 in eastern China numbered 32—the largest of all the regions. Secondly, in the southern region of central China, there was a total of 26 cities. Only five cities in southwestern China were in the top 100. In the northwestern region, there were 12 cities in the top 100.

6.4 Conclusion and Discussion

6.4.1 *A Comparative Analysis of Environmentally Friendly Cities in China*

In the evaluation and analysis of cities with the five environmentally friendly characteristics in China in 2013, we analyzed the number of the cities in the top 100 across the different regions and the results are shown in Fig. 6.2. Of the cities in northern China, 2.8 % were in the top 100, while the number of the cities in the top 100 in northeast China was 6 % of the total number of cities evaluated. The number of cities in the top 100 in eastern China was 11.3 % of the total number of cities evaluated, while the number of cities in the top 100 in south-central China was 9.2 % of the total number of cities evaluated. The number of cities in the top 100 in southwestern China was only 1.8 % of the number of cities evaluated, while the number of the cities in the top 100 in northwestern China was 4.2 % of the number of cities evaluated. According to the above data, in the proportion of the top 100 environmentally friendly Chinese cities, the proportion of cities in the top 100 in eastern China was equal to the sum of the proportions of the cities in the top 100 in northeastern, northwestern and southwestern China, or twice of that of the northeast. From the overall development of the cities, the strength of the construction of the environmentally friendly city in eastern China was noticeably high and showed much potential. The number of top cities in the north, southwest and northwest areas was less than 5 % so efforts are needed in these areas. Overall, the construction of the environmentally friendly city in eastern China was outstanding and was followed by the northeast, the north, the northwest and the southwest. Chinese cities need to reduce sulfur dioxide emissions in the future and actively promote the use of clean energy. Meanwhile, they should strengthen the construction of their urban public transport systems and put reasonable controls on the number of private cars. This would play an important role in the promotion of urban environmentally friendly characteristics.

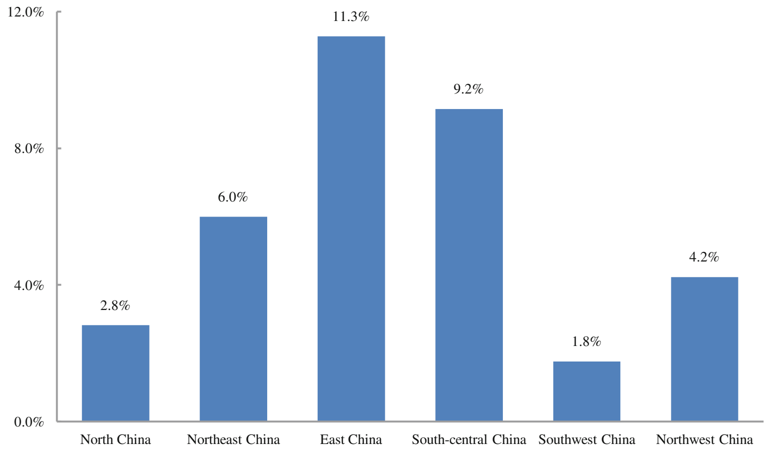

Fig. 6.2 Proportions of the number of the top 100 cities in the different regions of China to the total number of the cities evaluated

6.4.2 Suggestions for the Construction of the Environmentally Friendly City

Based on the above evaluation and analysis, and on successful experiences both at home and abroad, we believe that in the construction of the environmentally friendly city we should first carry out research on the carrying capacity of the urban ecology. Then, based on the acquired knowledge, we are able determine the scale and layout of the structure of the urban development and build diversified and ecological urban patterns to place urban production, living and consumption within the range of the ecological environment carrying capacity. We should also establish benign interactive relations between the overall development and the ecological environment of the city. Only then can we lay a firm foundation for the sustainable development of the city.

6.4.3 Urban Ecological Planning Based on the Ecological Carrying Capacity

The ecological carrying capacity is an objective attribute of an ecosystem, reflecting whether the structure and function of such an ecosystem is robust and has the ability to adjust and maintain itself [10]. The ecological carrying capacity generally includes land carrying capacity, environmental carrying capacity and resources carrying capacity etc. The ecological carrying capacity has been regarded as one of the main methods of prediction and evaluation of Strategic Environmental Assessment (SEA) in China [11]. Eco city construction in China should initially be based on the ecological carrying capacity, urban resource conditions and the environmental capacity and limits of the ecosystem. With this information, we should follow the principle adapted to the structure and function to inform urban planning and to control overall population distribution in the future and the division of urban function areas in accordance with ecological principles. In the process of city planning, we must respect nature, take protection of the natural ecology as a motivating factor, adhere to the principle of sustainable and environmentally-friendly development and develop in a scientific and measured manner. City planning needs to take both the natural environment and people into consideration. At the same time, the influence of the residents on the environment should be controlled within appropriate carrying capacity limits. In order to protect the ecosystem, we should guide the development of the city in a measured way. The ecosystem is a complete entity with a certain structure and function and so is the urban ecosystem. Therefore, in urban ecological planning, we should follow a systematic and holistic principle. We should fully consider the basic conditions and characteristics of the city itself, take the characteristics of the region in which the city belongs into account and set reasonable and measured development goals. Furthermore, we should focus on the protection and promotion of the historical and cultural heritage of the city.

6.4.4 Designating the "Musical Notation" of the City on the Basis of the Ecological Carrying Capacity

The urban function zoning should be based on the environmental function zoning at the macro level. Urban environmental function zoning has an important role in protecting the environment from pollution [12]. For example, the environmental function zoning for urban land is generally divided into commercial and recreational areas, residential areas, scenic areas and industrial areas etc. The supporting facilities should be planned sensibly according to the employment profile and population mobility in different areas. In addition, the urban functional zoning must also set the key protection areas of drinking water, historical relics and monuments etc. [13]. So, in urban functional zoning, the city's status and features are combined. According to the ecological carrying capacity of different areas of the city, we should promote the participation and cooperation of the public, municipal government, social groups and organizations. We must also define the "musical notation" of the city to determine the urban function partition on the basis of actively listening to various viewpoints and fully considering the features and future development of the city. The "musical notation" of the city consists of the "red line", the "green line", the "purple line", the "blue line" and the "yellow line" of urban planning. Of these, the "red line" refers to the urban road border within the city planning range; the "green line" refers to the controlling line of various green areas, mountains, and scenic spots within city planning range; the "purple line" refers to the controlling line of protecting historical and cultural sites and historical buildings; the "blue line" refers to the controlling line of protecting rivers, lakes, and wetlands within the city planning range and the "yellow line" refers to the protection range of land for basic facilities [14].

The "five lines" of the city, especially the "green line", "purple line" and "blue line", are of great significance to the sustainable development of the city. Therefore, once they are decided, they should be strictly enforced, and legislation made to prevent and counteract the randomness of urban planning and construction. In the protection of ecological and environmental issues these lines cannot be overstepped [15].

In urban planning, we should also pay particular attention to the development patterns of the city. Whether the urban patterns are suitable or not is directly related to the city's layout and transportation systems etc. Therefore, urban development patterns must be fully and carefully considered and chosen. Because the sustainable development of Chinese cities is facing problems such as an acute shortage of water, challenges to living standards, land and forest resources, high energy consumption, energy shortages and the rapid growth of energy consumption in buildings and transportation etc., then planning of "the compact city" pattern and construction following the public transportation-oriented urban development model are undoubtedly the choices for building a resource-saving and environmentally friendly city [16].

6.4.5 Constructing the Smart City Based on the Ecological Carrying Capacity

In the process of eco city construction in recent years, the smart city arose as a new concept and a new direction in eco city development [17]. The smart city has six main featrues: an intelligent economy, intelligent transportation, intelligent environment, intelligent residents, intelligent living and intelligent administration. The main goal of the smart city is the sustainable development of a city whose aim is the rapid and ethical solving of the problems of urbanization quickly and ethically by applying new generation information technologies [18]. As a result, the smart city will rapidly push forward the construction and development of the eco city in China.

There are no fixed modes in the construction of an eco city. Therefore, different nations, different geographical regions and different cities at different stages of development must determine the scale and layout of the structure of urban development according to their own unique features on the basis of the ecological carrying capacity of the city in order to build diversified ecological urban patterns that are centered on the development of the circular economy, the transformation of the traditional material and one-way energy consumption modes of production, lifestyles and consumption, thereby putting urban production, lifestyles and consumption within the range of the carrying capacity of the ecological environment in order to achieve the integrated development of economic, social and environmental systems and promote harmony between man and nature. Development is an eternal theme of human life and happiness is a goal human beings relentlessly pursue. Therefore, no matter what kind of modes the eco city construction adopts they will have a common theme, which is "development and happiness". We believe that through the joint efforts and constant exploration of Chinese people, eco cities will spring forth like flowers decorating the beautiful landscape of China one after another, combining natural beauty, cultural soul, historical heritage and the spirit of the age.

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Chapter 7
The Development Mode of the Resource-Saving City

Lingfen Kang and Kaiming Li

Abstract This report calculated and ranked the comprehensive indices of the resource-saving city and the health indices of eco cities in the 284 cities at or above prefecture-level from 2008 to 2013 according to the evaluation index system of the resource-saving city, and focused on the evaluation and analysis of those cities whose construction of the resource-saving eco city is of a better standard. Through a comparative analysis of the comprehensive indices and every single indicator of each city, the report studied the differences in construction of the resource-saving eco city in different cities, compared and analyzed the changes in specific cities from 2008 to 2013, studied the differences in eco city construction in some cities over time and explored the reasons for the differences in order to provide theoretical guidance and practical reference for the construction of resource saving eco cities both in China and globally.

Keywords The resource-saving city · The eco city · Health index · Assessment report

7.1 Introduction

Resources are the material basis of human survival and development. A city is a place of resource clusters and concentrated resource consumption. A resource-saving city is a city that safeguards the sustainable development of the economies and societies of cities through comprehensive measures and the improvement of resource utilization efficiency in the fields of production, circulation and consumption in order to achieve maximum economic and social benefits while using the lowest possible resource consumption [1]. The construction of a resource-saving city aims to reduce resource consumption, improve the efficiency of resource utilization under the precondition of ensuring urban economic efficiency and the

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quality of people's lives, in order to enable it to meet the practical needs of contemporary urban development and the needs of future urban development. To build a resource-saving society is an effective way of alleviating the conflict between supply and demand of resources, which is a necessary step to take in order to guarantee national economic and social security and to realize the sustainable development of a social economy as well as being an important measure of the degree of civilization of human society.

The construction of the resource-saving society and resource-saving cities in China began in the 1970s. In recent years, a lot of theoretical research and many studies into the resource-saving society or city have been carried out focusing on the methods, evaluation system, evaluation principles and countermeasures of the construction of resource conserving cities. In practice, some cities, such as Shanghai, Beijing, Nanjing, Shenzhen and Guangzhou took the lead in actions related to the construction of resource-conserving cities. There are still great differences in resource-saving efforts and measures due to differences in history, natural and geographical conditions, economics and the amount of attention paid to saving resources.

7.2 Research Methodology

7.2.1 Constructing the Index System

The resource-saving city is a type of civilized eco city. It not only has the general characteristics of a civilized eco city, but also the specific characteristics of a resource-saving eco city. Therefore, in order to reflect the principle of combining the universality and particularity of the eco city in the evaluation of the construction of ecological civilization, an evaluation index system containing 13 core indicators (adjusted to 14 in 2015) and 5 characteristic indicators of the resource-saving city has been established, aimed at using different methods of guidance and evaluation corresponding to the different types of eco city. The 13 core indicators are totally consistent with the 6 types of city, reflecting the general characteristics of the eco city. The 5 characteristic indicators of the 6 types of eco city are different. The 5 characteristic indices of resource-saving cities reflect the situation of resource conservation and efficient utilization of such resources as urban land, water, electricity and other resources. The specific indicators are the rate of clean energy utilization (%), the proportion of the third industry in GDP (%), water consumption per million Yuan GDP (tons/million Yuan), electric power consumption per capita (KWH/person · year) and the economic aggregation index [the ratio of clean energy utility (%) was adjusted to the public vehicle number owned, per million people in 2015] (see Table 7.1). Among these, the economic aggregation index equals the proportion of the land area of a city accounted for in the urban land area of the country/the proportion the city's GDP accounted for in the urban GDP of the country, reflecting the utilization efficiency of land resources [1].

Table 7.1 Evaluation index system of the resource-saving city

The first grade indicator	The second grade indicator	The third grade indicator (core indices)		Special indices	
		No.	Indices	No.	Indices
The comprehensive indicator of the resource-saving city	Ecological environment	1	Forest coverage rate (%) [green coverage of built- up areas (%)]	15	The public vehicle number owned per million people
		2	PM2.5 [good air quality days (day)]		
		3	The water quality of lakes [Water consumption per capita (ton/per person)]		
		4	Public green areas per capita [green areas per capita (m^2/per person)]		
		5	Hazard-free treatment rate of household garbage (%)		
	Ecological economy	6	Comprehensive energy consumption per unit of GDP (Tons of standard coal/Yuan)		
		7	Comprehensive utilization of general industrial solid waste (%)	16	The economic aggregation index
		8	The rate of urban sewage treatment (%)	17	Water consumption in million Yuan GDP (tons/million Yuan)
		9	Informatization infrastructure [Internet broadband access subscribers (Thousand families)/the total number of urban households at the end of a year]	18	The electric power consumption per capita (KWH/person · year)
		10	Per capita GDP (Yuan/per person)	19	The proportion of the third industry in GDP (%)
	Ecological society	11	Population density (population/km^2)		
		12	The rate of the popularization of ecological environmental protection knowledge and rules and regulations, and that of intact infrastructure pipes (water resources, environment and public facilities management practitioners in the city/Urban population at the end of the year		

(continued)

Table 7.1 (continued)

The first grade indicator	The second grade indicator	The third grade indicator (core indices)		Special indices	
		No.	Indices	No.	Indices
		13	The public satisfaction with the urban ecological environment [the number of civilian vehicles/Urban road length (km)]		
		14	The effect of government investment and construction (expenditure of urban maintenance and construction/city GDP)		

7.2.2 Data Sources

In order to maintain the evaluation results of various types of eco city and the comparability of a type of eco city over the timeframe involved, the data of the evaluation indices of resource-saving eco cities still come from *The Yearbook of Chinese Environment*, *China City Statistical Yearbook*, *The Statistical Yearbook of Urban Construction in China*, *The Statistical Yearbook of the regional economy in China*, the statistical yearbook of every city, the report on the urban national economic and social development and the report on the work of the government etc.

7.2.3 Evaluation Methods

According to the established evaluation index system and evaluation methods of the resource-saving city (see Chap. 3 of the evaluation report on health status of eco cities in China), we calculated and ranked the indicators of different cities and focused on the analysis and evaluation of the comprehensive indices of those resource-saving cities ranking highest by the two-dimensional form and set up the evaluation standard. We judged those cities whose comprehensive indices of the resource-saving city ranked between 1st and 20th to be extremely economical eco cities. Those cities whose comprehensive indices of the resource-saving city ranked between 21st and 35th were judged to be resource efficient eco cities, and those cities whose comprehensive indices of the resource-saving city ranked between 36th and 50th were judged to be moderately resource efficient eco cities.

7.3 Results and Findings

7.3.1 The Evaluation Results of 2008

Of the 114 cities participating in the evaluation, 20 cities, including Shenzhen, Nanjing, Guangzhou, Shanghai, Beijing, Dongguan, Zhuhai, Xiamen, Hangzhou, Xi'an, Jinan, Dalian, Wuxi, Wuhan, Ningbo, Haikou, Nanning, Tianjin, Hohhot and Huangshan, of which the comprehensive indices of the resource-saving city rank in the top 20, are judged to be resource-saving eco cities. The 15 cities comprising Chengdu, Shenyang, Zhengzhou, Nanchang, Suzhou, Changchun, Qingdao, Changsha, Langfang, Hefei, Dongying, Sanya, Lijiang, Fuzhou and Yulin, of which the comprehensive indices of the resource-saving city rank from 21st to 35th, are judged to be economical eco cities. 15 cities including Yinchuan, Yantai, Taiyuan, Hanzhong, Zhongshan, Baotou, Weihai, Zhenjiang, Jiaxing, Urumqi, Chongqing, Zhoushan, Ganzhou, Harbin and Taian, of which the comprehensive indices of the resource-saving city ranked from the 21st to 35th, are judged to be moderately resource efficient eco cities.

In terms of the spatial distribution of the top 50 resource-saving cities, 21 cities are located in eastern China. Of these, there are 9 extremely economical eco cities, 5 economical cities, and 7 relatively economical cities. In the southern China region, there are 8 resource-saving cities. Among these 8 cities, there are 6 extremely economical eco cities, 1 economical city, and 1 relatively economical city. The Northwestern region is the same the Southern region. There are 6 resource-saving cities, among which there is 1 extremely economical eco city, 2 economical cities and 3 relatively economical cities. There are 5 resource-saving cities in both northern China and Central China, and 3 resource-saving cities in both the Southwest and Northeast. There are three main reasons for such distributions: Firstly, the natural conditions in eastern China and southern China are good and there are more cities above the prefecture-level. Secondly, the climate in eastern and southern China is pleasant with rich rainfall and a good ecological environment. Finally, their geographical locations are good, their economies and societies are more developed, and great importance is attached to the construction of the ecological environment and the saving of resources.

In the cities of which the comprehensive indices of the resource-efficient city rank in the top 50, the rankings of the comprehensive indices of most of the cities are consistent with the rankings of the health indices of the eco city of these cities, but are inconsistent with the rankings of the characteristic indices of the resource-saving city. For example, the comprehensive indices of the resource-saving city and health indices of the eco city of such cities as Shenzhen, Guangzhou, Shanghai, Xiamen, Hangzhou, Jinan and Dalian are higher but their characteristic indices of resource conservation are not very high. This is mainly because when compared to other cities, the advantages conferred by the economic development and ecological environment of these cities are outstanding, but in terms of the conservation of resource utility they still need to be strengthened. Some cities are the opposite. For example, the resource-efficient city comprehensive index of Xi'an ranks it 10th, but its eco city health index ranks 38th and its resource-saving characteristic index ranks it 7th. This is mainly because the utilization rate of the main clean energies and the proportion of the tertiary industry in the GDP of Xi'an are somewhat higher with both indicators ranking very close to the top, the rate of electric power consumption per capita is low, the economic aggregation index is higher and its ranking is also relatively close to the top, which results in the resource-saving city comprehensive index of Xi'an being somewhat higher. Other cities such as Haikou, Lijiang, Hanzhong and Ganzhou are in a similar situation.

From the perspective of the characteristic indices of the resource-saving condition, the proportion of the third industry in the GDP of cities including Beijing, Haikou, Guangzhou, Shanghai, Hohhot and Shenzhen is higher and their individual rankings are in the forefront, which is beneficial to the resource conservation of the whole city. The utilization rate of clean energies of cities including Dongguan, Ningbo, Nanjing, Xi'an, Hangzhou, Shenzhen, Zhuhai is higher and their individual ranking is higher, which largely reduces the use of coal, oil and other resources. The water consumption per million Yuan of GDP of such cities as Ganzhou, Zhongshan, Yulin and Langfang is lower and their individual ranking places higher too, which gives a great boost to these cities' rank in the top 50 resource-saving cities. The electric power consumption per capita of these cities including Hanzhong, Lijiang and Ganzhou is lower and their individual rankings are located in the forefront. The economic aggregation index of such cities as Hanzhong, Lijiang, Huangshan, Yulin and Ganzhou is higher and their individual ranking is at the forefront. However, in some cities whose resource-saving city comprehensive indices rank at the forefront, for example Shenzhen, Nanjing, Guangzhou, Shanghai and Beijing, their rankings of water consumption of ten thousand Yuan GDP, electricity consumption per capita and their economic aggregation index are lower, and they need to take further measures to improve the utility efficiency of water, electricity and land resources.

7.3.2 The Evaluation Results of 2009

The 20 cities for which the resource-saving city comprehensive indices rank in the top 20 are Guangzhou, Shenzhen, Nanjing, Beijing, Shanghai, Zhuhai, Dongguan, Xiamen, Hangzhou, Dalian, Hohhot, Baotou, Jinan, Langfang, Tianjin, Wuhan, Changsha, Nanning, Sanya and Heyuan. They are extremely economical eco cities. The 15 cities whose resource-saving city comprehensive indices rank from 21st to 35th including Wuxi, Nanchang, Haikou, Yulin, Suzhou, Ganzhou, Xi'an, Qingdao, Ningbo, Taiyuan, Changchun, Chengdu, Fuzhou, Huangshan and Jiaxing, are judged to be economical eco cities. The 15 cites whose resource-saving city comprehensive indices rank from 36th to 50th, including Hefei, Dongying, Weihai, Zhongshan, Yantai, Yinchuan, Zhenjiang, Lijiang, Zhoushan, Tai'an, Yichun, Baoding, Zhengzhou, Lianyungang and Hanzhong, are judged to be relatively economical eco cities.

In terms of spatial distribution, there are 21 cities whose resource-saving city comprehensive indices rank in the top 50 located in eastern China, of which 6 are judged to be extremely resource-saving eco cities, 7 are economical cities and 8 are moderately economical cities. In southern China, there are 9 resource-saving cities, among which 7 are extremely economical eco cities, 1 is an economical city and 1 is a relatively economical city. In northern China, there are 7 resource-saving cities, among which 5 are extremely economical eco cities, 1 is an economical city and 1 is a relatively economical city. In central China, there are 6 resource-saving cities, of which 2 are extremely economical eco cities, 2 are economical cities and 2 are moderately economical cities. There are 4 in northwestern China, 2 in the southwest, and 1 in northeastern China. The reasons for such distributions are the same as for those in 2008.

In 2009, from the characteristic indices reflecting the status of resource conservation, the proportion of GDP that the third industry accounts for in such cities as Beijing, Haikou, Sanya, Guangzhou, Shanghai and Hohhot is higher and their individual ranking is at the top, which is very favorable in terms of the resource conservation of the whole city. The rate of clean energy utility in the following cities —Guangzhou, Nanjing, Xi'an, Dongguan, Ningbo, Shenzhen, Hangzhou, Zhuhai, Beijing and Shanghai is higher and their individual rankings are at the top, greatly reducing the use of coal, oil and other resources. The water consumption per ten thousand Yuan GDP of such cities as Langfang Yulin, Zhongshan, Lianyungang, Baotou and Dongying is lower and their individual rankings are higher, aiding the cities to be ranked in the top 50 resource-saving cities. The electricity consumption per capita of Ganzhou, Yichun, Hanzhong, Yulin and Lijiang etc., is lower and their individual rankings are close to the top. The economic agglomeration index of Lijiang, Hanzhong, Ganzhou, Huangshan and Yulin is higher and their individual rankings are close to the top of the list. However, in some cities where the resource-saving city comprehensive indices rank at the forefront, for example Shenzhen, Nanjing, Guangzhou, Shanghai and Beijing, the rankings of water consumption per ten thousand Yuan of GDP, electricity consumption per capita and economic aggregation index lag behind and they need to take further measures to improve utility efficiency in their use of water, electricity and land resources.

7.3.3 The Evaluation Results of 2010

The top 20 cities, according to the resource-saving city comprehensive indices, namely Guangzhou, Shenzhen, Nanjing, Beijing, Shanghai, Zhuhai, Hangzhou, Xiamen, Xi'an, Yulin, Wuhan, Dalian, Jinan, Sanya, Nanning, Langfang, Ganzhou, Dongguan, Tianjin and Changchun are judged to be extremely economical eco cities. The 15 cities that include Heyuan, Changsha, Haikou, Shenyang, Hohhot, Nanchang, Huangshan, Hefei, Wuxi, Qingdao, Yinchuan, Ningbo, Chengdu, Weihai and Fuzhou, for which the resource-saving city comprehensive indices rank from 21st to 35th, are resource-saving eco cities. The 15 cities including Suzhou, Zhenjiang, Zhangjiajie Yantai, Lijiang, Hulunbuir, Dongying, TaiYuan, Harbin, Zhongshan, Lianyungang, Baotou, Jiaxing, Taian and Zhengzhou, of which the resource-saving city comprehensive indices rank from 36th to 50th are extremely economical eco cities.

In terms of spatial distribution of the top 50 cities according to the ranking of the resource-saving city comprehensive indices, 20 are located in eastern China, of which 6 are judged to be extremely economical eco cities, 7 are economical cities and 7 are relatively economical cities. There are altogether 9 resource-saving cities in southern China, of which 6 are extremely economical eco cities, 2 are economical cities, and 1 is a relatively economical city. In northern China, there are 7 resource-saving cities, of which 3 are extremely economical eco cities, 1 is an economical city and 3 are relatively economical cities. In central China, there are 6 resource-saving cities, of which 2 are extremely economical eco cities, 2 are economical cites and 2 are relatively economical cities. In the Northwest and the Northeast, there are 3 resource-saving cities and there are 2 in the Southwest. The reasons for such distributions in eastern China and southern China are the same as those in 2008.

From the perspective of the characteristic indices reflecting the condition of resource-saving in 2010, the proportion of the third industry of GDP in such cities as Beijing, Haikou, Sanya, Zhangjiajie, Guangzhou, Hohhot and Shanghai is higher and their individual rankings are at the forefront, which aids the resource-saving status of the whole city. The utilization rate of clean energy in such cities as Xi'an, Dongguan, Guangzhou, Nanjing, Ningbo and Shenzhen is higher and their individual rankings are located at the forefront, greatly reducing their use of coal, oil and other resources. The water consumption per ten thousand Yuan of GDP in such cities as Yulin, Langfang, Zhongshan, Lianyungang and Dongying is lower and their individual rankings are the forefront, contributing to the ranking of the city remaining in the top 50 resource-saving cities. The electricity consumption per capita of such cities as Ganzhou, Hulunbuir, Yulin and Lijiang is lower and their individual rankings are located at the forefront. The economic aggregation indices of such cities as Hulunbuir, Lijiang, Zhangjiajie, Ganzhou, HeYuan and Huangshan is higher and their individual rankings are at the forefront. However, for some cities whose resource-saving city composite indices rank at the top, for example Shenzhen, Nanjing, Guangzhou, Shanghai and Beijing, their water consumption per ten thousand Yuan GDP, electricity consumption per capita and economic aggregation indices rank lower. Therefore, they need to take further measures to improve the efficiency of their use of electricity, water and land resources.

7.3.4 The Evaluation Results of 2011

In 2011, the resource-saving city comprehensive indices of the 20 cities including Shenzhen, Guangzhou, Beijing, Shanghai, Nanjing, Hangzhou, Zhuhai, Xiamen, Xi'an, Hulunbuir, Dongguan, Haikou, Sanya, Dalian, Tianjin, Jinan, Shenyang, Wuhan, Wuxi and Ningbo ranked in the top 20 making them extremely economical eco cities. The resource-saving city comprehensive indices of the 15 cities including Yulin, Yinchuan, Changsha, Changchun, Hohhot, Qingdao, Huangshan, Yantai, Chengdu, Nanchang, Hefei, Suzhou, Jiaxing, Zhoushan and Zhenjiang rank from 21st to 35th, so they are judged as economical eco cities. The resource-saving city comprehensive indices of the 15 cities including Weihai, Fuzhou, Lijiang, Baotou, Ganzhou, Harbin, Langfang, Zhengzhou, Nanning, Tai'an, Shaoxing, Yichun, Taiyuan, Dongying and Zhangjiajie rank from 36th to 50th, making them relatively economical eco cities.

In terms of spatial distribution, most of the cities with resource-saving city comprehensive index rankings in the top 50 are located in eastern China. Altogether there are 21 cities, of which 8 are judged to be extremely economical cities, 8 are economical cities and 5 are relatively economical cites. In southern, central and northern China respectively, there are 7 resource-saving cities. There are 6 extremely economical eco cities and one relatively economical city in southern China. In northern China, there are 3 extremely economical eco cities, one economical city and 3 relatively economical cities. In central China, there is one extremely economical and ecological city, 2 economical cities and 4 relatively economical cities. In both northwestern and northeastern China, there are 3 resource-saving cities. There are 2 additional resource-saving cities in the southwestern region. The reasons for such distributions are the same as those in 2008.

In 2011, from the perspective of the characteristic indices reflecting the condition of resource-saving, the proportion of the third industry in the GDP of such cities as Beijing, Haikou, Sanya, Gguangzhou, Hohhot and Shanghai is higher and their individual rankings are located at the forefront, which is beneficial to saving resources for the whole city. The clean energy utilization rate of such cities as Guangzhou, Shenzhen, Xi'an, Dongguan and Ningbo is higher and their individual rankings are located at the forefront, greatly reducing the use of coal, oil and other resources. The water consumption per ten thousand Yuan of GDP in such cities as Yulin, Hulunbuir, Langfang, Weihai and Tai'an is lower and their individual rankings are located at the forefront, contributing to those cities remaining in the top 50 resource-saving cities. The electricity consumption per capita of such cities as Ganzhou, Yichun, Hulunbuir and Zhangjiajie is lower and their individual rankings are at the forefront. The economic aggregation index of such cities as Hulunbuir, Lijiang and Zhangjiajie is higher, and their individual rankings are at the forefront. However, in some cities where the resource-saving city comprehensive indices rank very highly, for example Shenzhen, Nanjing, Guangzhou, Shanghai and Beijing, the rankings of the water consumption per ten thousand Yuan of GDP, electricity consumption per capita and economic aggregation index still lag behind. Therefore, they need to take further measures to improve the efficient use of their electricity, water and land resources.

7.3.5 The Evaluation Results of 2012

In 2012, the resource-saving city comprehensive indices of the 20 cities including Shenzhen, Guangzhou, Shanghai, Dalian, Wuxi, Nanjing, Hangzhou, Beijing, Xiamen, Dongying, Daqing, Weihai, Qingdao, Shenyang, Suzhou, Zhuhai, Ningbo, Tianjin, Changzhou and Zhenjiang ranked in the top 20, so they are judged to be extremely economical eco cities. The resource-saving city comprehensive indices of the 15 cities including Zhoushan, Yantai, Changsha, Wuhan, Jinan, Fuzhou, Hohhot, Shaoxing, Jiaxing, Karamay, Nanning, Huangshan, Changchun, Nanchang and Hefei ranked from 21st to 35th, and they are judged to be economical eco cities. The resource-saving city comprehensive indices of the 15 cites including Zhongshan, Chongqing, Xi'an, Chengdu, Xinyu, Huzhou, Harbin, Zhengzhou, Kunming, Haikou, Quanzhou, Baotou, Taian, Taiyuan and Jilin ranked from 36th to 50th, so they are relatively economical eco cities.

As can be seen, in 2012 most of the cities with resource-saving city comprehensive indices in the top 50 are located in eastern China. There are 23 cities, of which 12 are judged to be extremely economical eco cities, 8 are economical cities and 3 are relatively economical cities. The second is the Northeastern region, accounting for 7 resource-saving cities, of which 3 are extremely economical eco cities, one is an economical city and 3 are relatively economical cities. The south accounts for 6 resource-saving cities, of which 3 are extremely economical eco cities, one is an economical city and 2 are relatively economical cities. In northern China, there are 5 resource-saving cities, while there are 4 in central China, 3 in southwestern China and 2 in the northwest. The reasons for such distributions are predominantly due to the good natural conditions, pleasant climates, abundant rainfall, good ecological environments, relatively dense urban distribution and more developed economies and societies in eastern and southern China. Furthermore, more attention is paid to the construction of the ecological environment and the saving of resources.

From the characteristic indices reflecting the resource conservation conditions in 2012, the proportion of the tertiary industry in the GDP of such cities as Beijing, Haikou, Guangzhou, Shanghai, Hohhot and Shenzhen is higher and their individual ranking is at the forefront, which is beneficial in terms of saving resources across the whole city. The number of public vehicles per million people in cities such as Shenzhen, Guangzhou, Beijing, Xiamen and Daqing is higher and their individual ranking is at the forefront, greatly reducing energy use. The water consumption per ten thousand Yuan of GDP of such cities as Weihai, Zhongshan, Yantai and Jiaxing is lower and their individual ranking is at forefront, which contributes to the city's rank in the top 50 resource-saving cities. The economic aggregation index of such cities as Shenzhen, Guangzhou, Shanghai, Xiamen, Wuxi and Suzhou is higher and their individual rankings are close to the top. However, in some cities where the resource-saving city comprehensive indices rank at the top, such as Shenzhen, Nanjing, Guangzhou, Hangzhou, Shanghai and Beijing, the ranking of the water consumption per ten thousand Yuan of GDP and electricity consumption per capita lags behind, so they need to take further measures to save water and electricity resources and to improve their efficient utilization of resources.

7.3.6 The Evaluation Results of 2013

The cities where the resource-saving city comprehensive indices rank in the top 20 are Huangshan, Zhoushan, Sanya, Zhuhai, Fuzhou, Xiamen, Dalian, Dhenyang, Haikou, Jingdezhen, Nanning, Huizhou, Yantai, Weihai, Qingdao, Guangzhou, Harbin, Jinan, Xi'an and Suzhou. The rankings of the resource-saving city comprehensive indices of these 20 cities are at the top, and their rankings of the urban health indices of cities are relatively close to the top too. Of the 284 cities participating in the evaluation, these cities are outstanding in their evaluation of the construction of the resource-saving city.

The resource-saving city evaluation report of 2013 classified the 50 cities whose resource-saving city comprehensive indices rank at the top and analyzed their spatial distribution, classifying the top 20 resource-saving cities, such as Huangshan and Sanya, as extremely economical and ecological cities. The 15 cities ranked from 21st to 35th, such as Beijing and Hangzhou were judged to be economical eco cities and the 15 cities ranked from 36th to the 50th, such as Yangzhou and Shenzhen, were judged to be relatively economical and ecological cities.

The resource-saving cities in 2013 are mainly distributed in southern and eastern China with most being of located in Eastern China. Extremely economical cities are mainly distributed along the southeastern route. The reasons for such a distribution is predominantly because eastern China and southern China have good natural conditions, pleasant climate, abundant precipitation, good ecological environments, relatively dense urban distribution and more developed economies and societies. Furthermore, more attention in those regions is paid to the construction of the ecological environment and the saving of resources.

According to the specific administrative areas to which the above mentioned cities belong, the numbers of the top 100 resource-saving cities in the different regions were studied in terms of their spatial distribution. Table 7.2 shows that the number of the cities whose rankings of the resource-saving city comprehensive indices in 2013 are in the top 100 is largest in eastern China, and altogether in this region there are 44 cities accounting for 56.4 % of the total number of the cities. The second is southern China where there are 15 cities which account for 40.5 % of the total number of cities in this region. There are 13 cities in northeastern China, accounting for 38.2 % of the total number of cities in this region. There are 5 cities in central China, 11 cities in northern China, 6 cities in the northwest and 6 cities in the southwest respectively, in the top 100, accounting respectively for 11.9, 34.4, 20.0 and 19.4 % of the total number of cities in these regions. The distribution of cities in southern China and eastern China is relatively dense. Their economies are relatively developed and urban construction pays more attention to ecological construction.

Table 7.2 The number of distribution of the cities where the comprehensive indices rank in the top 100 in the assessment of resource-saving cities in different areas in 2013

Regions	Northwest	North China	Northeast	Southwest	Central China	South China	East China
The total number of cities	30	32	34	31	42	37	78
The number of cities among the top 100 cities	6	11	13	6	5	15	44
The proportion of the total number of cities (%)	20.0	34.4	38.2	19.4	11.9	40.5	56.4

7.4 Conclusion and Discussion

7.4.1 Temporal Changes in the Rankings of the Cities

We can see from Table 7.3 the changes of the rankings of the 50 cities whose resource-saving city comprehensive indices rank highly from 2008 to 2013. The rankings of the resource-saving city comprehensive indices of Shenzhen, Guangzhou and Shanghai from 2008 to 2012 are stable and always remain in the top five cities. Among them, Guangzhou is the most outstanding city in the construction of a resource-saving city. Its ranking rose from 3rd in 2008, to 1st in 2009 and 2nd from 2009 to 2012. The ranking of Nanjing has declined year by year from 2nd in 2008 down to 6th in 2012. It rose from 5th in 2008 to 4th in 2009 and 2011, and in 2010 it rose to 3rd place. The development of Dongguan is very unstable. In 2008, its comprehensive index ranked 6th and in 2009 it fell to 7th. In 2010, it fell further to 18th and in 2011 there was a slight increase to 11th. However, in 2012 it fell to 101st. Zhuhai is relatively stable. From 2008 to 2011 it maintained 6th or 7th. Xiamen and Hangzhou are relatively stable, always placing between 6th and 9th. Cities such as Suzhou, Qingdao, Dalian, Wuxi and Shenyang have made great progress in 2012. Xi'an experienced large fluctuations between 2009 and 2012, declining from 10th in 2008 down to 27th. In 2010 and 2011 it climbed up to 9th and then in 2012 it dropped to 38th. The development of Hohhot and Ningbo also experienced great fluctuations too.

In 2013, the overall rankings of the above cities showed a downward trend. For example, such cities as Shenzhen, Nanjing, Guangzhou, Shanghai and Beijing ranked closer to the top but their rankings fell respectively from 37th to 53rd, 16th, 63rd and 21st. The cities ranking from 1st to 5th respectively are Huangshan, Sanya, Zhuhai, Zhoushan and Fuzhou. There are two reasons for this: Firstly, the number of cities involved in the evaluation increased to 284. For some cities newly participating in the evaluation, whose resource-saving construction degree was not good and whose rankings were closer to the top caused the rankings of cities originally at the top of the list to decline. Secondly, the results of the 2013

Table 7.3 Comparison of the comprehensive indices of resource-saving cities from 2008 to 2013

Cities	Rankings (2008)	Rankings (2009)	Rankings (2010)	Rankings (2011)	Rankings (2012)	Rankings (2013)
Shenzhen	1	2	2	1	1	37
Nanjing	2	3	3	5	6	53
Guangzhou	3	1	1	2	2	16
Shanghai	4	5	5	4	3	63
Beijing	5	4	4	3	8	21
Dongguan	6	7	18	11	101	88
Zhuhai	7	6	6	7	15	3
Xiamen	8	8	8	8	9	6
Hangzhou	9	9	7	6	7	22
Xi'an	10	27	9	9	38	18
Jinan	11	12	13	16	26	20
Dalian	12	13	12	13	4	9
Wuxi	13	21	29	20	5	45
Wuhan	14	16	11	18	23	34
Ningbo	15	29	32	19	20	56
Haikou	16	23	23	15	44	8
Nanning	17	18	15	44	31	11
Tianjin	18	15	19	14	17	30
Holhot	19	10	25	10	28	93
Huangshan	20	34	27	29	32	1
Chengdu	21	31	33	26	39	60
Shenyang	22	53	24	17	13	7
Zhengzhou	23	48	50	43	45	100
Nanchang	24	22	26	30	34	54
Suzhou	25	25	36	32	14	19
Changchun	26	30	20	24	33	43
Qingdao	27	28	30	28	12	15
Changsha	28	17	22	23	22	58
Langfang	29	14	16	42	79	213
Hefei	30	36	28	31	35	32

calculation data show that the resources saving degree of some cities is on a downward trend. For example, cities like Dongguan, Shanghai, Wuxi, Zhengzhou and Langfang. Of these, the trend in Langfang and Zhengzhou is the most obvious with those cities falling from 29th and 23rd to 213th and 100th respectively. From 2009 to 2013, the resource-saving city comprehensive indices of Xiamen and Zhuhai were relatively stable and remained in the top 10 rankings. Zhuhai, Dalian, Haikou, Nanning, Huangshan, Shenyang and Qingdao showed a fluctuating upward trend, with Huangshan being the most outstanding resource-saving city leaping from 20th in 2009 to 1st in 2013.

Shanghai, one of the top cities has a very dense population but its natural resources are scarce. In building the resource-saving city, the municipal government of Shanghai attaches great importance to saving energy and reducing emissions, and makes great efforts to develop renewable energy and improve the efficiency of its conventional energy usage. It takes major projects as the carrier by which to promote the construction of circular economy businesses, and delineates Chongming Eco Island, Lingang New City and Hongqiao Business District as three demonstration areas for conservation, while constructing several low-carbon comprehensive development practice areas including conservation oriented communities and commercial areas and industrial parks, in order to create a new development model for the construction of a conservation oriented city.

Shenzhen has a very good performance in the construction of a resource-saving city and its comprehensive index ranks either first or second. At present, Shenzhen has established an industrial system of a circular economy, an ecological security system, an institution innovation system and the infrastructure system of a circular economy focusing on the recycling of water resources, energy and waste. The energy consumption per ten thousand Yuan of GDP, and water consumption, dropped significantly and the recycling rate of renewable resources is now greater than 98 %. Shenzhen has taken a variety of measures and practices in order to conserve more of its water resources. For example, the water conservation office in Shenzhen has overseen a series of water-saving campaigns to promote and carry out water-saving activities in the city by holding activities in Shenzhen such as the identification of "the good water-saving family", "the water-saving business" and "the water-saving residential area". Shenzhen has also carried out "the three simultaneous examinations and approval" of water saving so as to manage the planned use of water and water usage for construction projects, actively promoted new water-saving technologies and formulated and promulgated the "water-saving equipment list" to limit the production, sale and use of water consuming appliances.

Beginning in 2005, for five years Beijing promulgated an action plan of "speeding up the development of a circular economy and the construction of a resource-saving and environmentally friendly city". A lot of work has been done on the adjustment of industrial structure, saving energy and protecting the environment. Furthermore, remarkable results have been achieved in energy saving and emission reduction, and environmental quality has been significantly improved. The resource saving actions in Beijing have reached many industries and achieved a wide and diversified range of energy-saving measures. In order to achieve the goals of constructing a resource conservation oriented city, the government has established regulations and laws, changed "elastic" requirements into more rigid regulations and carried out mandatory constraints on non-resource-saving activities. Beijing has actively adjusted its industrial structure, increased the tertiary industry of low energy consumption in per added value, improved the energy consumption structure to make the energy consumption of the added value per million Yuan of the three industries tend to decline, strictly pursued the elimination of backward production capacity, and adjusted the location of, or fully withdrew, a group of businesses that consumed high amounts of energy and produced high levels of pollution. The implementation of these measures has enabled Beijing to become a city whose energy consumption indicators continue to reduce.

7.4.2 Spatial Change of City Ranking

Across the whole of China, the distribution of the level of urban resource conservation is very uneven. It can be seen that the 50 resource-saving cities whose comprehensive indices rank highest are mostly located on the Southeastern coast and fewer than 5 cities are located in the Northwest, Southwest and Northeast regions respectively. The data shows that despite the fact that the resource-saving city construction has made remarkable achievements, various cities have also taken active measures in pursuit of resource conservation and energy-saving. However, the reality shows that there is a huge range of difference in the level of urban resource-saving. The number of resource-saving cities in northwestern China dropped from 5 in 2008 to 3 in 2011 with these cities mainly being found in Ningxia and Shaanxi. The number of resource-saving cities in the southwestern region reduced from 3 in 2008 to 2 in 2011, with those two cities being Chengdu in Sichuan and Lijiang in Yunnan. In northern China, central China, southern and eastern China, the resource-saving cities whose rankings of the comprehensive indices are higher are more numerous and have shown a slight increase. Therefore, the cities in the northwest, southwest and northeast need to transform their economic structure as soon as possible and develop into a more circular economy in order to rapidly development the social economy, reduce the economic development and resource-saving gaps between the southern developed cities and themselves.

As the 2012 data shows, the resource-saving cities whose comprehensive indices rank in the top 50 are mainly located in areas which put forward resource conservation oriented urban construction relatively early in China, such as Chang Zhu Tan (There is one city: Changsha), the urban economic development circle of Wuhan (the city of Wuhan), the Yangtze River Delta (12 cities, namely Shanghai, Wuxi, Nanjing, Hangzhou, Suzhou, Changzhou, Zhenjiang, Ningbo, Zhoushan, Jiaxing, Shaoxing and Huzhou), and the Pearl River Delta (4 cities including Shenzhen, Guangzhou, Zhuhai and Zhongshan). The total number of cities is 18 accounting for 36 % of the total. Only five cities in the Northwest and Southwest were in the top 50. They are Oklahoma, Xi'an, Chongqing, Chengdu and Kunming, accounting for only 10 % of the total. This shows that the central western regions in China, especially the western regions, need to further strengthen their pace of construction of a resource-saving city, and better advocate and promote the idea of saving resources at governmental level to fundamentally change people's ideas of saving energy and resources.

From the rankings of the comprehensive indices of the construction of the resource-saving cities in 2012, there were still differences in the regional distribution of cities and there was a general trend of increased growth. Firstly, the number of cities in eastern China and northeastern China showed a trend of increased growth, especially the Yangtze River Delta from the quantity of resource-saving cities in the direction of constructing resources saving cities. It plays an important guiding role in China. Secondly, the quantity of cities and resource conservation efforts in the Midwest region were lower. In addition, of the 50 cities whose composite indices rank at the top, the extremely economical cities are mainly distributed in eastern China, showing once again the regional differences in the construction process of resource conservation oriented cities in China (Table 7.4).

Figure 7.1 shows the change in the number of resource-saving cities whose comprehensive indices rank in the top 50 in each region from 2009 to 2013 in China. From the figure we can see that over these five years, the number of cities in eastern China was relatively stable remaining between 20 and 23. In southern China, the number of cities between 2011 and 2012 significantly decreased, while in 2013 it significantly increased. The number of cities in central China (except for 2011) has declined from 6 in 2009 to 2 in 2013. In northern China, the number of cities declined from 7 in 2009 to 4 in 2013. In the northeastern regions of China, the number of cities showed a rapid increase from 1 in 2009 up to 7 in 2013. In both the northwest and southwest, the overall number of cities was much lower and in these five years there were ups and downs but little overall change. The changes in the above data show that the distribution of the top 50 cities of the comprehensive indices in the different regions is not stable and the number of cities in central China and northern China is declining, while the number of cities in northeastern and southern China is on the rise showing that there are larger differences in the building process of resource conservation oriented cities in these areas.

In the different regions of China, the number of resource-saving cities whose comprehensive indices rank in the top 50 is changing (Fig. 7.1). The number of cities in the northwest tended to decrease, from 5 cities in 2008 to 2 cities in 2012. In the northern, central and southern regions of China, the number of cities increased then decreased and the number of cities in northeastern, eastern and southwestern China remained stable. In 2012, the number increased significantly and compared to 2011, 1, 2 and 4 cities increased respectively. This shows that the distribution of cities whose composite indices rank in the top 50 shows a tendency of differentiation, especially in the northwest where the number of cities significantly reduced, whereas the number of cities in eastern and northeastern China increased significantly, which in some degree shows the differences in the process of resource-saving city construction and the saving of resources in these areas.

The construction and evaluation of resource-saving cities to some extent shows the differences between cities in the construction of the resource-saving city and the eco city. Although the evaluation results are constrained by the rationality of the evaluation system, the integrity of the data and whether the evaluation method is scientific or not, they do objectively reflect the deficiencies and problems of urban resource-saving in China, especially the correlation between the spatial distribution of the number of cities ranking close to the top and the differences in regional

Table 7.4 Distribution of the 50 resource-saving cities whose comprehensive indices rank at the top in different regions in 2008–2013

Regions	Cities (2008)	Cities (2009)	Cities (2010)	Cities (2011)	Cities (2012)	Cities (2013)
Northwest	Urumqi, Yinchuan, Xi'an, Yulin, Hanzhong	Yinchuan, Xi'an, Yulin, Hanzhong	Yinchuan, Xi'an, Yulin	Yinchuan, Xi'an, Yulin	Karamay, Xi'an	Xi'an, Urumqi
Southwest	Chengdu, Chongqing, Lijiang	Chengdu, Lijiang	Chengdu, Lijiang	Chengdu, Lijiang	Chongqing, Chengdu, Kunming	Chongqing, Kunming, Lijiang
North China	Holhot, Baotou, Tianjin, Beijing, Langfang	Holhot, Baotou, Tianjin, Beijing, Langfang, Taiyuan, Baoding	Holhot, Baotou, Tianjin, Beijing, Langfang, Hulunbuir, Taiyuan	Holhot, Baotou, Tianjin, Beijing, Langfang, Hulunbuir, Taiyuan	Beijing, Tianjin, Holhot, Baotou, Taiyuan	Beijing, Tianjin, Qinhuangdao, Erdos
Central China	Zhengzhou, Wuhan, Changsha, Nanchang, Ganzhou	Zhengzhou, Wuhan, Changsha, Nanchang, Yichun, Ganzhou	Zhengzhou, Wuhan, Changhsha, Zhangjiajie, Nanchang, Ganzhou	Zhengzhou, Wuhan, Changsha, Zhangjiajie, Nanchang, Yichun, Ganzhou	Changsha, Wuhan, Nanchang, Zhengzhou	Shenyan, Wuhan
South China	Guanghzou, Zhongshan, Dongguang, Shenzhen, Zhuhai, Haikou, Sanya, Nanning	Guanghzou, Zhongshan, Dongguan, Heyuan, Shenzhen, Zhuhai, Haikou, Sanya, Nanning	Guanghzou, Zhongshan, Dongguan, Heyuan, Shenzhen, Zhuhai, Haikou, Sanya, Nanning	Guangzhou, Dongguan, Shenzhen, Zhuhai, Haikou, Sanya, Nanning	Shenzhen, Guangzhou, Zhuhai, Nanning, Zhongshan, Haikou	Sanya, Haikou, Nanning, Guilin, Guangzhou, Shenzhen, Zhuhai, Zhaoqing, Huizhou
East China	Hefei, Huangshan, Nanjing, Zhenjiang, Wuxi, Jiaxing, Suzhou, Hangzhou, Fuzhou, Shanghai, Zhoushan, Ningbo,	Hefei, Huangshan, Nanjing, Zhenjiang, Wuxi, Jiaxi, Suzhou, Hangzhou, Fuzhou, Shanghai, Zhoushan, Ningbo,	Hefei, Huangshan, Nanjing, Zhenjiang, Wuxi, Jiaxing, Suzhou, Hangzhou, Fuzhou, Shanghai, Ningbo, Xiamen, Jinan,	Hefei, Hangshan, Nanjing, Zhenjiang, Wuxi, Jiaxin, Suzhou, Hangzhou, Fuzhou, Shanghai, Zhoushan, Ningbo,	Shanghai, Wuxi, Nanjing, Hangzhou, Xiamen, Dongying, Qingdao, Suzhou, Weihai,	Wuxi, Changzhou, Suzhou, Nantong, Lianyungang, Yangzhou, Zhenjiang, Hangzhou, Huzhou,

(continued)

Table 7.4 (continued)

Regions	Cities (2008)	Cities (2009)	Cities (2010)	Cities (2011)	Cities (2012)	Cities (2013)
	Xiamen, Jinan, Dongying, Taian, Dalin, Yantai, Weihai, Qingdao, Lianyungang	Xiamen, Jinan, Dongying, Taian, Dalian, Yantai, Weihai, Qingdao, Lianyungang	Dongying, Taian, Dalian, Yantai, Weihai, Qingdao, Lianyungang	Xiamen, Jinan, Dongying, Taian, Dalian, Yantai, Weihai, Qingdao, Shaoxing	Changzhou, Zhenjiang, Ningbo, Yantai, Zhoushan, Jiaxing, Jinan, Fuzhou, Shaoxing, Huangshan, Hefei, Xinyu, Huzhou, Taian	Zhoushan, Lishui, Hefei, Bengbu, Huangshan, Fuzhou, Xiamen, Jingdezhen, Jiujiang, Xinyu, Jinan, Qingdao, Yantai, Weihai
Northeast	Harbin, Changchun, Shenyang	Changchun	Harbin, Changchun, Shenyang	Harbin, Changchun, Shenyang	Dalian, Daqing, Shenyang, Changchun, Harbin, Quanzhou, Jilin	Shenyang, Dalian, Yingkou, Changchun, Tonghua, Liaoyuan, Harbin

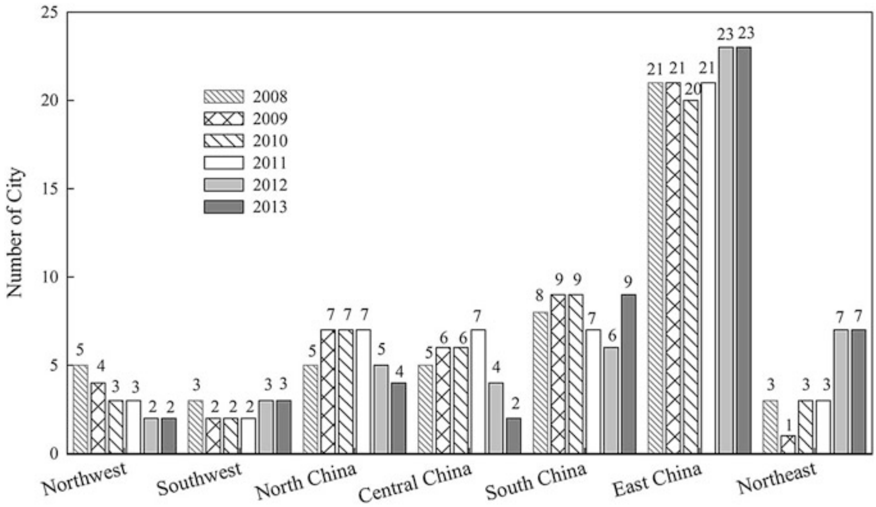

Fig. 7.1 Number of distribution of resource-saving cities whose comprehensive indices rank in the top 50 in 2008–2013 in China

economic development. The main reasons for the gradual reduction in the number of resource-saving cities in eastern and mid-western regions are: firstly, the different spatial distribution of cities; secondly, the differences in industrial structures in the construction of the resource-saving city and finally, the differences in people's opinions and the government's decision making.

In order to improve the level of resource saving of a city, utilize resources sustainably and lay a solid foundation for the sustainable development of both society and economy, the government, businesses and individual as the subjects of resource consumption must make greater efforts to build a resource-conserving society and take corresponding measures in city planning, production, consumption, service, cultural propaganda and raising individual consciousness in order to ensure better performance in the construction of resource-saving cities.

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Chapter 8
Evaluation Report on the Construction of the Circular Economy Oriented City

Guoquan Qian and Cuiyun Wang

Abstract The circular economy oriented city refers to human settlements with a sound ecological environment, developed ecological industries, harmonious and happy citizens, a distinct ecological culture and clean and efficient management. It is a complex artificial ecosystem integrating five aspects—ecology, economy, culture, society and politics—into one. This report combines the core indicators of the health index evaluation of the eco city, chooses the five characteristic indices reflecting the features of a circular economy and establishes the evaluation index system of a circular economy oriented city. The report makes use of this index system to evaluate the 116 cities chosen from 2008 to 2012 and the 284 cities selected in 2013, focusing on the evaluation and analysis of the 50 circular economy oriented cities whose comprehensive index ranks at the top. Based on this, the report makes an in-depth analysis of the ranking changes to the comprehensive index of some cities from 2008 to 2013 and the regional distribution of the top 50 cities.

Keywords The circular economy oriented city · Comprehensive index · Health index · Evaluation

8.1 Introduction

The current economic and social development of China is in a key period because the process of industrialization and urbanization is accelerating and GDP per capita has entered the development stage of \$1000–\$3000. International experience shows that the stage of low-income countries moving to medium-income countries is an extremely important historical stage in the growth of any country. It is not only a "golden development period", but also a period of "emerging problems", especially with current rapid economic and population growth. The problems of insufficient

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resources, such as water, land, energy and mines are becoming more and more obvious and the situation of ecological construction and environmental protection is becoming ever more serious.

The cities in which more than half the world's population live are the areas in which resource consumption is the most clustered. According to statistics from the Environmental Agency of the United Nations, cities consume about 75 % of the world's natural resources and produce 75 % of the world's waste at the same time [1]. So the circular economy should be enthusiastically promoted and developed in the city. In addition, resource consumption in the traditional economic model was highly intensive and caused serious damage to the environment, resources diminished and the environmental carrying capacity rapidly declined. Exploring new models of economic development has become a pressing concern if sustainable development of the city is to be achieved.

The construction of the circular economy oriented city is an attempt by urban developers to adapt to the current situation and can be seen as a product of the regional development of the eco industrial park, organizing the city into an ecological network system by adjusting industrial structure, changing the mode of management and constructing the ecological industry chain within the scope of the city. As far as its connotation is concerned, the circular economy oriented city is a comprehensive system of economy, society and nature. It not only includes the city's economic system, but is also a composite system with humans as the principal component, the natural environment as the basis and with resource flows as the power behind the coordinated development of economy, society and nature.

8.2 Research Methodology

8.2.1 Evaluation Index System of the Circular Economy Oriented City

Based on the connotation and features of the circular economy oriented city combined with the basic requirements of eco city construction, *The Report on the Construction and Development of Chinese Eco Cities* in 2012 established a set of evaluation index systems for a circular economy oriented city, reflecting the basic characteristics of the eco city and the characteristics of the circular economy oriented city from three aspects: ecological environment, ecological economy and ecological society. The index system includes 13 core indicators that reflect the common nature of the eco city and 5 characteristic indicators that reflect the nature of the circular economy oriented city [2]. In the annual evaluation of 2012, according to the problems reflected in the process of evaluation and the degree of difficulty in obtaining indicators, the index system has been adjusted, fine-tuned and perfected. When the circular economy oriented city was evaluated in 2013 and 2014, the index system was adjusted a small amount on the basis of the index system of 2012 but 13 core indices and five characteristic indices were kept.

The index adopted by the evaluation report on the construction of the circular economy oriented city in 2015 was also adjusted on the basis of 2014's index. Of the core indicators, the index of "biodiversity [urban green space area (Hectare)]" and "the expected life expectancy per capita [the natural population growth rate (%)]" were removed, and the "informationization infrastructure [the number of subscribers with internet broadband access (ten thousand families)/the total number of urban households at the end of the year (ten thousand families)]" index, the "population density (i.e., population/km^2)" index and the "effect of government investment and construction (the expenditure of the fund of the urban maintenance and construction/city GDP)" index increased, and the range of the index was adjusted from the original 13–14 items. Based on the principle of "reduce, reuse and recycle", the characteristic indicators were selected from five aspects: the energy productivity rate, the amount of resource consumption, the comprehensive utilization rate of resources, the rate of recycling of renewable resources and the amount of waste emissions. Finally, "the energy productivity rate" replaced "the amount of general industrial solid waste production (ten thousand tons)". Five characteristic indicators were established, namely: (1) the amount of sulfur dioxide emissions (ten thousand tons), represented by the "amount of industrial sulfur dioxide emissions per unit of GDP (kg/ten thousand ¥)" at the time of calculation; (2) the rate of energy output (%), represented by the "the gas-using population/the total urban population at the end of the year (%)" at the time of calculation; (3) the amount of the comprehensive utilization of industrial solid waste, represented by "the rate of the comprehensive utilization of general industrial solid waste (%)" at the time of calculation; (4) the power consumption per unit of GDP (kWh/ten thousand ¥), and (5) the amount of the industrial wastewater emissions per unit of GDP (tons/ten thousand ¥).

Eventually the evaluation index system of the circular economy oriented city consisting of 19 indicators was formed, including 14 core indicators reflecting the common nature of the eco city and the 5 characteristic indicators reflecting the nature of the circular economy oriented city. See Table 8.1.

8.2.2 Methods and Scopes of Evaluation of the Circular Economy Oriented City

8.2.2.1 Data Source and Methods of Evaluation of the Circular Economy Oriented City

The evaluation data of the circular economy oriented city mainly comes from the environment yearbook of China, the yearbook of Chinese cities, the local urban yearbook and local environment bulletin, and the social development report etc. The evaluation method of the circular economy oriented city is the same as the method used in the overall evaluation report of the health conditions in Chinese eco cities (see "the overall evaluation report").

Table 8.1 Evaluation index system of the circular economy oriented city

The first grade indicators	The second grade indicators	No.	The third grade indicators (core indices)	No.	The fourth grade indicators (special indices)
The comprehensive indicators of the circular economy oriented city	Ecological environment	1	Forest coverage rate (%) [green coverage of built up areas (%)]	15	The amount of industrial sulfur dioxide emissions per unit of GDP (kg/ten thousand ¥)
		2	PM2.5 [good air quality days (day)]		
		3	The water quality of lakes [Water consumption per capita (ton/per person)]		
		4	Public green areas per capita [green areas per capita (m^2/per person)]	16	The rate of energy output (ten thousand tons) (the gas-using population/the total urban population at the end of the year)
		5	Hazard-free treatment rate of household garbage (%)		
	Ecological economy	6	Comprehensive energy consumption of per unit of GDP (Tons of standard coal/yuan)		
		7	Comprehensive utilization of general industrial solid waste (%)	17	The amount of comprehensive utilization of industrial solid waste (ten thousand tons) [the rate of comprehensive utilization of general industrial solid waste (%)]
		8	The rate of urban sewage treatment (%)		
		9	GDP per capita (yuan/per person)		
		10	Informatization infrastructure [Internet broadband access subscribers (Thousand families)/the total number of urban households at the end of a year]	18	The power consumption per unit of GDP (kWh/ten thousand ¥)
	Ecological society	11	Population density (population/km^2)		
		12	The rate of the popularization of ecological environmental protection knowledge and rules and regulations, and that of intact infrastructure pipes (water resources, environment and public facilities management practitioners in the city/Urban population at the end of the year)	19	The amount of industrial wastewater emissions per unit of GDP (tons/ten thousand ¥)
		13	The public satisfaction with the urban ecological environment [the number of civilian vehicles/Urban road length (km)]		
		14	The effect of government investment and construction (expenditure of urban maintenance and construction/city GDP)		

8.2.2.2 Evaluation Scopes and Time of the Circular Economy Oriented City

The evaluation of the circular economy oriented city is in accordance with the evaluation index system of the circular economy oriented city. The evaluation in *The Development Report on the Construction of the Eco City in China (2012–2014)* used statistical data from 2008 to 2012, which selected 116 cities to be evaluated and focused on the evaluation and analysis of the top 50 cities in the ranking of the comprehensive index of China's circular economy oriented cities. While the evaluation in *The Development Report on the Construction of the Eco City in China (2015)* used statistical data from 2013 and the number of cities increased to 286 prefecture-level cities, some of the data relating to Simao City and Chaohu City were missing, so they were not included in the evaluation, bringing the actual number of cities evaluated to 284. Based on this, we closely analyzed and evaluated the top 100 cities in the rankings of the comprehensive index of the circular economy oriented city in 2013 in China.

8.3 Research Results

8.3.1 Evaluation and Analysis of the Circular Economy Oriented City

Through the calculation of the core indicators and the characteristic indicators, we determined the comprehensive index of the circular economy oriented city from 2008 to 2013. Through the calculation of the core index, we obtained the health index of the eco city from 2008 to 2013. Through the calculation of the characteristic index, we obtained the characteristic index of the circular economy oriented city from 2008 to 2013 and we ranked them respectively (see Tables 8.2, 8.3, 8.4, 8.5, 8.6 and 8.7).

According to the scores of the comprehensive index of the development of the circular economy oriented city in China, it can be seen from Table 8.2 that the top 10 cities in 2008 were Shenzhen, Shanghai, Nanjing, Beijing, Suzhou, Hangzhou, Yantai, Jinan, Tianjin and Wuxi. Of these cities, the characteristic index ranking of the top four cities, namely Shenzhen, Shanghai, Nanjing and Beijing, and that of Jinan ranked eighth and lagged behind their health index ranking illustrating that the developmental level of the circular economy of those five cities lagged behind their construction level of the eco city, especially that of Shenzhen which ranked in first place and whose health index ranked at the top of the list, while its characteristic index only ranked 59th. So in the future, these cities should concentrate on developing their circular economies and should improve the level of their circular economies. Contrastingly, Suzhou's and Yantai's health index ranked behind their characteristic index, showing that their construction level of their eco cities lagged

Table 8.2 Rankings of the top 50 circular economy oriented cities in 2008 in China

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Shenzhen	0.8743	1	0.9019	1	0.8962	59
Shanghai	0.8704	2	0.8673	3	0.9127	10
Nanjing	0.8702	3	0.8692	2	0.9109	11
Beijing	0.8639	4	0.8636	4	0.9061	26
Suzhou	0.8625	5	0.8375	15	0.9284	1
Hangzhou	0.8602	6	0.8438	7	0.9174	4
Yantai	0.8549	7	0.8344	21	0.9178	3
Jinan	0.8536	8	0.8415	8	0.9087	20
Tianjin	0.8521	9	0.8383	12	0.9093	16
Wuxi	0.852	10	0.8372	16	0.9102	13
Wuhan	0.8519	11	0.8381	13	0.9091	17
Xiamen	0.8514	12	0.8529	5	0.8961	60
Zhuhai	0.8512	13	0.8517	6	0.8967	58
Qingdao	0.8506	14	0.8361	18	0.9088	19
Chengdu	0.8502	15	0.8334	24	0.9108	12
Ningbo	0.849	16	0.8322	27	0.91	14
Chongqing	0.8489	17	0.8276	33	0.9143	7
Shenyang	0.8483	18	0.8389	11	0.9026	37
Dalian	0.8482	19	0.8403	9	0.9013	43
Benxi	0.8473	20	0.839	10	0.9011	44
Changsha	0.8471	21	0.8352	20	0.904	31
Changchun	0.847	22	0.8361	19	0.9031	34

(continued)

Table 8.2 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Jiaxing	0.8464	23	0.8319	28	0.9059	27
Nanning	0.8463	24	0.8367	17	0.9014	42
Weihai	0.8462	25	0.8326	25	0.905	29
Zhengzhou	0.8456	26	0.8335	23	0.9032	33
Shaoxing	0.845	27	0.827	35	0.9083	22
Baotou	0.845	28	0.8307	30	0.9047	30
Zhangjiajie	0.8448	29	0.8183	51	0.9171	5
Nanchang	0.8447	30	0.8379	14	0.898	53
Jining	0.8447	31	0.8195	48	0.9156	6
Xuzhou	0.8447	32	0.8213	45	0.9136	8
Fuzhou	0.8439	33	0.8325	26	0.9014	41
Harbin	0.8439	34	0.8251	36	0.9083	23
Shijiazhuang	0.8432	35	0.8231	41	0.909	18
Handan	0.8429	36	0.8119	59	0.921	2
Hefei	0.8424	37	0.8312	29	0.9001	48
Quanzhou	0.8419	38	0.8206	46	0.9095	15
Baoding	0.8418	39	0.8272	34	0.9028	35
Haikou	0.8403	40	0.8336	22	0.8948	65
Maanshan	0.8399	41	0.8243	38	0.9025	39
Xi’an	0.8398	42	0.8301	31	0.897	57
Yinchuan	0.8386	43	0.83	32	0.8953	64
Qinhuangdao	0.8381	44	0.8229	42	0.9007	46

(continued)

Table 8.2 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Xiangtan	0.8379	45	0.8229	43	0.9004	47
Huzhou	0.8378	46	0.8232	40	0.9	49
Lianyungang	0.8369	47	0.8198	47	0.9017	40
Daqing	0.8365	48	0.8235	39	0.8976	55
Luoyang	0.8359	49	0.8142	54	0.9056	28
Pingdingshan	0.8355	50	0.8119	58	0.9072	24

Table 8.3 Rankings of the top 50 circular economy oriented cities in 2009 in China

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Shanghai	0.87	1	0.8745	2	0.9069	5
Shenzhen	0.8694	2	0.8999	1	0.8912	62
Nanjing	0.8653	3	0.8685	4	0.9045	8
Beijing	0.8627	4	0.8707	3	0.8993	23
Hangzhou	0.8582	5	0.8469	7	0.9113	2
Suzhou	0.8539	6	0.8386	13	0.9119	1
Tianjin	0.8497	7	0.8384	14	0.9053	6
Xiamen	0.8488	8	0.8539	5	0.8916	58
Wuhan	0.8485	9	0.8386	11	0.9032	11
Zhuhai	0.8481	10	0.8519	6	0.8921	53
Jinan	0.8477	11	0.8406	9	0.9003	18
Wuxi	0.8469	12	0.8379	15	0.9014	15
Yantai	0.8459	13	0.8337	22	0.9034	10
Qingdao	0.8444	14	0.8355	18	0.8995	21
Dalian	0.8437	15	0.8415	8	0.8935	46
Baotou	0.8435	16	0.8339	20	0.8995	22
Ningbo	0.843	17	0.83	28	0.9021	13
Chongqing	0.8419	18	0.8212	40	0.9088	4
Nanning	0.8418	19	0.8373	16	0.894	42
Chengdu	0.8412	20	0.8314	26	0.8981	28
Jiaxing	0.8408	21	0.8339	21	0.8953	36
Changsha	0.8408	22	0.8386	12	0.8915	60

(continued)

Table 8.3 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Nanchang	0.8406	23	0.8392	10	0.8908	66
Changchun	0.8401	24	0.8333	23	0.8948	39
Hefei	0.8399	25	0.8356	17	0.8926	51
Fuzhou	0.8394	26	0.833	24	0.894	43
Shijiazhuang	0.8388	27	0.8235	35	0.9014	14
Jining	0.8386	28	0.8197	43	0.9047	7
Weihai	0.8386	29	0.8346	19	0.8914	61
Xuzhou	0.8379	30	0.8202	42	0.9031	12
Harbin	0.8379	31	0.8237	33	0.8997	20
Zhengzhou	0.8379	32	0.8263	32	0.8973	32
Shenyang	0.8377	33	0.8278	30	0.8958	35
Handan	0.837	34	0.8121	57	0.9097	3
Baoding	0.8364	35	0.8283	29	0.8933	48
Haikou	0.8363	36	0.8329	25	0.8894	69
Shaoxing	0.8362	37	0.8271	31	0.8939	44
Qinhuangdao	0.8361	38	0.8237	34	0.8968	33
Yinchuan	0.8359	39	0.83	27	0.8912	64
Zhangjiajie	0.8353	40	0.8145	51	0.9043	9
Maanshan	0.835	41	0.8184	45	0.8999	19
Quanzhou	0.8331	42	0.8203	41	0.895	38
urumqi	0.8328	43	0.8217	39	0.8933	47
Huzhou	0.8327	44	0.8222	38	0.8927	50

(continued)

Table 8.3 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Xi'an	0.8325	45	0.823	36	0.8918	56
Kunming	0.8322	46	0.8122	56	0.9013	16
Benxi	0.8319	47	0.8146	50	0.8984	27
Zhongshan	0.8313	48	0.8226	37	0.8903	68
Xiangtan	0.8313	49	0.8156	49	0.8965	34
Jiaozuo	0.8311	50	0.8137	52	0.898	29

Table 8.4 Rankings of the top 50 circular economy oriented cities in 2010 in China

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Shanghai	0.8737	1	0.8728	2	0.9133	8
Shenzhen	0.8709	2	0.8919	1	0.8972	62
Nanjing	0.8685	3	0.8659	4	0.9111	14
Hangzhou	0.8661	4	0.8523	6	0.9191	4
Beijing	0.8655	5	0.8682	3	0.905	31
Suzhou	0.8625	6	0.8368	20	0.9292	1
Yantai	0.8568	7	0.8355	23	0.92	3
Tianjin	0.8551	8	0.8402	11	0.9124	12
Wuhan	0.8543	9	0.8386	16	0.9125	11
Jinan	0.8538	10	0.8413	10	0.9093	21
Qingdao	0.853	11	0.8373	17	0.9117	13
Zhuhai	0.8528	12	0.8542	5	0.8972	61
Shenyang	0.8527	13	0.8415	9	0.9073	24
Wuxi	0.8514	14	0.8367	21	0.9097	20
Dalian	0.8511	15	0.844	8	0.9026	45
Xiamen	0.8509	16	0.8521	7	0.896	65
Changsha	0.8509	17	0.8394	14	0.9063	26
Changchun	0.8506	18	0.8398	12	0.9055	29
Ningbo	0.8494	19	0.8319	30	0.911	17
Weihai	0.849	20	0.8369	19	0.9056	28
Hefei	0.8487	21	0.8371	18	0.9048	33
Harbin	0.8487	22	0.8289	33	0.9126	10

(continued)

Table 8.4 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Fuzhou	0.8483	23	0.8338	26	0.9074	23
Nanjing	0.8483	24	0.8387	15	0.9029	44
Jiaxing	0.8481	25	0.8336	27	0.9072	25
Handan	0.8479	26	0.8157	55	0.9264	2
Zhangjiajie	0.8479	27	0.8223	44	0.9183	6
Shaoxing	0.8475	28	0.8286	34	0.9108	19
Chongqing	0.8474	29	0.8226	43	0.9171	7
Nanchang	0.8471	30	0.8394	13	0.9004	51
Jining	0.847	31	0.8205	47	0.9187	5
Baotou	0.8468	32	0.8339	25	0.9048	34
Chengdu	0.8465	33	0.8328	29	0.9053	30
Shijiazhuang	0.8457	34	0.8234	39	0.9131	9
Xi'an	0.8452	35	0.8366	22	0.8999	53
Quanzhou	0.8444	36	0.8232	41	0.911	16
Zhengzhou	0.8438	37	0.8297	31	0.9036	41
Yinchuan	0.8437	38	0.8352	24	0.8986	57
Qinhuangdao	0.8431	39	0.8259	36	0.9062	27
Xuzhou	0.8409	40	0.8174	51	0.911	15
Haikou	0.8408	41	0.833	28	0.8961	64
Kunming	0.8407	42	0.8172	52	0.9109	18
Daqing	0.8405	43	0.8278	35	0.9001	52
Huzhou	0.8394	44	0.8244	37	0.9015	48

(continued)

Table 8.4 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Lianyungang	0.8394	45	0.8209	46	0.9048	32
Maanshan	0.838	46	0.8188	49	0.9044	35
Guiyang	0.8377	47	0.8237	38	0.8993	54
Baoding	0.8377	48	0.8292	32	0.8944	70
Urumqi	0.8368	49	0.8223	45	0.8992	55
Jiaozuo	0.8358	50	0.8171	53	0.9025	46

Table 8.5 Rankings of the top 50 circular economy oriented cities in 2011 in China

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Shenzhen	0.8682	1	0.8864	1	0.8969	65
Shanghai	0.8663	2	0.8595	2	0.9129	12
Huangzhou	0.8638	3	0.8464	7	0.921	4
Nanjing	0.8634	4	0.8566	4	0.9109	18
Beijing	0.86	5	0.8582	3	0.9046	42
Chongqing	0.8562	6	0.8201	36	0.9385	1
Suzhou	0.8553	7	0.8272	20	0.9267	3
Tianjin	0.8516	8	0.8336	11	0.913	11
Yantai	0.8515	9	0.8271	22	0.9197	6
Wuhan	0.8512	10	0.8327	13	0.9132	10
Zhuhai	0.8511	11	0.8507	5	0.8973	63
Changsha	0.85	12	0.8333	12	0.9106	20
Jinan	0.85	13	0.8336	10	0.9102	21
Dalian	0.8487	14	0.8358	8	0.906	32
Xiamen	0.8486	15	0.8476	6	0.896	66
Wuxi	0.8476	16	0.8295	17	0.9102	22
Nanchang	0.8475	17	0.832	14	0.9076	27
Shenyang	0.8473	18	0.8338	9	0.9057	35
Hefei	0.847	19	0.8271	21	0.9115	16
Ningbo	0.8468	20	0.8261	26	0.9122	14
Changchun	0.8464	21	0.8304	16	0.9073	28
Jiaxing	0.8445	22	0.8262	25	0.9082	25

(continued)

Table 8.5 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Chengdu	0.8441	23	0.828	19	0.9058	33
Fuzhou	0.8439	24	0.8254	27	0.908	26
Handan	0.8438	25	0.8088	50	0.927	2
Shaoxing	0.8427	26	0.8205	35	0.911	17
Xi’an	0.8427	27	0.8316	15	0.9002	56
Jining	0.8424	28	0.8115	47	0.9206	5
Weihai	0.8424	29	0.8254	28	0.9055	37
Shijiazhuang	0.8417	30	0.8165	41	0.9134	9
Quanzhou	0.8415	31	0.8171	40	0.9124	13
Yinchuan	0.8412	32	0.8267	24	0.9022	50
Baotou	0.8412	33	0.8245	30	0.9043	45
Harbin	0.8406	34	0.8226	33	0.905	39
Urumqi	0.8403	35	0.8231	32	0.9043	47
Nanjing	0.8403	36	0.825	29	0.9025	49
Kunming	0.8403	37	0.8118	46	0.9161	8
Qingdao	0.84	38	0.8153	43	0.9117	15
Daqing	0.8396	39	0.8241	33	0.902	49
Zhengzhou	0.8395	40	0.8214	31	0.9045	52
Lianyungang	0.8389	41	0.8193	34	0.9055	44
Kalamayi	0.8379	42	0.8268	38	0.897	36
Haikou	0.8377	43	0.828	23	0.8955	64
Qinhuangdao	0.8374	44	0.8134	18	0.909	68

(continued)

Table 8.5 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Xuzhou	0.8371	45	0.8114	44	0.9106	24
Huzhou	0.8359	46	0.8179	48	0.9018	19
Pingdingshan	0.835	47	0.8086	39	0.9099	53
Baoding	0.8341	48	0.8124	52	0.9043	23
Guiyang	0.8331	49	0.8159	45	0.8991	46
Zhongshan	0.8328	50	0.82	42	0.8949	61

Table 8.6 Rankings of the top 50 circular economy oriented cities in 2012 in China

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Shanghai	0.8737	1	0.8705	2	0.8819	2
Shenzhen	0.8566	2	0.9054	1	0.7817	64
Tianjin	0.8446	3	0.8297	16	0.8834	1
Nanjing	0.8409	4	0.8481	3	0.8219	9
Suzhou	0.8364	5	0.8376	11	0.8333	5
Beijing	0.8341	6	0.8404	9	0.8293	7
Wuxi	0.8339	7	0.8460	5	0.8026	29
Daqing	0.8338	8	0.8360	14	0.7907	52
Dalian	0.8329	9	0.8462	4	0.7981	35
Zhuhai	0.8294	10	0.8457	6	0.7871	58
Shenyang	0.8282	11	0.8397	10	0.7983	33
Qingdao	0.8278	12	0.8348	15	0.8095	20
Hangzhou	0.8276	13	0.8405	8	0.7940	45
Wuhan	0.8266	14	0.8238	20	0.8339	4
Xiamen	0.8263	15	0.8409	7	0.7883	56
Kalamayi	0.8259	16	0.8373	12	0.7962	38
Weihai	0.8239	17	0.8369	13	0.7901	53
Yantai	0.8233	18	0.8265	17	0.8148	13
Ningbo	0.8205	19	0.8242	18	0.8110	19
Jinan	0.8195	20	0.8158	29	0.8292	8
Zhongshan	0.8139	21	0.8163	28	0.8077	24
Jiaxing	0.8134	22	0.8213	21	0.7928	46

(continued)

Table 8.6 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Chongqing	0.8129	23	0.8186	23	0.7983	34
Hefei	0.8128	24	0.8149	30	0.8074	25
Maanshan	0.8128	25	0.8046	43	0.8339	3
Nanning	0.8125	26	0.8203	22	0.7922	49
Changsha	0.8124	27	0.8241	19	0.7819	63
Zhengzhou	0.8109	28	0.8094	36	0.8147	14
Fuzhou	0.8105	29	0.8164	27	0.7954	39
Shaoxing	0.8102	30	0.8174	25	0.7915	51
Changchun	0.8101	31	0.8168	26	0.7927	48
Baotou	0.8098	32	0.8099	35	0.8094	21
Kunming	0.8095	33	0.8060	40	0.8185	11
Nanchang	0.8088	34	0.8180	24	0.7848	61
Xuzhou	0.8068	35	0.8048	42	0.8119	18
Huzhou	0.8062	36	0.8148	31	0.7837	62
Quanzhou	0.8060	37	0.8102	33	0.7952	41
Chengdu	0.8045	38	0.8082	37	0.7949	42
Jilin	0.8044	39	0.8068	39	0.7984	32
Harbin	0.8043	40	0.8080	38	0.7947	43
Haikou	0.8042	41	0.8140	32	0.7789	66
Xiangtan	0.8040	42	0.8009	47	0.8120	17
Xi'an	0.8037	43	0.8100	34	0.7872	57
Jining	0.8029	44	0.7991	49	0.8128	16

(continued)

Table 8.6 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Yichang	0.8015	45	0.8044	44	0.7941	44
Qujing	0.8013	46	0.7904	65	0.8295	6
Luoyang	0.8008	47	0.7928	64	0.8217	10
Qinhuangdao	0.8007	48	0.7979	52	0.8079	22
Rizhao	0.8005	49	0.7985	51	0.8057	27
Yueyang	0.8000	50	0.8042	45	0.7889	55

Table 8.7 Rankings of the top 50 circular economy oriented cities in 2013 in China

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Sanya	0.889351	1	0.8755	2	0.910134	1
Haikou	0.854578	2	0.8502	11	0.861129	3
Guangzhou	0.826703	3	0.8447	13	0.799723	6
Shenzhen	0.825554	4	0.7989	65	0.865497	2
Beijing	0.82334	5	0.8191	36	0.829764	5
Changsha	0.807573	6	0.7907	78	0.832936	4
Shenyang	0.803819	7	0.8600	8	0.719522	16
Zhoushan	0.803762	8	0.8615	7	0.717214	18
Fuzhou	0.801609	9	0.8521	9	0.725913	12
Qingdao	0.800115	10	0.8351	21	0.747643	8
Zhuhai	0.797758	11	0.8923	1	0.65594	48
Hefei	0.789995	12	0.8185	38	0.747174	9
Huangshan	0.789108	13	0.8408	16	0.711569	20
Wuhan	0.788353	14	0.8317	24	0.723404	13
Xi'an	0.784335	15	0.8385	17	0.703094	26
Weihai	0.78281	16	0.8334	22	0.706876	23
Jinan	0.781776	17	0.8263	31	0.714994	19
Huizhou	0.781136	18	0.8621	6	0.659704	46
Changchun	0.77974	19	0.8037	57	0.743786	10
Dalian	0.77762	20	0.8503	10	0.668654	35
Chengdu	0.775496	21	0.7848	87	0.761567	7
Harbin	0.775469	22	0.8105	45	0.722927	14
Yantai	0.775044	23	0.8352	20	0.684769	31

(continued)

Table 8.7 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Tianjin	0.773963	24	0.8210	35	0.703476	25
Changzhou	0.772512	25	0.8301	27	0.686137	30
Nanjing	0.770439	26	0.8437	14	0.660523	43
Xiamen	0.769424	27	0.8708	3	0.617369	79
Yangzhou	0.766269	28	0.8354	19	0.662609	41
Shanghai	0.764946	29	0.7902	80	0.727065	11
Wuhu	0.764434	30	0.8435	15	0.64582	56
Liaoyuan	0.764102	31	0.8036	58	0.704813	24
Foshan	0.763035	32	0.8118	43	0.689839	29
Zhenjiang	0.761572	33	0.8322	23	0.655594	49
Wuxi	0.761239	34	0.8027	59	0.699099	28
Beihai	0.757682	35	0.8101	46	0.679119	32
Tongchuan	0.75674	36	0.8274	29	0.650759	52
Urumqi	0.756009	37	0.8123	42	0.671602	34
Chongqing	0.753868	38	0.8228	33	0.650496	53
Dongying	0.752306	39	0.8142	41	0.659479	47
Suzhou	0.751142	40	0.8365	18	0.623108	75
Nanjing	0.750033	41	0.8051	52	0.667418	38
Nanchang	0.74979	42	0.8040	56	0.668414	36
Bengbu	0.749525	43	0.8310	25	0.627249	70
Daqing	0.748622	44	0.7737	97	0.711023	21
Hangzhou	0.748547	45	0.8301	28	0.626254	72
Jingdezhen	0.746458	46	0.8498	12	0.591418	102

(continued)

Table 8.7 (continued)

City	The scores of the comprehensive index	The ranking of the comprehensive index	The scores of the health index	The ranking of the health index	The scores of the characteristic index	The ranking of the characteristic index
Kunming	0.744406	47	0.8095	47	0.646798	54
Xinyu	0.743279	48	0.8657	5	0.559614	134
Ningbo	0.742218	49	0.7927	72	0.666469	40
Nantong	0.741201	50	0.8093	48	0.639045	60

behind the developmental levels of their circular economies. The cities whose development of the eco city and the circular economy city were more coordinated were Hangzhou, Tianjin and Wuxi.

The top 10 cities in 2009 (Table 8.3) were Shanghai, Shenzhen, Nanjing, Beijing, Hangzhou, Suzhou, Tianjin, Xiamen, Wuhan and Zhuhai. Their construction levels of their eco cities and the developmental levels of their circular economies were close to each other. Among them, the cities whose developmental levels of their eco cities and circular economies were more coordinated were Nanjing, Hangzhou and Wuhan. The cities whose construction levels of their eco cities were ahead of the developmental levels of their circular economies were Shanghai, Shenzhen, Beijing, Xiamen and Zhuhai, and the cities whose construction levels of their eco cities lagged behind the developmental levels of their circular economies were Suzhou and Tianjin.

The top 10 cities in 2010 (Table 8.4) were Shanghai, Shenzhen, Nanjing, Hangzhou, Beijing, Suzhou, Yantai, Tianjin, Wuhan and Jinan. Of these, the cities whose ranking of health indices were close to the characteristic indices were Shanghai, Hangzhou, Tianjin and Wuhan, and their developmental levels of their eco cities and circular economies were more coordinated. The construction levels of ecology in Shenzhen, Nanjing, Beijing and Jinan were higher and the developmental levels of the circular economies of Suzhou and Yantai were also higher.

The top 10 cities in 2011 (Table 8.5) were Shenzhen, Shanghai, Hangzhou, Nanjing, Beijing, Chongqing, Suzhou, Tianjin, Yantai and Wuhan. Of these, the cities whose construction levels of their eco cities and developmental levels of their circular economies were similar and whose development of their eco cities and their circular economies were more coordinated were Hangzhou, Tianjin and Wuhan. The cities whose construction levels of their eco cities were ahead of the developmental levels of their circular economies were Shenzhen, Shanghai, Nanjing and Beijing, while the cities whose construction levels of their eco cities lagged behind the developmental levels of their circular economies were Chongqing, Suzhou and Yantai.

The top 10 cities in 2012 (Table 8.6) were Shanghai, Shenzhen, Tianjin, Nanjing, Suzhou, Beijing, Wuxi, Daqing, Dalian and Zhuhai. Of these, the cities whose construction level of their eco cities and developmental levels of their circular economies were more coordinated were Shanghai, Nanjing and Beijing. The cities whose construction levels of their eco cities were ahead of the developmental levels of their circular economies were Shenzhen, Wuxi, Daqing, Dalian and Zhuhai. The cities whose construction levels of their eco cities lagged behind the developmental levels of their circular economies were Tianjin and Suzhou.

The top 10 cities in 2013 (Table 8.7) were Sanya, Haikou, Guangzhou, Shenzhen, Beijing, Changsha, Shenyang, Zhoushan, Fuzhou, and Qingdao. Of these, the cities whose construction levels of their eco cities and developmental levels of their circular economies were similar and the development of the eco city and the circular economy were more coordinated were Haikou, Sanya and Fuzhou. The cities whose construction levels of their eco cities were ahead of the developmental levels of their circular economies were Shenyang and Zhoushan, while the cities whose construction levels of their eco cities lagged behind the developmental levels of their circular economies were Changsha, Guangzhou, Shenzhen, Beijing and Qingdao.

8.3.2 A Comparative Analysis of Circular Economy Cities from 2008 to 2013

According to the calculation results of the comprehensive indices of China's circular economy oriented cities, we analyzed the change in the comprehensive index ranking of some cities from 2008 to 2013 (see Table 8.8). Generally speaking, compared with 2008 to 2012, the change in the rankings in 2013 was much larger. The reasons for this mainly lie in the following two aspects: On the one hand, the indicators used in calculating the health index of the circular economy oriented city in 2013 were adjusted on the basis of the index in 2012. In the core indicators, the "biodiversity [urban green space area (hectare)]" index and "the life expectancy per capita [the natural growth rate of population (%)]" index were removed, and the "information infrastructure [the number of the subscribers with Internet broadband access (ten thousand families)/the total number of urban households at the end of the year (ten thousand families)]" index, the "population density (i.e., population/km^2)" index and the "effect of government investment and construction (the expenditure of urban maintenance and construction/urban GDP)" index were increased, and the number of indices changed from the original 13–14. In the characteristic indices, the "rate of energy production" index replaced "the amount of general industrial solid waste production (ten thousand tons)". On the other hand, from 2008 to 2012, 116 cities were selected for the calculation of the comprehensive indices and the number of cities selected in 2013 reached 286. However, as some data were missing from two cities, only 284 cities were ranked, which led to a larger variation in the rankings of some cities.

It can be seen from Table 8.8 that the ranking situation of the 11 cities of Shenzhen, Beijing, Jinan, Wuhan, Zhuhai, Qingdao, Chengdu, Dalian, Changchun, Nanning and Weihai was stable for 6 years. Of these, the comprehensive indices of the circular economy oriented cities including Shenzhen and Beijing were rather stable from 2008 to 2013 remaining in the top five. Jinan remained near 11th place from 2008 to 2011, but slipped to 20th and 17th in 2012 and 2013 respectively. Wuhan, Zhuhai and Qingdao remained in the top 20. The comprehensive indices of Changchun and Weihai rose slightly. Though the rankings of the comprehensive indices for Chengdu, Dalian and Nanning experienced some change, this was very limited.

The rankings of the comprehensive indices of the circular economy oriented city were stable from 2008 to 2012, but there was a significant drop in 2013 in some cities including Shanghai, Nanjing, Hangzhou, Suzhou, Wuxi, Xiamen, Ningbo, Tianjin, Chongqing and Nanchang. The 10 cities excluding Tianjin and Chongqing

Table 8.8 Changes in the rankings of the comprehensive indices of circular economy oriented cities from 2008 to 2013

City	2008	2009	2010	2011	2012	2013
Shenzhen	1	2	2	1	2	4
Shanghai	2	1	1	2	1	29
Nanjing	3	3	3	4	4	41
Beijing	4	4	5	5	6	5
Suzhou	5	6	6	7	5	40
Hangzhou	6	5	4	3	13	45
Yantai	7	13	7	9	18	23
Jinan	8	11	10	13	20	17
Tianjin	9	7	8	8	3	24
Wuxi	10	12	14	16	7	34
Wuhan	11	9	9	10	14	14
Xiamen	12	8	16	15	15	27
Zhuhai	13	10	12	11	10	11
Qingdao	14	14	11	38	12	10
Chengdu	15	20	33	23	38	21
Ningbo	16	17	19	20	19	49
Chongqing	17	18	29	6	23	38
Shenyang	18	33	13	18	11	7
Dalian	19	15	15	14	9	20
Benxi	20	47	/	/	/	※
Changsha	21	22	17	12	27	6
Changchun	22	24	18	21	31	19
Jiaxing	23	21	25	22	22	109
Nanning	24	19	24	36	26	26
Weihai	25	29	20	29	17	16
Zhengzhou	26	32	37	40	28	79
Shaoxing	27	37	28	26	30	75
Baotou	28	16	32	33	32	111
Zhangjiajie	29	40	27	/	/	※
Nanchang	30	23	30	17	34	42

Note "/" means that the city did not enter the top 50 from 2008 to 2012; "※" means that the city did not enter the top 100 in 2013

are all located in the eastern region of China and their common characteristic is that their economies are developed and their populations are dense. In 2013, the "population density" index was added to the system of core indices, so the above rankings reflected new changes. However, an eco city in accordance with ecological law should be an urban ecological system with a sensible structure including a moderate population density. Thus, the increase of the "population density" index is both necessary and appropriate. There is a change in the rules for the cities of

Jiaxing, Zhengzhou, Shaoxing and Baotou similar to the above mentioned cities, but the decrease is much larger. In addition to the above reasons, it is also associated with the increase in the number of cities selected in 2013.

Although there are fluctuations in the rankings of Changsha and Shenyang, their rankings are experiencing growth. Changsha rose from 21st in 2008 to 6th in 2013 and Shenyang rose from 18th to 7th. The rise of Changsha is due to the vigorous development of their circular economy. Furthermore, in 2013, the ranking of the characteristic index of the circular economy in Changsha was 4th in the nation. The rise of the ranking of Shenyang is mainly because of the construction of their eco city as well and the health index of their eco city secured 8th place in the rankings in 2013 in all of China.

8.3.3 Analysis of the Regional Distribution of China's Top 50 Circular Economy Oriented Cities in 2008–2013

Figure 8.1 shows the changes to the comprehensive indices of the top 50 circular economy oriented cities in every large region of China from 2008 to 2013. As can be seen from the diagram, over the six years the number of cities in eastern and southern China was initially stable followed by a slow rise. The number of cities in the first 5 years in eastern China remained at 21 and 22, while in 2013 it rose to 24. In the first 5 years in southern China, the number of cities in both 2008 and 2010 was 4, while in the other 3 years the number of cities was 5, and in 2013 it rose to 9.

The trends in Central China and northern China were similar, showing a general decline. Apart from in 2012, the number of cities in Central China declined—from 7 in 2008 to 2 in 2013. Similarly, the number of cities in northern China also declined from 7 in 2008 to 2 in 2008. The number of cities in northeastern China was stable between 2009 and 2011 at 5. In the remaining three years, it had

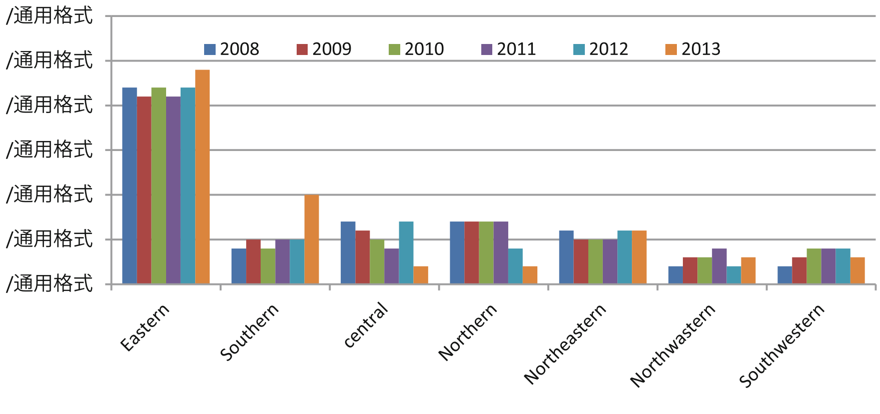

Fig. 8.1 Regional distribution of China's top 50 circular economy oriented cities in 2008–2013

increased to 6. The number of cities in the Northwestern and Southwestern regions was generally lower and over the six years there was little change. The changes to the above data show that the distribution of the top 50 cities of the comprehensive indices across different areas is not stable with the number of cities in central China and northern China falling, while in eastern China and southern China it is rising, showing that differences exist in the construction process of the circular economy oriented city and the development of the circular economy in these areas.

8.4 Results

From the changes to the rankings of the comprehensive indices of the circular economy oriented cities from 2008 to 2013 it can be seen that the change in the rankings in 2013 is much larger than that in the previous five years. This is because the indices used in the calculation of the health index and the characteristic index of the circular economy oriented cities in 2013 were adjusted and the number of cities selected increased from the original 116–286. The cities in which the development of the circular economy oriented city is better include Shenzhen, Shanghai, Nanjing, Beijing, Suzhou, Hangzhou, Tianjin, Sanya, Haikou, Zhuhai, Guangzhou, Changsha, Shenyang and Qingdao among others. The development of the circular economies in these cities is very effective and their constructions of their eco cities are more prominent too.

Generally speaking, the rankings of cities in the southeast coastal areas are relatively high, such as Hangzhou, Suzhou, Shanghai, Shenzhen and Nanjing. The rankings of cities in northwestern inland areas are relatively low, such as Xi’an, Yinchuan and Jinchang. The rankings of the garden cities are relatively high, such as Nanjing, Beijing, Suzhou and Hangzhou. The rankings of the resource-based cities are relatively low, such as Daqing and Pingdingshan. The cities listed as the pilot cities of the circular economy are beginning to emerge, such as Guiyang, Jinchang and Xiangtan. Among the municipalities directly under the control of the central government, the rankings are relatively high, including Shanghai, Tianjin and Beijing.

Looking at the distribution of circular economy oriented cities, they are mainly clustered in eastern China, while the areas with the smallest number are the northwestern and southwestern areas, showing that the construction of the circular economy oriented city is closely related to the condition of the local ecological environment and local societies and economies. Over the six years in question, the number of cities in eastern China and southern China are stable, showing only a small rise, while the trend in central China and northern China is one of a general decline. The number of cities in northeast China is basically stable and the number of cities in northwestern and southwestern China as a whole is lower. Although there are ups and downs, overall there is little change.

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Chapter 9
Development Model of Landscape and Leisure Oriented Cities

Xisheng Tai and Mingtao Li

Abstract A landscape and leisure oriented city is a type of eco city which uses the urban landscape to carry the historical and cultural characteristics of the city, linking man with nature and providing urban residents with an environment conducive to a leisurely life and spiritual enjoyment. The landscape and leisure oriented city combines two elements—urban landscape and urban leisure—and through rational planning and construction of its landscape patterns can continuously improve the quality of urban residents' leisure time, increase the public's life happiness index, build a harmonious society and improve the overall development of politics, culture and the economy. Paying attention to the promotion of urban leisure embodies the humanization of modern urban planning and construction and the promotion of a high quality urban environment. By building the evaluation index system of landscape and leisure oriented cities, which is composed of the five characteristic indices of the landscape and leisure oriented city, namely the landscape patch connectivity, the 500 m radius of the service rate of green space in parks, city tourism revenue's percentage of the city's GDP, the number of theaters and cinemas shared by ten thousand people, the number of parks shared by ten thousand people and 14 core indices of the eco city, this research selects 150 cities above prefecture-level, according to their social, economic and political development levels and compares their landscape patterns and leisure levels. It also selects the top 100 cities in order to evaluate their urban construction. Then, the longitudinal comparison and analysis of cities in different regions is carried out by taking the 19 indices as the urban attribute and by taking the geographical division as the grouping basis and at the same time the degree of correlation between the 19 indices is discussed. Based on these analyses, this research promotes the ideas of constructing and developing landscape and leisure oriented eco cities. Firstly, the city needs to have a sound natural ecology and social environment. Secondly, the layout of the city's landscape structure needs to be suitable, with a certain number of attractive landscape resources. Thirdly, its level of economic development,

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infrastructure construction, leisure service industry, facilities and equipment has to meet its urban residents' leisure needs.

Keywords Landscape and leisure · Natural ecology · The level of economic development · Social environment

9.1 Preface

With the ongoing development of society, politics and economy, in order to address and solve the conflict between economic development and protection of environment and resources, researchers in various fields including ecologists and landscape experts acting as a government think-tank put forward the scientific concept of sustainable development. The process of urbanization development specifically refers to the intention to construct an eco city. Based on the characteristics of different cities, the city's ecological construction develops in different directions, among which the landscape and leisure oriented city is seen as an ideal living environment and in which the natural ecosystem and the artificial ecosystem work together, the layout of the natural landscape is appropriate and efficient and the urban residents are close to nature and enjoy their lives. The arrangement of the urban landscape pattern can effectively improve the ecological service function of the urban landscape and protect the city's ecological security, while also giving full play to the ecological service role of the urban landscape in its residents' daily leisure time. The organic uniting of the plan of landscape construction with the plan of urban construction according to such standards as ornamental function, aesthetic enjoyment, spiritual experience and leisure entertainment can sustain the vitality of the city and increase the livability of the city.

An urban park landscape is defined as an area of concentrated distribution of green space and water, whose layout is closely related to such functions as temperature regulation and absorption, degradation of air pollutants, regulation of microorganisms in the atmosphere, decrease in levels of atmospheric haze and the control of detaining dust, the process of hydrological regulation and an improvement in the degree of comfort in the living environment. However, with the development of the social economy and the accelerated process of urbanization, the scale and population of cities has rapidly increased and the demand for construction land has continued to increase accordingly, resulting in the loss of ecological and agricultural land, an increase in the degree of landscape fragmentation and dispersion, a change to landscape patterns and the absence of a safe urban life [1]. The elements of an urban landscape pattern include landscape type, patch size, shape and spatial adjacency relationship and the impact of these components on urban landscape ecological effects in the process of urbanization is focus of current eco city construction and a hot topic of research. The yearly statistical analysis of the evolution of landscape patterns in the process of urban ecological construction is an effective way to solve the dilemma of analyzing natural ecological succession in the city at present. Firstly, we should match the change in the natural ecological process with the change in landscape patterns and then combine it with the change in landscape patterns brought about by urban construction and analyze the influence of the urban construction process on the natural ecological process. As for the ecological process of urbanization, the construction of a set of indices of landscape patterns is needed to reflect the change in landscape patterns in the process of urbanization and any change to the ecological functions of the landscape caused by this process [2]. The study of urbanization, by fixing quantitative for urban landscape through the index of landscape pattern can provide basic data for both research into the urban landscape structure and the ecological process and further our understanding of urban development [3].

The definition of "leisure" by Ma Huidi, a domestic scholar, has been widely cited in academic circles. She held that "leisure refers to relaxing the body and mind in a variety of 'playful' ways during non-laboring and non-working hours to achieve the aim of health care, physical fitness, and physical and mental pleasure" [4, 5]. In February 2013, the General Office of the State Council promulgated *The Outline of National Tourism and Leisure,* which considers the planning of urban residents' leisure time in the form of national policy as a measure of building a moderately prosperous society, and provides guidance and advice for China's "ecological" urban construction from which it can be seen that urban leisure plays an important role in the development of a peaceful society. Through investigations and analyses, researchers have found that in the process of urbanization the development of the leisure service industry, the improvement of the level of urban leisure and the improvement in people's living conditions are helpful in the promotion of the urbanization process. Furthermore, if no attention is paid to the development of the leisure industry in the process, it will hinder the improvement of the level of urban leisure, which runs contrary to the ultimate aim of urbanization, namely the improvement of the livability of a city [6]. In the process of the investigation, Song Ziqian and other researchers classified the factors that affect the degree of satisfaction of residents' leisure time into three categories: the residents' own ideas, the property of leisure activities and social environment factors such as public leisure facilities and the overall awareness regarding social leisure, which influences the residents' leisure time and pursuits [7]. Of these, it is easiest to implement the planning and construction of public leisure facilities and this can also directly improve the city's livability, which should draw more attention to the process of urbanization in China.

Urbanization in China has come a long way in its development and some problems have accompanied this development. For example, the reduction of urban open spaces, the decrease of ecological benefits, weak economic foundations, unreasonable industrial structures, and too much emphasis on the ecological system taking precedence over the natural system and ignoring the social ecosystem [8].

In the study of eco cities, the evaluation index system can not only reflect the status and nature of the eco city system but it can also monitor the process of the development of the eco city system. The supervision and evaluation of the construction and development process of the eco city can enable the eco city to avoid the development bottleneck in good time. Therefore, since the construction of the eco city is regional, dynamic and complex, establishing the evaluation index system according to different types of eco city is necessary in order to evaluate its developmental process.

9.2 Materials and Methods

9.2.1 Research Objects

This research has selected 150 cities whose ecological developments are seen as good among the 286 cities as measured by the core indicators. Data were collected (Table 9.1) according to the evaluation index system of the landscape and leisure oriented city, and then the top 100 cities were selected for evaluation and analysis in accordance with their ranking (Table 9.2).

9.2.2 Research Methods

The elements of a landscape pattern include: the type of landscape, and the size, shape and spatial adjacency relationships of patches. Landscape patch connectivity is a comprehensive reflection of the various elements of a landscape pattern. The 500 m radius of service rate of green space in the park directly reflects the accessibility of the landscape and the service function of the landscape. The number of parks and theaters not only reflects the manner of leisure, but also describes the number of urban leisure resources. The urban tourism proportion of the city's GDP reflects the tourism resources (the natural landscape and the cultural landscape) and the level of service industry present (catering, transportation and accommodation). In addition, the strong development of the tourism industry can promote the city's overall awareness of the importance of leisure. This research takes basic data on the present status of the land use formed after the vectorization of remote sensing images, uses an ArcGIS software platform to obtain information on the park green patches, and calculates the 500 m radius of service rate [formula (9.1)]. It then proceeds to count landscape patch connectivity by Fragstats, the professional software of landscape ecology [formula (9.2)]. The number of parks in the city is obtained from *the China Urban Construction Statistics Yearbook (2013 Edition)*, the number of theaters in the city is obtained from *the China City Statistical Yearbook (2014 Edition)* and urban tourism revenue and GDP are obtained from *the China Regional Economic Yearbook (2014 Edition).*

The data collected are counted and analyzed using Excel (Microsoft Office 2007 Software), ANOVA and Correlation (SPSS software 16). ANOVA analysis groups analyzes the cities according to geographical division by taking the 19 indicators

Table 9.1 Evaluation indices of a landscape and Leisure City

The first grade indicator	The second grade indicator	Core indices		Characteristic indices	
		No.	The third grade indicator	No.	The fourth grade indicator
The comprehensive indicator of the landscape and leisure oriented city	Ecological environment	1	Forest coverage rate (%) [green coverage of urban built-up area (%)]	15	Landscape patch connectivity
		2	PM2.5 [good air quality days (day)]		
		3	The water quality of lakes [Water consumption per capita (ton/per person)]	16	500 m radius service rate of public green space (%)
		4	public green areas per capita [green areas per capita (m^2/per person)]		
		5	Hazard-free treatment rate of household garbage (%)	17	The percentage of tourism revenues of a city in GDP (%)
	Ecological economy	6	Comprehensive energy consumption per unit of GDP (Tons of standard coal/yuan)		
		7	Comprehensive utilization of general industrial solid waste (%)	18	The number of theaters per ten thousand people
		8	The rate of urban sewage treatment (%)		
		9	per capita GDP (yuan/per person)	19	The number of parks per ten thousand people
		10	informatization infrastructure [Internet broadband access subscribers (Thousand families)/the total number of urban households at the end of a year]		
	Ecological society	11	Population density (population/km^2)		
		12	The rate of the popularization of ecological environmental protection knowledge		

(continued)

Table 9.1 (continued)

The first grade indicator	The second grade indicator	Core indices		Characteristic indices	
		No.	The third grade indicator	No.	The fourth grade indicator
			and rules and regulations, and that of intact infrastructure pipes (water resources, environment and public facilities management practitioners in the city/Urban population at the end of the year)		
		13	The public satisfaction with the urban ecological environment [the number of civilian vehicles/Urban road length (km)]		
		14	The effect of government investment and construction (expenditure of urban maintenance and construction/city GDP)		

included in the 4 comprehensive factors—natural ecology, social environment, economy and landscape leisure as a measure of a city's properties.

$$\text{500 m radius service rate of public green space (F)} = \frac{\text{500 m buffer zone area (P)}}{\text{Urban built} - \text{up area (S)}} \times 100\,\% \quad (9.1)$$

$$\text{Landscape patch connectivity} = \left[\frac{\sum_{j \neq k}^{n} C_{ijk}}{\frac{ni(ni-1)}{2}}\right] \times 100\,\% \quad (9.2)$$

[C_{ijk} is connectivity between the patch j and the patch k in the i type plaque (0 indicates unconnected, 1 indicates connected); ni is the number of i type plaque].

Table 9.2 List of the top 100 landscape and Leisure oriented cities (2013)

Northeast China	North China	East China	South China	Central China	Northwest China	Southwest China
R-city	R-city	R-city	R-city	R-city	R-city	R-city
29-Harbin	2-Qinhuangdao	4-Hangzhou	1-Zhuhai	20-Wuhan	35-Xi'an	8-Lijiang
47-Shenyang	44-Beijing	5-Zhoushan	3-Xiamen	74-Yichang	41-Kalamayi	14-Kunming
51-Dalian	56-Taiyuan	9-Jingdezhen	6-Sanya	87-Changsha	43-Urumqi	34-Chengdu
52-Jingzhou	67-Shijiazhuang	13-Shaoxing	7-Guangzhou	90-Xiangtan	49-Yinchuan	59-Guiyang
64-Dandong	73-Datong	17-Nanjing	10-Fuzhou	94-Jiaozuo	55-Baoji	82-Yibin
66-Changchun	85-Chengde	18-Jiaxing	11-Guilin	95-Luoyang	60-Erdos	83-Zunyi
68-Benxi	96-Hohhot	21-Hefei	12-Beihai	97-Zhuzhou	71-Xining	89-Deyang
81-Liaoyang	22-Taizhou	15-Foshan	91-Lanzhou			
92-Fushun	23-Suzhou	16-Haikou	100-Tianshui			
99-Yingkou	24-Weihai	19-Nanning				
	26-Zhenjiang	25-Shenzhen				
	27-Wuxi	28-Dongguang				
	36-Wuhu	30-Huizhou				
	37-Huzhou	31-Zhongshan				
	38-Xinyu	32-Liuzhou				
	39-Bengbu	33-Zhaoqing				
	40-Ningbo	45-Jiangmen				
	42-Wenzhou	63-Shantou				
	46-Lishui	72-Meizhou				
	48-Quzhou	76-Zhanjiang				
	50-Qingdao	77-Quanzhou				
	53-Jinhua	79-Qingyuan				
	54-Anqing	84-Zhangzhou				

(continued)

Table 9.2 (continued)

Northeast China	North China	East China	South China	Central China	Northwest China	Southwest China
R-city	R-city	R-city	R-city	R-city	R-city	R-city
	57-Changzhou					
	58-Jiujiang					
	61-Lianyungang					
	62-Rizhao					
	65-Maanshan					
	69-Jinan					
	70-Yangzhou					
	75-Shanghai					
	78-Nanchang					
	80-Dongying					
	86-Linyi					
	88-Yantai					
	93-Huaian					
	98-Tai'an					

Note "R" stands for "rank" in this table

9.3 Results and Discussions

9.3.1 ANOVA Analysis

Of the top 100 landscape and leisure oriented eco cities in 2013, 10 cities are in Northeast China, 7 in northern China, 37 in eastern China, 23 in southern China, 7 in Central China, 9 in the Northwest, and 7 in the Southwest (Table 9.2). They are grouped according to their geographical region and the analysis of variance is carried out (Table 9.3) by taking the 19 evaluation indices of the landscape and leisure oriented eco city as variables (Table 9.1).

The ANOVA analysis results (Table 9.3) of the top 100 landscape and leisure oriented eco cities in 2013, which are divided into geographical groups according to the 19 indices, shows that there are significant differences between the percentage of urban tourism revenue in GDP in different regions, the number of days of good air quality, the hazard-free treatment rate of household garbage, the comprehensive energy consumption per unit of GDP, the comprehensive utilization rate of general industrial solid waste, the percentage of the number of Internet broadband users in the total number of urban households at the end of the year, population density, the percentage of staff in the industry of water environment and public facilities management in the city in the total urban population by the end of the year, and the percentage of the expenditure of city maintenance and construction in the GDP of the city. Among the characteristic indices of the landscape and leisure oriented eco city, and especially the percentage that urban tourism revenue accounts for in the GDP of different regions there exist significant differences, which directly relate to the uneven distribution of tourism resources (natural landscape and cultural landscape) in the different regions. In addition, the uneven development of the level of service industry (catering, accommodation, transportation) in different regions will affect the level of tourism development.

9.3.2 Pearson Correlation Analysis

This research, taking the 19 indices as representative of the urban environment studies the correlation between each index (Table 9.4) of the top 100 landscape and leisure oriented eco cities in 2013 using Pearson correlation analysis.

The correlation analysis results (Table 9.4) of the 19 indices of the top 100 landscape and leisure oriented eco cities in 2013 shows that there is a significant positive correlation between landscape patch connectivity and percentage of urban maintenance and construction expenditure in the city's GDP. There is a significant positive correlation between the 500 m radius of the service rate of green space in parks and the percentage of urban tourism revenue accounted for in GDP and that of the staff in the water environment public facility management industry in the total population of the city at the end of the year. There is a significant positive

Table 9.3 ANOVA analysis results of 19 indices of the top 100 landscape and Leisure oriented eco cities grouped according to geographical area in 2013

19 indices[a]		Sum of squares	Degree of freedom	Mean square	F	Significance[b]
Landscape 1	Between groups	0.442	6	0.074	1.911	0.087
	In the group	3.582	93	0.039		
	Sum	4.024	99			
Landscape 2	Between groups	11.976	6	1.996	2.168	0.053
	In the group	85.609	93	0.921		
	Sum	97.586	99			
Landscape 3	Between groups	0.224	6	0.037	2.595	*0.023*
	In the group	1.336	93	0.014		
	Sum	1.559	99			
Landscape 4	Between groups	0.045	6	0.007	0.896	0.502
	In the group	0.772	93	0.008		
	Sum	0.817	99			
Landscape 5	Between groups	3.272	6	0.545	1.142	0.345
	In the group	44.428	93	0.478		
	Sum	47.700	99			
Natural ecology 1	Between groups	173.382	6	28.897	1.696	0.131
	In the group	1584.802	93	17.041		
	Sum	1758.184	99			
Natural ecology 2	Between groups	110010.217	6	18335.036	4.701	*0.000*
	In the group	362752.075	93	3900.560		
	Sum	472762.293	99			
Natural ecology 3	Between groups	132933.908	6	22155.651	1.955	0.080
	In the group	1054002.75	93	11333.363		
	Sum	1186936.66	99			

(continued)

Table 9.3 (continued)

19 indices[a]		Sum of squares	Degree of freedom	Mean square	F	Significance[b]
Natural ecology 4	Between groups	24496.598	6	4082.766	1.220	0.303
	In the group	311217.501	93	3346.425		
	Sum	335714.099	99			
Natural ecology 5	Between groups	3245.003	6	540.834	4.065	*0.001*
	In the group	12374.341	93	133.057		
	Sum	15619.343	99			
Economy 1	Between groups	6.384	6	1.064	9.239	*0.000*
	In the group	10.710	93	0.115		
	Sum	17.094	99			
Economy 2	Between groups	8722.031	6	1453.672	4.473	*0.001*
	In the group	30225.841	93	325.009		
	Sum	38947.872	99			
Economy 3	Between groups	223.533	6	37.256	0.342	0.913
	In the group	10118.556	93	108.802		
	Sum	10342.089	99			
Economy 4	Between groups	119209.134	6	19868.189	4.907	*0.000*
	In the group	376585.523	93	4049.307		
	Sum	495794.657	99			
Economy 5	Between groups	7.317E9	6	1.219E9	1.255	0.286
	In the group	9.036E10	93	9.717E8		
	Sum	9.768E10	99			
Social environment 1	Between groups	2163267.622	6	360544.604	2.584	*0.023*
	In the group	1.298E7	93	139525.906		
	Sum	1.514E7	99			

(continued)

Table 9.3 (continued)

19 indices[a]		Sum of squares	Degree of freedom	Mean square	F	Significance[b]
Social environment 2	Between groups	0.549	6	0.091	2.553	*0.025*
	In the group	3.331	93	0.036		
	Sum	3.880	99			
Social environment 3	Between groups	854556.289	6	142426.048	1.997	0.074
	In the group	6632850.719	93	71320.975		
	Sum	7487407.009	99			
Social environment 4	Between groups	34.175	6	5.696	2.382	*0.035*
	In the group	222.429	93	2.392		
	Sum	256.604	99			

[a]Landscape 1—landscape connectivity; Landscape 2—the 500 m radius service rate of the green space in parks; Landscape 3—the percentage of urban tourism income in GDP; Landscape 4—the number of theatres and cinemas per ten thousand people; Landscape 5—the number of parks per ten thousand people; Natural ecology 1—the forest coverage rate (green coverage of urban built-up areas); Natural ecology 2—PM2.5 (the number of days of good air quality); Natural ecology 3—the water quality of lakes and rivers (the sum of water consumption per person); Natural ecology 4—public green area per capita (the green area per capita); Natural ecology 5—the hazard-free treatment rate of household garbage; Economy 1—the comprehensive energy consumption in GDP per unit; Economy 2—the comprehensive utilization of general industrial solid wastes; Economy 3 – the rate of urban wastewater treatment; Economy 4—informatized infrastructure (the number of city/Internet broadband access subscribers/the total number of households at the end of the year); Economy 5—GDP per capita; Social environment 1—population density; Social environment 2—the popularity of ecological environmental protection knowledge and regulations, the intact rate of infrastructure (the number of employees in the industry of water resources, environment and public facilities management/the urban population at the end of the year); Social environment 3—the public satisfaction rate with the urban ecological environment (the number of civilian vehicles/urban road length); Social environment 4—the government investment and social environment construction effect (the spending on city maintenance and construction/urban GDP)
[b]The significance of variance analysis of those indicators where there are significant differences between groups is emphasized by bold italics, according to the geographic grouping

correlation between the percentage of urban tourism revenue in GDP and that of the staff in water environment public facility management industry in the total population of the city at the end of the year. However, there is a strong negative correlation between the percentage of urban tourism revenue in GDP and GDP per capita. There is a significant negative correlation between the number of cinemas and theaters per ten thousand people and population density, and the percentage that the expenditures of urban maintenance and construction account for in

Table 9.4 Correlation analysis results of the 19 Indices of the Top 100 Landscape and Leisure Oriented Eco Cities in 2013

		L2	L3	L4	L5	NE1	NE2	NE3	NE4	NE5	E1	E2	E3	E4	E5	SE 1	SE2	SE3	SE4
L1[a]	r	−0.043	0.137	−0.246[a]	−0.037	−0.087	0.070	0.072	0.011	0.025	0.129	−0.036	−0.090	−0.042	−0.186	−0.034	0.080	−0.096	0.205[a]
	P	0.674	0.175	0.014	0.712	0.387	0.488	0.474	0.910	0.804	0.201	0.726	0.375	0.675	0.064	0.736	0.428	0.340	0.040
L2	r		0.352[b]	−0.083	0.155	0.127	0.115	0.236[a]	0.181	0.002	−0.173	0.081	−0.087	0.199[a]	0.022	−0.003	0.456[b]	−0.024	0.142
	P		0.000	0.409	0.123	0.209	0.253	0.018	0.072	0.982	0.086	0.425	0.388	0.047	0.827	0.974	0.000	0.811	0.158
L3	r			0.055	0.149	0.063	0.195	−0.104	−0.073	0.090	0.054	−0.010	−0.087	−0.151	−0.28[b]	−0.189	0.333[b]	0.094	0.000
	P			0.587	0.140	0.532	0.052	0.302	0.470	0.375	0.597	0.925	0.387	0.134	0.005	0.059	0.001	0.350	0.995
L4	r				0.081	0.010	0.034	−0.158	−0.127	0.087	−0.116	−0.088	0.157	−0.045	0.123	−0.212[a]	−0.086	0.345[b]	−0.209[a]
	P				0.425	0.923	0.736	0.116	0.207	0.387	0.249	0.386	0.119	0.658	0.223	0.034	0.392	0.000	0.037
L5	r					0.161	0.080	0.684[b]	0.660[b]	−0.171	−0.085	−0.112	0.170	0.475[b]	0.102	−0.030	0.018	−0.034	0.162
	P					0.109	0.431	0.000	0.000	0.090	0.401	0.266	0.092	0.000	0.312	0.769	0.860	0.740	0.108
NE1	r						0.133	0.234[a]	0.221[a]	0.321[b]	−0.093	−0.042	0.116	0.161	0.157	0.049	0.094	−0.188	0.096
	P						0.187	0.019	0.027	0.001	0.360	0.682	0.250	0.110	0.120	0.627	0.353	0.061	0.343
NE2	r							0.003	0.048	−0.098	0.144	−0.123	−0.088	−0.067	−0.192	−0.197[a]	0.001	−0.075	−0.035
	P							0.975	0.632	0.335	0.152	0.223	0.382	0.508	0.055	0.049	0.992	0.457	0.733
NE3	r								0.907[b]	−0.135	−0.074	−0.028	0.052	0.783[b]	0.383[b]	0.302[b]	0.266[b]	−0.257[b]	0.203[a]
	P								0.000	0.181	0.464	0.783	0.610	0.000	0.000	0.002	0.007	0.010	0.043
NE4	r									−0.128	−0.030	−0.107	0.047	0.757[b]	0.390[b]	0.264[b]	0.230[a]	−0.278[b]	0.164
	P									0.206	0.769	0.289	0.643	0.000	0.000	0.008	0.021	0.005	0.104
NE5	r										−0.222[a]	−0.020	0.065	−0.004	0.202[a]	0.034	0.080	0.115	−0.017
	P										0.027	0.841	0.523	0.966	0.044	0.735	0.431	0.256	0.864
E1	r											−0.35[b]	−0.103	−0.32[b]	−0.148	−0.441[b]	0.050	−0.075	−0.049
	P											0.000	0.308	0.001	0.140	0.000	0.622	0.456	0.629
E2	r												−0.183	0.004	−0.047	0.276[b]	−0.120	0.100	0.021
	P												0.069	0.965	0.643	0.005	0.234	0.324	0.839
E3	r													0.162	0.149	0.107	−0.113	0.129	−0.213[a]
	P													0.106	0.138	0.289	0.264	0.199	0.033
E4	r														0.421[b]	0.423[b]	0.193	−0.036	0.147
	P														0.000	0.000	0.054	0.719	0.145

(continued)

Table 9.4 (continued)

		L2	L3	L4	L5	NE1	NE2	NE3	NE4	NE5	E1	E2	E3	E4	E5	SE 1	SE2	SE3	SE4
E5	r															0.183	0.405[b]	−0.098	−0.095
	P															0.068	0.000	0.330	0.348
SE1	r																0.003	−0.056	0.046
	P																0.979	0.583	0.652
SE2	r																	−0.117	0.139
	P																	0.247	0.167
SE3	r																		−0.217[a]
	P																		0.030

Note “L” stands for Landscape, “NE” stands for Natural Ecology, “E” stands for Economy and “SE” stands for Social Environment

L1—landscape connectivity; L2—500 m radius service rate of the green space in parks; L3—the percentage of urban tourism income in GDP; L4—the number of theatres and cinemas per ten thousand people; L5—the number of parks per ten thousand people; NE1—the forest coverage rate (green coverage of urban built-up areas); NE 2—PM2.5 (the number of days of good air quality); NE3— the water quality of lakes and rivers (the sum of water consumption per person); NE 4—public green area per capita (the green area per capita); NE5—the hazard-free treatment rate of household garbage; E1—the comprehensive energy consumption in GDP per unit; E2—the comprehensive utilization of general industrial solid wastes; E3—the rate of urban wastewater treatment; E4—informatized infrastructure (the number of city/Internet broadband access subscribers/the total number of households at the end of the year); E5—GDP per capita; SE1—population density; SE2—the popularity of ecological environmental protection knowledge and regulations, the intact rate of infrastructure (the number of employees in the industry of water resources, environment and public facilities management/the urban population at the end of the year); SE3—the public satisfaction rate with the urban ecological environment (the number of civilian vehicles/urban road length); SE4—the government investment and social environment construction effect (the spending on city maintenance and construction/urban GDP)

[a]There is a significant correlation between two indicators ($P < 0.05$)

[b]There is a highly significant correlation between two indicators ($P < 0.01$)

GDP. Finally, it was found that there is a significant positive correlation between the number of parks per thousand residents and water consumption per capita and green area per capita.

9.4 Results and Suggestions

From the comparative analysis of the geographical region division it can be seen that significant differences exist in the 4 comprehensive factors affecting the development level of the landscape and leisure oriented eco cities in different regions. Social environment factors accounted for 3/4, economic factors accounted for 3/5, natural ecological factors accounted for 2/5 and landscape and leisure factors accounted for 1/5. Therefore, the 4 comprehensive factors impacting on the development level of the landscape and leisure oriented eco cities in order of their importance are: social environment > economy > natural ecology > landscape leisure. Among the landscape leisure factors, the percentage of urban tourism revenue in GDP as a comprehensive index reflects the number of urban landscape leisure resources and the significant differences in the level of urban landscape leisure services and the overall landscape leisure awareness of urban residents in different regions.

From the analysis of correlations among the 19 indicators of landscape and leisure oriented eco cities, it can be seen that those in charge of urban construction and management have paid more attention to the construction of the urban landscape. Appropriate scientific measures will increase urban landscape patch connectivity, and the input of manpower, material resources and financial resources into the urban maintenance and construction will promote the improvement of landscape layout to a large extent. The management and maintenance of the green space in parks as an important urban landscape leisure resource needs a large number of practitioners in the water conservancy and environmental public facility management industry. To a large extent, the high-quality green space services in urban parks and easy accessibility to them can improve the level of landscape leisure in the city, cultivate the overall leisure awareness of urban residents and stimulate the development of urban tourism. The percentage of the city's income from tourism in its GDP reflects the level of development of city tourism and directly increases employment in the third industry. At the same time, more urban residents are also needed to engage in the management and maintenance of water conservancy, environment and public facilities. In China, the income of urban residents is more affected by the second industry, which explains why there is a significant negative correlation between the proportion of a city's revenue from tourism in its GDP and the amount of GDP per capita. At present, the income of people in developed cities is higher and in most cases they choose to travel to other regions and abroad and to sightsee in places with rich natural landscapes and with cultural landscape resources, where the income of the local residents mainly comes from such industries as agriculture, forestry, animal husbandry and fisheries and where only a minority of the population participates in the tourism industry to obtain income. This reflects the phenomenon that in the areas where tourism is developed the GDP per capita is often low. In recent years, the development of the film industry—especially imported films—has stimulated the market, and the investment and construction of large theaters in small and medium cities have increased the number of theaters but the attraction of such literary and artistic forms as the modern drama and the musical play has been lukewarm, limiting the increase in the number of theaters. The limited increase in the number of urban theaters cannot catch up with the growth rate of the city population, which also limits leisure activities such as watching movies or the visiting the theatre. The negative correlation between the number of theaters per million people and the percentage of expenditure on urban maintenance and construction in a city's GDP also demonstrates the fact that less attention is paid to the way city residents enjoy their leisure by watching movies or going to the theatre in the process of the urban development and construction, and the ways that city residents enjoy their leisure time is currently subject to the market economy.

As with other types of eco city, the construction and development of the landscape and leisure oriented eco city first needs a sound environment—more specifically a sound natural environment and social environment. Secondly, the level of economic development is the primary factor supporting urban construction while adjusting and controlling the lifestyles of urban residents is a secondary factor in the construction and development of the landscape and leisure oriented eco city. Thirdly, overall social leisure awareness, residents' own factors, the nature of leisure activities and leisure resources (landscape resources, leisure services and facilities) together constitute the leading factors in the construction and development of the landscape and leisure oriented eco city.

The construction and development of the landscape and leisure oriented eco city should, under the guiding strategy of sustainable development take the characteristics of the natural landscape of the city into consideration and give full play to the advantages of the region, encouraging the participation of the whole of society and striving to make those cities which are suitable for the development of landscape and leisure into eco cities with which their residents are satisfied. In view of the evaluation analysis of China's urban development in 2013 this report puts forward the following countermeasures and suggestions for the construction of landscape and leisure oriented cities: government guidance, theoretical support, social participation and legal guarantees.

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Chapter 10
Distribution Pattern and Practical Exploration of the Green Consumption City in China

Tianpeng Gao, Wenxiu Yao and Xiangwen Fang

Abstract The evaluation system of the green consumption city is established on the basis of an analysis of the concept of the green consumption city and the need to construct green consumption cities, by selecting five characteristic indicators, namely the Engel coefficient, consumption expenditure accounting for the proportion of disposable income (CEPDI), real estate sales per unit of GDP (REGDP), the ratio of sidewalk area to road area (RSARA), and the number of public steam (electric) vehicles operating per unit of urban road area (PVURA), with the combination of 14 core indicators of the eco city. A total of 100 green consumption cities in China were ranked using this evaluation system in order to obtain the ranking order of green consumption cities in 2013. Meanwhile, the main policies implemented in China in 2014 in order to advocate green consumption were reviewed. The current problems and countermeasures in the construction of green consumption cities in China at the present stage were summarized, and typical cities were chosen and analyzed to provide suggestions to assist in the construction of the green consumption city.

Keywords The green consumption city in China · Distribution patterns

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10.1 Introduction

General Secretary Xi Jinping pointed out in the review of the NPC and CPPCC delegation of Jiangxi province on March 6, 2015 that we should focus on promoting the protection of the ecological environment, as we protect our eyes and treat the ecological environment as we treat our life. He said that the environment is people's livelihood, the green mountain is beauty and the blue sky is happiness. He said we cannot be soft on any acts resulting in the destruction of the ecological environment and cannot allow them to continue. Therefore, green consumption should focus on protection of the environment. The so-called consumption-oriented city is a relative concept related to the production-oriented city and it has obvious environmental, economic and social characteristics on which the green consumption city is based so as to provide green products for consumers and to support the economic development of the city with its strong demand for green consumption. The aim of the green consumption city is to practice green consumption while at the same time providing a healthy lifestyle and consumption pattern. Consumption in China has shifted to the consumption-driven era of economic development and the model of consumption has shifted gradually from one of traditional quantity consumption to a focus on the quality of consumption instead, along with a significant increase in the income levels of urban and rural residents [1]. Today, people pay more and more attention to environmental protection and their quality of life. Green consumption has been an inevitable choice for humans trying to solve environmental problems (such as climate problems, air pollution and water pollution etc.). As a healthy, safe, high-quality consumption model, green consumption will set the trend and be the ultimate model of consumption in China enabling the country to cater to the wishes of its vast number of consumers seeking high-quality consumption rather than traditional unsustainable patterns of consumption. Therefore, the construction of the green consumption city will become the model for urban construction.

10.2 Research Methodology

10.2.1 Designation of Evaluation System and Collection of Overall Urban Samples

In *The Report on the Construction and Development of the Eco City in China (2015)*, statistical data were obtained from 284 randomly selected inland cities in China in 2013 and green consumption cities were selected by applying the Analytic Hierarchy Process [2] and the five characteristic indicators (Engel coefficient, CEPDI, REGDP, RSARA and PVURA) of the green consumption city. One hundred cities were selected and ranked according to the calculation results.

10.2.2 Formula of Characteristic Indicators of the Green Consumption City

Engel Coefficient = amount of food expenditure/total expenditure amount × 100 %
CEPDI = consumption expenditure of urban residents per capita/disposable income of urban residents per capita
REGDP (%) = annual real estate sales/annual GDP
RSARA = sidewalk area/road area
PVURA (%) = the number of public vehicles/urban road area at the end of the year

10.3 Results and Findings

10.3.1 Distribution Patterns of the Green Consumption City in China

The number of cities that participated in the evaluation in North China accounts for 11 % of the total number of cities evaluated and six of these cities were in the top 100, accounting for 6 %. The number of cities evaluated in the Northeast accounts for 12 % of the total number of the cities evaluated and 14 of these cities were in the top 100, accounting for 14 %. The number of cities evaluated in the East accounts for 20 % of the total number of cities evaluated and 28 of these cities were in the top 100, accounting for 28 %. The number of cities evaluated in Southern China accounts for 16 % of the total number of cities evaluated and 20 of these cities entered the top 100, accounting for 20 %. The number of cities evaluated in Central China accounts for 19 % of the total number of cities evaluated and 14 of these cities entered the top 100, accounting for 14 %. The number of cities evaluated in the Southwest accounted for 11 % of the total number of cities evaluated and six of these cities entered the top 100, accounting for 6 %. The number of cities evaluated in the Northwest accounts for 11 % of the total number of cities evaluated and 12 of these cities entered the top 100, accounting for 12 %. It can be seen that the number of cities in the top 100 in Eastern China is more than 25 % of the top 100 green consumption cities in China. The number of cities in the top 100 green consumption cities in Northern China is the same as that in the Southwest region, and the number of cities in the top 100 green consumption cities in the Northeastern region is the same as that in Central China. It can be seen that:

The number of cities in the top 100 in South China = the number of cities in the top 100 in North China + the number of cities in the top 100 in the Northeast Region = the number of cities in the top 100 in the Southwest Region + the number of cities in the top 100 in Central China = 1/2 (the number of the cities in the top 100 in Northwest China + the number of cities in the top 100 in East China), as shown in Figs. 10.1 and 10.2.

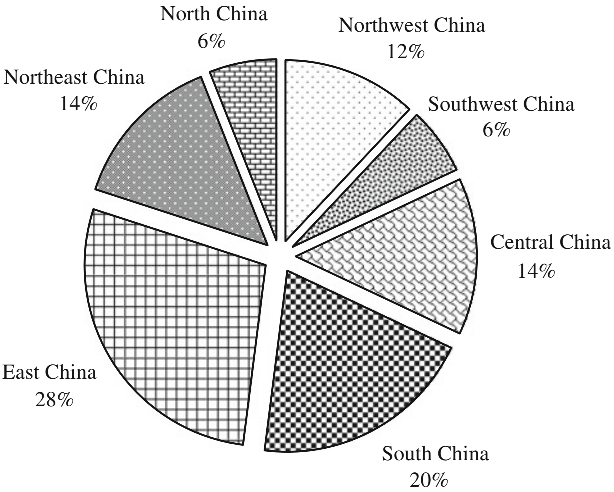

Fig. 10.1 Ratio of the top 100 green consumption cities accounting for the total number of cities evaluated

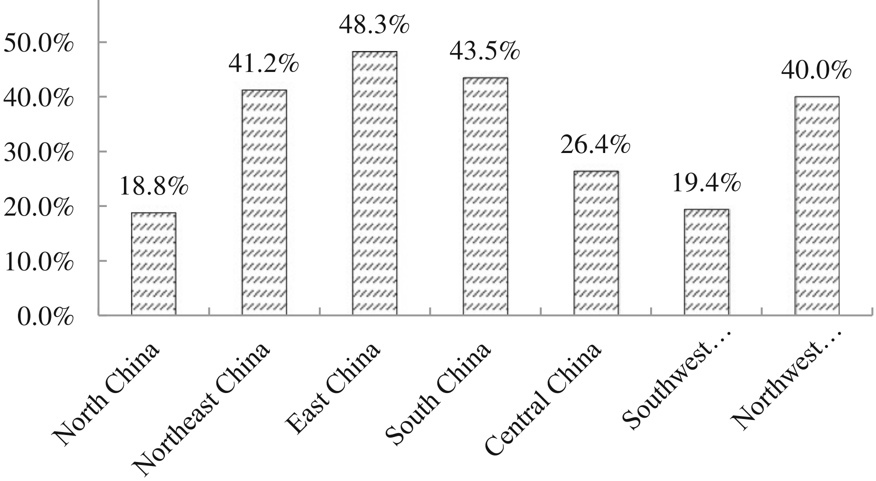

Fig. 10.2 Ratio of the top 100 green consumption cities in all regions accounting for the total number of cities evaluated

Figure 10.2 shows the proportion of the top 100 green consumption cities in each region to the total number of cities evaluated in the corresponding region. 18.8 % of the cities in North China are in the top 100 green consumption cities. The number of cities in the top 100 in Northeast China accounts for 41.2 % of the total number of cities evaluated in this region. The number of cities in the top 100 in East

China accounts for 48.3 % of the total number of cities evaluated in this region. The number of cities in the top 100 in South China accounts for 43.5 % of the total number of cities evaluated in this region, which is close to that of Northeast China. The number of cities in the top 100 in Central China accounts for 26.4 % of the total number of cities evaluated in this region. The number of cities in the top 100 in Southwest China accounts for 19.4 % of the total number of cities evaluated in this region and the number of cities in the top 100 in Northwest China accounts for 40.0 % of the total number of cities evaluated in this region. From this figure, the number of cities in the top 100 in Northeast China, East China, South China, and Northwest China is more than 40 %.

Figure 10.3 shows the change in the number of green consumption cities whose comprehensive indices ranked in the top 50 from 2011 to 2013. As can be seen, over these five years the number of green consumption cities for which the comprehensive indices ranked in the top 50 in North China reduced from 7 in 2011 to 4 in 2013. The number in the Northeast region remained at 6 and has not changed in the past three years. The number in East China and Central China reduced after the initial increase, while in contrast the number in South China and Southwest China showed an increase after an initial decline. In the same way, the number of cities in the top 50 every year in Southern China is close to three times that of the Southwest area. In this 3-year period, the number of cities in the top 50 green consumption cities in the Northwest remained at 3 every other year and there were 7 cities altogether in 2013, showing that great efforts have been made and gratifying results

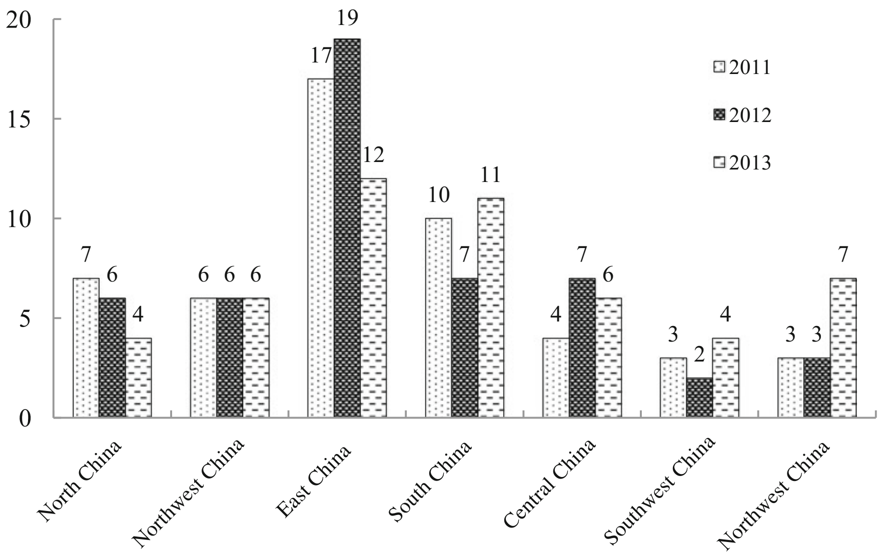

Fig. 10.3 Contrast in the distribution number of green consumption cities whose comprehensive indices ranked in the top 50 from 2011 to 2013

have been achieved in the construction of the green consumption city in Northwest China in 2013.

10.3.2 Practice in Green Consumption Cities in China

Green building standards have been implemented in housing construction, government investment projects, provincial demonstration projects, and large public buildings in Jiangsu Province since 2013. There was an increase in the number of green building projects to 144 in Jiangsu Province in 2013, which is about 1.5 times the number in 2012 and three times the number in 2011. Jiangsu Province ranked first and scored 738 points according to the Green Label Score by January 1, 2015. In the center of the urban area in the south of Jiangsu, the proportion of finished products among newly built houses is more than 60 % while that of the other areas is more than 40 %. Suzhou is the most typical city. The number of green buildings in Suzhou is the highest and as a result it is called the “garden city in China” due to its unique landscape. It is world famous for its beautiful scenery and elegant gardens that have a reputation of being “the most beautiful south of the Yangtze River” and “the most beautiful under heaven”. It is also well known as “a paradise on earth”, “an Oriental Venice” and “the Oriental Water City” across the world because of the characteristics of its rivers, lakes, and ancient bridges. Suzhou is one of the first batch of 24 national historical and cultural cities in China and is the birthplace of Wu culture in the Three Kingdoms period. The gardens in Suzhou are representative of private gardens in China and are listed as a world heritage site by UNESCO. The number of completed green buildings in Suzhou accounts for one-third of the total number of gardens in the province, as a result of their inheriting the elegant rustic style of the gardens in the Ming Dynasty (the comparison between the specific numbers is shown in Figs. 10.4, 10.5, 10.6 and 10.7).

10.4 Conclusion and Discussion

The cities with characteristic indices which have ranked in the top ten of green consumption cities since 2013 are Guiyang, Xining, Shanghai, Xi’an, Bazhong, Huaihua, Yinchuan, Harbin, Xinxiang and Wuzhong, and the health indices of these ten cities also ranked at the top, indicating that the ten cities have performed very well in terms of green consumption. From various characteristic indices reflecting the status of green consumption, the Engel coefficient in Yulin, Zhangjiajie, Changsha, Xiangtan, Zhuzhou, Changde, Yueyang, Hengyang, Tongliao and Yiyang is lower but their rank is near to the top, indicating that the proportion of food expenditure of residents in these cities is lower than that of other cities. The index of CEPDI in Zhangye, Shantou, Chaozhou, Sanmenxia, Jiuquan, Wuhai, Anqing, Chuzhou, Changchun, and Lanzhou is higher and the individual

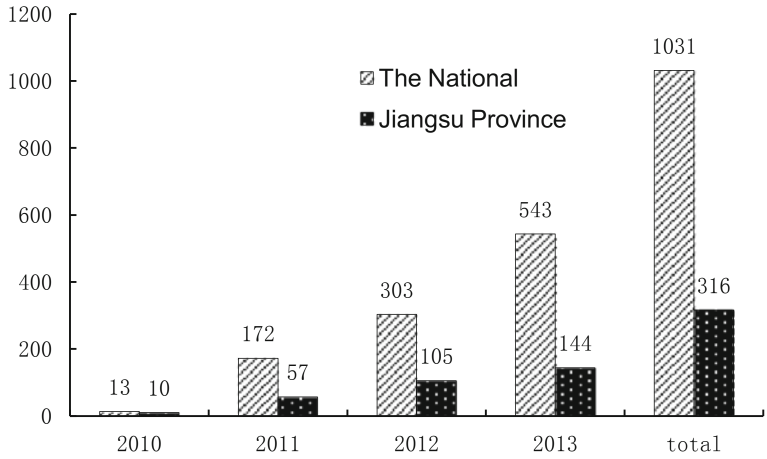

Fig. 10.4 Growing trend of green buildings in Jiangsu Province and the whole nation over the years 2010–2013

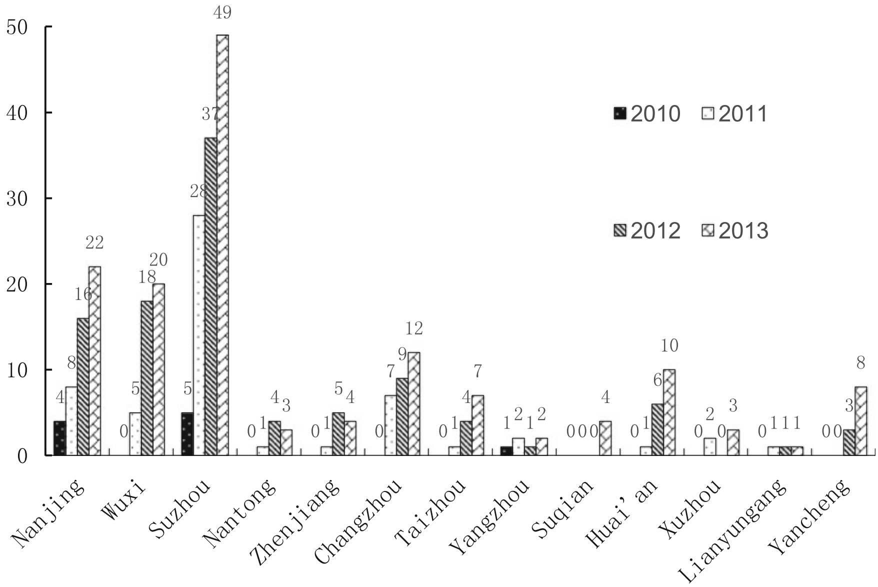

Fig. 10.5 Growing trend of green buildings in the cities in Jiangsu Province

items of these cities ranks close to the top. The cities whose REGDP ranked in the top 10 are Sanya, Xiamen, Guiyang, Fuzhou, Haikou, Langfang, Huizhou, Qingyuan, Zhuhai and Chengdu. The cities whose RSARA ranked in the top 10 are Bazhong, Qingyang, Heyuan, Baoji, Suining, Bayannao'er, Dazhou, Bozhou,

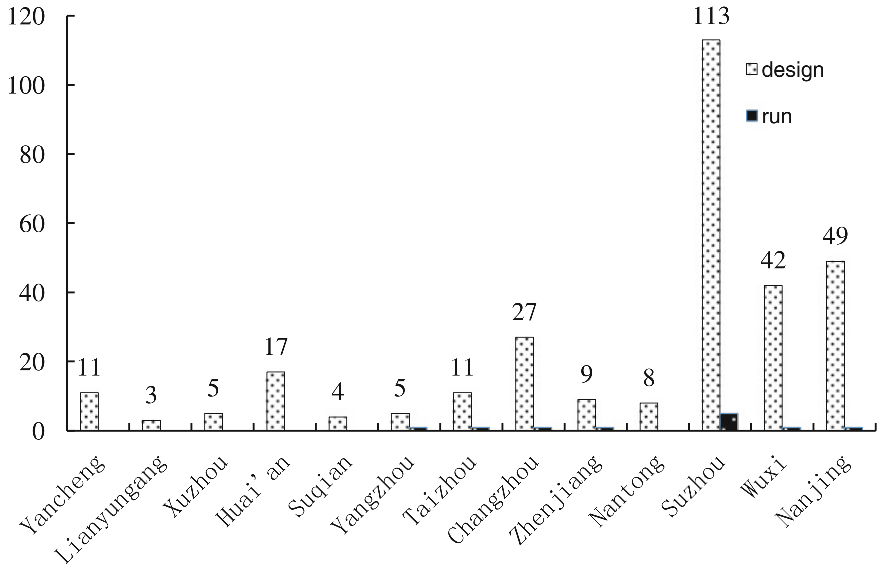

Fig. 10.6 Comparison between the numbers of design and operation identification in the cities in Jiangsu Province

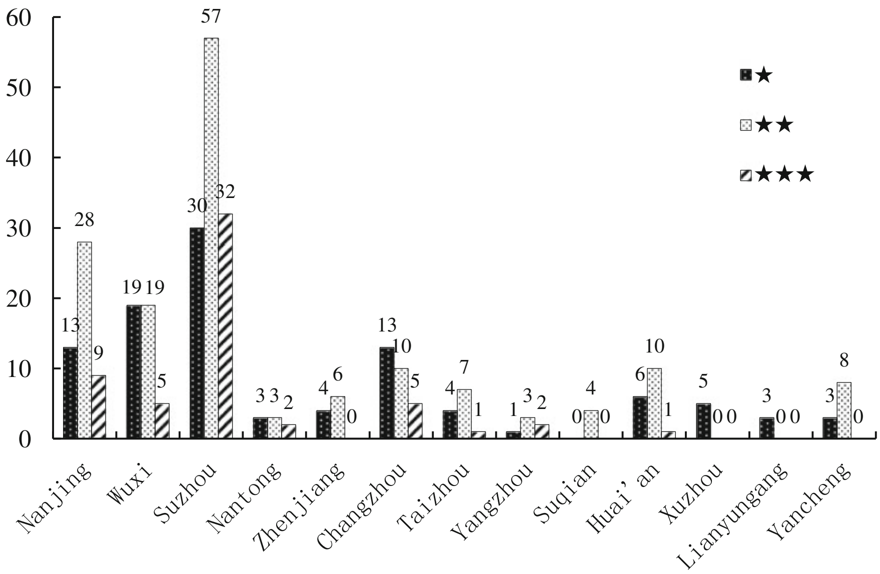

Fig. 10.7 Comparison between the identification numbers of one-star, two- star and three- star level cities in Jiangsu Province

Jiaozuo, and Tianshui. The cities whose PVURA ranked the top 10 are Shenzhen, Beijing, Zhongshan, Xining, Yunfu, Yan'an, Changzhi, Shanghai, Hengshui and Hohhot.

According to the comprehensive index during 2011–2013, the top 20 green consumption cities are Xiamen, Shenyang, Dalian, Guangzhou, Hangzhou and Shanghai, indicating that these cities have performed very well in the construction of infrastructure of their eco city and green consumption characteristics as did Xiamen, which rose rapidly to No. 2 in 2013 from No. 13 in 2012. The rank of Dalian over these three years changed little and the rank of Shenyang was consistent in 2012 and 2013. By analyzing the change in the number of green consumption cities whose comprehensive indices ranked in the top 50 in China, the number of cities in the top 50 in these three years in North China showed a downward trend. The northeast region remained unchanged overall. South China, Central China, and Southwest China showed a fluctuating trend over the three years. East China showed a large decrease in 2013, while Northwest China increased by a large margin in the same year.

In summary, the strength of Eastern China in the construction of the green consumption city is marked, and the minimum of Southern China is slightly higher than that of the other 5 regions. The ranking of some cities in Northern China declined and the ranking of the Northeast and Southwest regions changed slowly. More attention should be paid to increasing the intensity of green consumption eco city construction in order to strengthen the ecological foundation of urban construction in North China, Central China and the Southwestern region.

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Chapter 11
The Development Mode of the Comprehensive Innovative City

Gang Zeng, Tangwei Teng, Yongmin Shang, Yiwen Zhu, Junjiao Hai, Zefeng Mi and Hongting Chen

Abstract Under the guidance of the concepts of "Innovation, coordination, greenness, openness and sharing", the innovation-based eco city has the characteristics of innovation, entrepreneurship, green energy and eco-friendliness. The innovation-based ecological city model is the result of organic fusions between multiple paradigms such as the green city, the smart city, the innovative city, the humane city and the compact city. In order to accurately portray the present situation of China's innovation-based ecological city development and to guide the future development of the city, the author constructs an indexing system for the innovation-based ecological city that includes 14 core indicators relating to ecology and 5 expansion indicators relating to innovation and entrepreneurship, based on the social economic statistics of 2014. It sorts and classifies the levels of innovation-based eco city development of China's 286 cities above prefecture-level by means of weighted sum and clustering analysis. The study found that Beijing, Shenzhen, Shanghai, Suzhou, Guangzhou, Hangzhou, Xi'an, Dongguan, Zhuhai and Tianjin ranked in the top 10. According to the classification, the top hundred cities can be divided into four categories of development focus: innovation and entrepreneurship oriented, economically oriented, socially oriented and environmentally oriented. These top 100 cities can also be divided into seven categories in terms of geographical locations: the Yangtze River Delta, Pearl River Delta, West Coast of Taiwan Strait, Bohai Sea, Western China, Central China and northeastern China in descending levels of development. The development of the innovation-based ecological city in China shows the ladder model "based on the ecological environment, supported at the economic level and led by innovation and entrepreneurship".

Keywords Innovation-based ecological city · Evaluation index system · Clustering analysis · Spatial pattern

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11.1 Introduction

As China's national economic and social development enters the "the 13th 5 year plan", the new development concepts of innovation, coordination, greenness, openness and sharing have become the guidelines for the transformation of urban development, constantly improving the environmental quality of the city, residents' standard of living and the competitiveness of the city. The eco city is the ecological, efficient and harmonious environment for human settlement with full integration of nature, technology, and culture and the efficient use of material, energy and information in order to maximize people's creativity and productivity, and to improve their physical and mental well-being and the quality of the environment (Yanitsky [1]). The innovation-based eco city is a model of urban development with innovation as the core driving force of a knowledge economy (Yang et al. [2]), of which the ultimate goal is achieving sustainable economic and social development (You [3]). It can be said that the eco city not only emphasizes ecology as a core principle, but also needs to innovate in terms of knowledge, technology, management and culture so as to promote the city's efficient and sustainable operation. The construction of the eco city and the development of the innovative city are mutually beneficial and reinforcing (Zeng et al. [4]).

Therefore, the goal of the innovation-based eco city is to create a new urban eco construction on the basis of innovative city construction; to set up a vibrant new harmonious and livable urban model involving innovation and entrepreneurship, with green ecology as the core driving force and to construct the compact organic combination of elements such as the green city, the smart city, the innovative city, the humane city and the compact city (Fig. 11.1).

Of these elements, the green city is the cornerstone of the development of the innovation-based eco city, and also the product of the conscious coupling of urban ecological gardens, the ecological community and ecological parks. Therefore, in order to achieve the dynamic optimization and adjustment of city scale, the state of the resource and environment carrying capacity needs to be assessed so as to realize the implementation of green planning and design, strengthen the ecological corridor road construction and urban ecosystem restoration so as to focus on the protection of urban ecological security.

The innovative city is the core driving force in the construction of the innovation-based eco city. Under the support and guarantee of the city's comprehensive advantage, innovation factors at home and abroad accelerate gathering, different innovation factors interact frequently and cooperate closely. As a result, an innovation network at different spatial scales would be created, full of the vigor and vitality of eco innovation and the entrepreneurship ecosystem would be created. Consequently, the city would become a cradle of entrepreneurship and innovation and therefore a cradle of new culture, new ideas, new knowledge, new technology, new products and new formats.

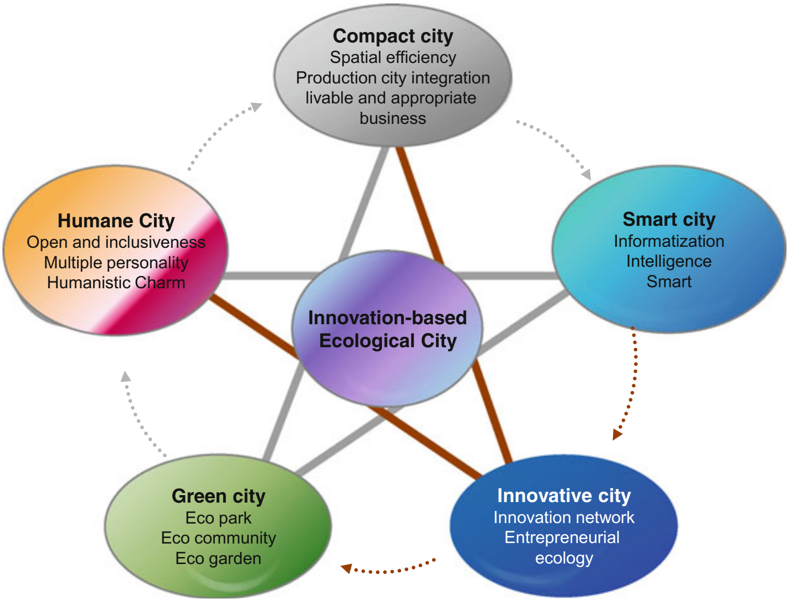

Fig. 11.1 Schematic diagram of the innovation-based eco city

The smart city is the technical foundation for the operation of the innovation-based eco city and it directly benefits from the organic support of innovative urban functions. Therefore what is required now is to strengthen the modern information infrastructure and promote big data and the Internet of things so as to create new formats and new models based on the security operation of city information and intelligence.

The humane city is the soft power of the innovation-based eco city, showing the characteristics of a high degree of openness, strong compatibility, an effectively extended historical context and a unique cultural tension and charm.

The compact city is the spatial characteristic of the innovation-based eco city in which the urban space can be effectively developed and utilized. It shows the features of an astute city structure, a high density of urban space utilization, integration of functions and is transit oriented.

The “five in one” strategy of construction involving the green city, smart city, urban innovation, humanities city and the compact city defines sustainable development in the win-win cooperation of production, ecology and living in the innovation-based eco city in order to realize the “three districts interaction and linkage” among ecological gardens, ecological communities and ecological parks.

11.2 Research Methodology

11.2.1 Establishment of the Innovation-Based Eco City Index System

The innovation-based ecological city index system consists of 14 core indicators and 5 extended indicators (Table 11.1). The 14 core indicators follow the index system of *The Report on the Development of China's Eco-cities* (Liu et al. [5]). The 5 extended indicators which indicate the transformation of city function in the global innovation competition give a scientific assessment of the eco-city's innovation and entrepreneurship capacity from the aspects of innovation input, innovation condition and innovation output. That is to say, while gathering global innovation resources, focusing on local innovation and entrepreneurship performance is more important. While introducing external innovative businesses, focusing on improving a city's innovation and entrepreneurship ecology, motivating and enthusing different innovation actors and nurturing the development of startup companies is more important. The extended indicators contain patents granted per billion of population, R&D expenditure as a percentage of GDP, volume of technology transaction contracts per capita, number of state-level technology business incubator and the number of listed companies on the growth enterprise market (GEM).

11.2.2 Measurement of the Innovation-Based Eco City Index

According to the innovation-based eco city index system, analysis was performed on 286 Chinese cities in 2014. With the themes of ecological environment, ecological economy, ecological society, innovation ability and entrepreneurial ability, the 5 s class indicators are divided into 19 third class indicators and are then normalized to quantify the secondary level indicators. The weight of first class indicators is set to 1 and the weight of second class indicators is 1/5. The weight of third class indicators is 1/5 divided by the number of third class indicators below in second class indicators (Table 11.1). The innovation-based eco city index is the sum of the score of each section.

The data come from *China City Statistical Yearbook 2015* [6], *China Urban Construction Statistical Yearbook 2014* [7], *China Statistical Yearbook for Regional Economy 2014* [8], the "National Economic and Social Development Statistics Bulletin" of each country level city as well as from related information on government websites.

Table 11.1 China's innovation-based eco city index system and its weightings

First class indicators	Second class indicators	Second class indicators' weight toward first class indicators	Third class indicators	Third class indicators' weight toward second class indicators	Mark number
Innovation-based eco city index	Ecological environment	1/5	Forest coverage (green coverage of built-up areas) (%)	1/5	(1)
			PM2.5 (number of fairly good air quality days) (day)	1/5	(2)
			Water quality of river and lake (water consumption per capita) (ton/person)	1/5	(3)
			Green area per capita (square meter/person)	1/5	(4)
			Harmless treatment rate of domestic waste (%)	1/5	(5)
	Ecological economy	1/5	Energy consumption per GDP (ton standard coal/1000 yuan)	1/5	(6)
			Comprehensive utilization rate of general industrial solid waste (%)	1/5	(7)
			Treatment rate of domestic sewage (%)	1/5	(8)
			GDP per capita (yuan/person)	1/5	(9)
			Informatization infrastructure [numbers of Internet broadband access subscribers (10,000 household)]	1/5	(10)
	Ecological society	1/5	Population density (person/square kilometer)	1/4	(11)
			Adoption rate of ecological and environmental protection knowledge, regulations and serviceability rate of	1/4	(12)

(continued)

Table 11.1 (continued)

First class indicators	Second class indicators	Second class indicators' weight toward first class indicators	Third class indicators	Third class indicators' weight toward second class indicators	Mark number
			infrastructure [number of water resources, environment and public facilities management employees (10,000 people)/city population at the year-end (10,000 people)]		
			The public satisfaction rate with the city's ecological environment [number of civilian vehicles (unit)/length of city road (kilometer)]	1/4	(13)
			The effect of government investment and construction (city's maintenance and construction expenditure/city's GDP)	1/4	(14)
	Innovation capacity	1/5	R&D expenditure as a percentage of GDP (%)	1/3	(15)
			Patents granted per billion of population (piece)	1/3	(16)
			Volume of technology transaction contracts per capita (10,000 yuan/person)	1/3	(17)
	Entrepreneurship capacity	1/5	Number of state-level technology business incubator (unit)	1/2	(18)
			Number of listed companies on the growth enterprise market (GEM) (unit)	1/2	(19)

11.2.3 Cluster Analysis of Innovation-Based Eco City Index

The evaluation results of the innovation-based eco city index were analyzed using a hierarchical clustering method in SPSS. Similar cities were classified according to their scores of ecological environment, ecological economy, ecological society, innovation ability and entrepreneurship. Finally, the characteristics of different types of cities according to clustering results were analyzed.

11.3 Results and Findings

11.3.1 Ranking of Innovation-Based Eco Cities

According to the scores and order of the innovation-based eco city index, the ranking of the Top 100 Chinese cities (2014) is obtained (Table 11.2) reflecting the current situation in China. In these rankings, Beijing, Shenzhen and Shanghai are the top three cities in the development of innovation-based eco cities particularly

Table 11.2 Ranking of the Top 100 innovation-based eco cities in China

Ranking	City	Ranking	City	Ranking	City	Ranking	City
1	Beijing	26	Changsha	51	Urumqi	76	Huangshan
2	Shenzhen	27	Huzhou	52	Yangzhou	77	Yinchuan
3	Shanghai	28	Zhoushan	53	Huizhou	78	Foshan
4	Suzhou	29	Tongling	54	Jiangmen	79	Liuzhou
5	Guangzhou	30	Weihai	55	Shaoxing	80	Jingdezhen
6	Hangzhou	31	Shenyang	56	Haikou	81	Yulin
7	Xi'an	32	Dalian	57	Zibo	82	Shizuishan
8	Dongguan	33	Erdos	58	Taizhou (Zhejiang)	83	Daqing
9	Zhuhai	34	Nantong	59	Jiayuguan	84	Laiwu
10	Tianjin	35	Jiuquan	60	Taizhou (Jiangsu)	85	Shantou
11	Wuxi	36	Dongying	61	Rizhao	86	Lishui
12	Nanjing	37	Changchun	62	Zhengzhou	87	Benxi
13	Xiamen	38	Kunming	63	Huainan	88	Wuhai
14	Wuhan	39	Harbin	64	Weifang	89	Chuzhou
15	Changzhou	40	Ezhou	65	Ma'anshan	90	Huaian
16	Sanya	41	Zhongshan	66	Jinhua	91	Huangshi
17	Wenzhou	42	Yingtan	67	Panjin	92	Xiangfan
18	Ningbo	43	Nanchang	68	Tongchuan	93	Heihe
19	Taiyuan	44	Wuhu	69	Xinyu	94	Qinhuangdao

(continued)

Table 11.2 (continued)

Ranking	City	Ranking	City	Ranking	City	Ranking	City
20	Chengdu	45	Fuzhou	70	Xuzhou	95	Zhuzhou
21	Qingdao	46	Yantai	71	Bengbu	96	Mianyang
22	Zhenjiang	47	Ji'nan	72	Quanzhou	97	Huaibei
23	Jiaxing	48	Nanning	73	Lhasa	98	Baotou
24	Hefei	49	Chongqing	74	Anshun	99	Xuancheng
25	Karamay	50	Yancheng	75	Jinchang	100	Tai'an

with regard to the aspects of innovation and entrepreneurship. Suzhou, Guangzhou, Hangzhou, Xi'an, Dongguan, Zhuhai and Tianjin all rank strongly in the top 10 with outstanding ecological economy, innovation ability and entrepreneurship being highlights of their overall characteristics. In addition, the top 20 cities are mostly located in eastern coastal areas, while the central and western regions rank relatively low in the total scores due to weak innovation and entrepreneurship.

When comparing the Top 100 list of 2014 innovation-based eco cities in China to the evaluation results of 2013 [1], it can be seen that the top four cities did not change with the order of Beijing, Shenzhen, Shanghai and Suzhou remaining as it was. It shows their significant advantages compared to all other Chinese cities. Xi'an and Dongguan respectively advance from originally 15th and 19th to 7th and 8th, joining the top 10 innovation-based eco cities. Wuhan and Chengdu respectively, are up from 31st and 33rd through to 14th and 20th, due to remarkable results in innovation and eco city construction. Jinchang, Qinhuangdao and some other cities also entered the top 100 cities for the first time, and although not placing very highly, show a good momentum of development.

11.3.2 Cluster Analysis of Innovation-Based Ecological City

In accordance with the cities' scores of the five aspects of ecological environment, ecological economy, ecological society, innovation ability and entrepreneurship, a cluster analysis tree diagram can be obtained (Fig. 11.2). According to the results presented in Fig. 11.2, the top one hundred cities can be divided into four categories: innovation oriented cities, economy oriented cities, society oriented cities and environment oriented cities.

On this basis, we calculated the average value of each category of the five aspects of ecological environment, ecological economy, ecological society, innovation ability and entrepreneurship (Fig. 11.3) in order to explore the different characteristics of these cities.

The first kind of city is the innovation and entrepreneurship oriented city, including 12 cities such as Beijing, Shenzhen, Shanghai and Suzhou among others, all ranking in the top 20 positions meaning that their innovation strengths and

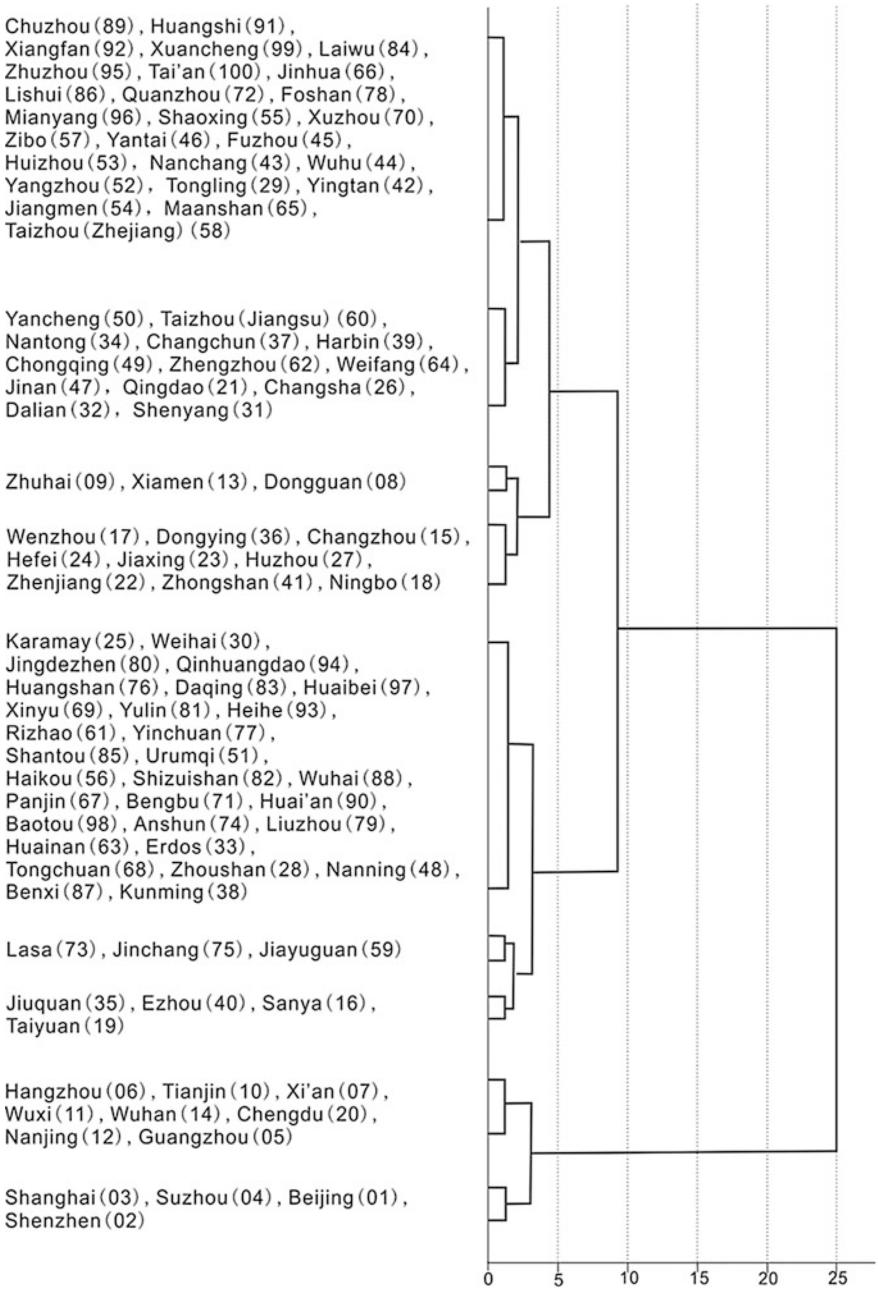

Fig. 11.2 Cluster dendrogram of Chinese innovation-based eco cities in 2014

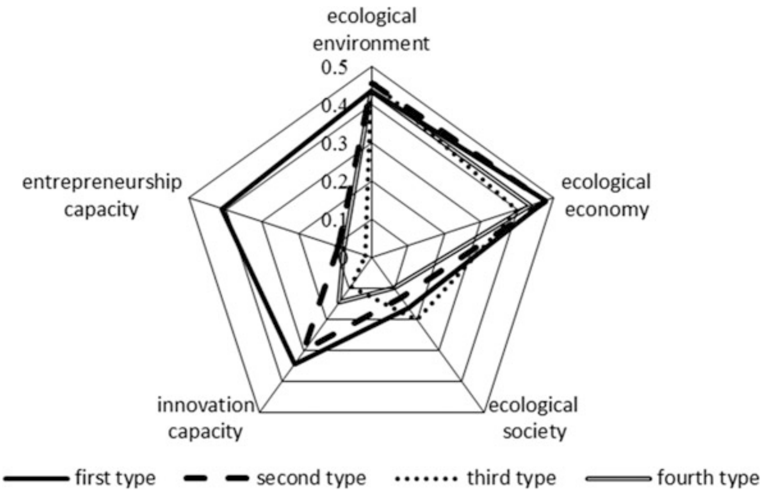

Fig. 11.3 Spider chart of Chinese innovation-based eco cities in 2014

ecological environment are at the leading level in China. The first advantage these cities have is in their innovation ability and entrepreneurship with the scores of these two aspects being 0.3436 and 0.4119 respectively, ranking the highest of the four categories and reflecting their excellent performance in both input links (R&D expenditure, the number of state-level science and technology enterprise incubators) and output links (the number of patents, technology market contract turnover and the GEM number of listed companies) of innovation and entrepreneurship. Furthermore, the first type of city has excellent scores on the ecological and economic indicators, indicating that these cities also have outstanding resource efficiency performance and possess good urban economic development situations. However, these cities have low average scores on their urban ecological environment (0.4335), which is the lowest of the four categories indicating that these cities during the vigorous development of their economic construction have not properly resolved economic and environmental co-development issues thereby affecting the quality of the environment of the cities. In the future, the first type of city should remain as their strength in innovation and entrepreneurship, as well as their good momentum of economy development, while the focus on optimization of urban air quality, water quality of rivers and lakes, green coverage and other aspects should be strengthened so that the public can get tangible benefits from such development.

The second kind of city is the economy oriented city, including 12 cities such as Dongguan, Zhuhai, Xiamen and Changzhou among others. These cities are at the middle-level overall, ranking from eighth to forty-first. These cities scored 0.4746 in the ecological economy theme, with a similar level of first class cities (0.4779). They have higher scores, notably in per capita GDP and the comprehensive utilization rate of general industrial solid waste, reflecting the fact that these cities have made real achievements in economic development. However, their scores on innovation ability and entrepreneurship show a significant difference compared to those of first class cities, showing that their innovation and entrepreneurship potential, as the basis of economic development, are still not being fully tapped. In addition, the second class cities get higher scores (0.4539) in the environment theme than the first class cities, ranking second in the four categories, reflecting the fact that these cities maintain a good balance between economic development and environmental protection. Their lower scores in the area of ecological society show that the economic activity in these cities has led to urban road congestion and other social problems that affect public life. In future work, the second class cities should at least try to ensure efficient completion of the task of economic development and then focus on the two following crucial points. Firstly, improving people's livelihoods and improving urban residents' satisfaction levels, especially with respect to their current weakness (such as population density, public urban ecology environmental satisfaction rate) and take appropriate actions to enable this. Secondly, there is the need to improve the ability of innovation and entrepreneurship, making up for their shortcomings so as to reach the level of a first class city.

The third type of city is the socially oriented city, including 37 cities such as Sanya, Taiyuan, Karamay and Zhoushan among others. These eco cities scored 0.2016 points for their social aspects, and ranked first in the four categories of city. Their ecological environmental themes also performed well with 0.4629 points. This reflects the performance of the third class cities in terms of social and environmental aspects, such as urban greening, air quality, water quality and other urban infrastructure construction. However, at the same time, the innovation level, the ability of entrepreneurship and the development of the ecological economy in these cities are relatively weak, making an entrepreneurial ability score of only 0.0178, indicating that their urban economic bases need to be improved. They also lack in innovation activities and their entrepreneurial atmosphere should be strengthened. In the future, third class cities need to keep the green economic development model based on a livable city through the introduction of appropriate policies to stimulate businesses, research institutions, individuals and innovation in order to create a vibrant entrepreneurial atmosphere. They should also use innovation as the driving power to support the development of a green urban economy and to build the developing model of innovation-based eco cities.

The fourth type of city is the environment oriented city. This type includes 39 cities such as Qingdao, Changsha, Tongling, Shenyang among others. Although Qingdao and Changsha rank high on the top 100 list, the other cities rank at a lower level. In general, this class of city does not have a significant performance in any of the five aspects. Compared with their other aspects, their ecological environmental theme score (0.4344) is notable and this could be to their potential advantage. In addition, the difference between their ecological economic themes and that of first class cities is not clear, with support the potential of their development. Unfortunately, their ecological society score was only 0.0975, indicating that their capacity to integrate the ecological environment with the ecological economy into ecological society is relatively weak, so their efforts of ecological community building need to be strengthened. In terms of innovation and entrepreneurship, there is a significant gap between fourth class cities and first class cities. Their score of innovation ability is only 0.1452 and their entrepreneurship score is only 0.0760. On the whole, fourth class cities have a sound ecological basis but they lack capacity-building. In the future they should focus on addressing restrictions to development, the comparative advantage of the ecological environment and ecological economy, promote social and ecological innovation and build entrepreneurial ability.

11.3.3 Spatial Distribution of Innovation-Based Eco Cities

Exploring the distribution of innovation-based eco cities gives a more accurate understanding of the spatial pattern of these cities. Based on the seven major economic regions in China, the spatial pattern of Top 100 innovation-based eco cities in 2014 can be split into seven areas including the Yangtze River Delta leading city area, the Pearl River Delta leading city area, the West Coast of Taiwan Strait following city area, the Bohai Sea following city area, the Western China following city area, the Central China backward city area and the Northeast China backward city area. Overall, the cities in the leading areas as a whole have a higher level of innovation and entrepreneurship, a better balance between economic development and environmental protection and stand at the head of innovation-based eco city construction. The overall scores in environmental indicators and social indicators of following areas are not inferior but most cities have large differences in innovation and entrepreneurship when compared to the leading area. Therefore, it is imperative for the cities of following areas to establish a sound environment as the basis for better innovation and entrepreneurial capacity. Compared to the following areas, the cities of backward areas lag behind in environmental and social aspects and they did not do well in innovation and entrepreneurship either. Therefore, cities of backward areas should consolidate the environment and social infrastructure during the development of their economies and strengthen their capacity for innovation and entrepreneurship. The specific circumstances of innovation and entrepreneurship, and environmental, social, and economic aspects, along with other aspects of these seven areas are outlined below.

11.3.3.1 Yangtze River Delta Leading City Area

The Yangtze River Delta leading city area is located in the Yangtze River Delta region of China, and includes the cities of Shanghai, Suzhou, Hangzhou, Wuxi and Nanjing among others. Their average rank was 36th in 2014, placing them in the advanced level of overall development. Yangtze River Delta leading cities ranked first in innovation and entrepreneurship. This reflects their ample power of development in regional innovation and construction of related facilities, and the openness of their knowledge communication channels. However, they show poor performance in ecological and social themes with an average score of only 0.1079 points, making an urgent need to increase investment in social and livelihood fields. In the future, the leading cities of the Yangtze River Delta region, should continue to play a driving role in high-tech industry, and continue to promote the advantages of a sound environment for innovation and entrepreneurship, thereby becoming a leading region through the demonstration of innovation-based eco cities.

11.3.3.2 Pearl River Delta Leading City Area

The Pearl River Delta leading city area is located in the Pearl River Delta of China and includes Shenzhen, Guangzhou, Zhuhai and Dongguan among other cities. In 2014 the area had an average position of 37th, which reflects the fruitful innovation-based eco city construction and excellent all-round strengths. The Pearl River Delta leading city area is more active in terms of innovation activities. Shenzhen and Guangzhou ranked 2nd and 5th in the Top 100 list thanks to their outstanding performance in R&D expenditure and number of patents among other innovation indicators. However, the area's ecological social aspect scored a similarly low (0.1541), and is their obvious shortcoming of all four aspects. In the future, these leading cities in the Pearl River Delta region should further intensify efforts in building ecological societies.

11.3.3.3 West Coast of Taiwan Strait Following City Area

The West Coast of Taiwan Strait following city area is located on the west side of Taiwan, China, and includes Xiamen, Fujian city and Quanzhou among other cities. The area had an average position of 43rd in 2014, placing it in a middling position of innovation and ecological construction. Its advantage is its ecological system theme. Xiamen is the most prominent city in the area, however, when compared to 2013 its ranking in 2014 declined slightly, caused by its weakness in innovation ability and entrepreneurship. In the future, the West Coast of Taiwan Strait following city area should continue to maintain the basis of its ecological environment and ecological benefits to society, then improve innovation and its efforts in entrepreneurship.

11.3.3.4 Bohai Sea Following City Area

The Bohai Sea following city area is located in the Bohai Sea region of China, and includes the cities of Beijing, Tianjin, Qingdao and Weihai among others. In 2014, the cities of the area had an average position of 51st. The internal differences of Bohai Sea following city area are significant: an outstanding level of urban development is seen in Beijing and Tianjin, with both cities ranking very high across the whole of China. There are many cities ranked relatively backward and they need to continue to strengthen so that the overall score of this urban area is no longer an issue. In the future, the Bohai Sea following city area should focus on the coordinated development of its economy and ecology, while strengthening cooperation and collaboration between cities within the region.

11.3.3.5 Western China Following City Area

The Western China following city area is located in western China and includes Xi'an, Chengdu, Chongqing and Kunming among other cities. In 2014, the urban area had an average position of 57th. The theme of ecological society is the main advantage of the region with a score of 0.1895, placing it at the top of all seven regions. The Western China following city area is not the lacking in overall strengths as there are prominent cities such as Xi'an and Chengdu. However, most cities in this area do not perform well in the rankings. Compared to 2013, the rankings of Chengdu, Urumqi and some other cities have increased, while the rankings of Anshun, Mianyang and several other cities have decreased, showing the unstable nature of development within the region. In the future, the Western China following city area should further develop its high-tech businesses, optimize industrial structure and improve resource utilization.

11.3.3.6 Central China Backward City Area

The Central China backward city area is located in the central region of China and includes Wuhan, Changsha and Nanchang among other cities. In 2014, the urban area had an average position of 60th. The overall strength of the Central China backward city area is not outstanding and scores in all five themes were mediocre with most cities ranking under 40th in the list, meaning serious efforts in innovation-based eco cities construction will be necessary. However, some individual indicators of some cities are more prominent. As Bengbu and Huainan both rank highly in terms of public satisfaction with the urban ecological environment, Xinyu and Huangshan also have high scores in terms of their forest cover and their air quality. The experience and corresponding work of these cities is worth studying.

11.3.3.7 Northeast China Backward City Area

The Northeast China backward city area is located in northeast China and includes the cities of Changchun and Harbin among others. In 2014, the city area has an average position of 63rd. The Northeast China backward city area exhibits poor performance in the two major themes of innovation ability and entrepreneurship, ranking bottom of all seven regions. Many cities in this urban area have over-developed their natural resources due to the slow process of transformation and upgrading of traditional industries and their lack of technological innovation. In the future, the Northeast China backward city area should focus on enhancing the city's all round ability, especially in the improvement of its ecological environment, improve the quality of life and increase investment in order to build a platform for innovation and entrepreneurship.

11.4 Conclusion and Discussion

The innovation-based eco city is a model of sustainable development where green cities, smart cities, innovative cities, humane cities and compact cities combine organically. Through the quantitative evaluation and cluster analysis of the innovation-based ecological city through the establishment of the index system, the following conclusions were reached.

In the innovation-based eco city index of China, the top 10 cities were Beijing, Shenzhen, Shanghai, Suzhou, Guangzhou, Hangzhou, Tianjin, Xi'an, Dongguan and Zhuhai, which all have prominent performance in their ecological economic levels, innovative ability and entrepreneurial ability. In general, cities in the eastern coastal areas rank higher than those of central and western regions.

The results of the cluster analysis suggest that the innovation-based eco cities fall into four categories: innovation and entrepreneurship oriented, economic oriented, social oriented and environmental oriented, which each have their own characters. In terms of future development, innovation and entrepreneurship oriented cities should focus on optimizing air quality, water quality in rivers and lakes, and their green coverage. Economic oriented cities should enhanced their social security system to improve people's livelihood and promote their innovation and enterprise capability. Social oriented cities should mainly foster innovation and create a conduit to an innovation and entrepreneurship environment so as to put the cities on the track of green development driven by innovation. As the development level is the lowest of all the cities, the development level of environmental oriented cities should aim to protect the eco-environment and pursue the all-round development of economy, society, innovation and entrepreneurship.

Based on their economic zones, the top 100 cities show the spatial pattern of the Yangtze River delta leading urban area, Pearl River delta leading urban area, West Coast of Taiwan Strait following city area, Bohai Sea following city area, Western China following city area and Central China backward city area and Northeast China backward city area. In general terms, the leading urban areas have high innovative entrepreneurial ability, while taking both economic and environmental benefits into consideration. Thus they take the lead nationwide in innovation-based eco city construction. Compared to the leading urban areas, the following urban areas are not inferior in indices of urban environment and social development but lag far behind in innovative entrepreneurial ability. The backward city areas fall behind in all fields. Therefore, the ladder model is shown wholly in innovation-based ecological city construction, with features of "based on the ecological environment, supported at the economic level and led by innovation and entrepreneurship".

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Appendix A
Memorabilia of Eco City Construction in China (November 2012–September 2015)

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In the report of the 18th National Congress of the Communist Party of China on November 8, 2012 there was an article talking about the construction of the ecological civilization for the first time proposing that China's grand goal is "to put the construction of ecological civilization in prominence, blend it into economic construction, political construction, cultural construction, social construction and throughout the whole process strive to build a beautiful China and realize the sustainable development of the Chinese nation". To put the construction of ecological civilization at the heart of the general layout demonstrates that our Party's understanding of the overall layout of socialism with Chinese characteristics has deepened, and to put the construction of the ecological civilization at the heart of the five-in-one also highlights the Chinese nation's spirit of responsibility to its descendants and to the world.

On December 13, 2012, Tianjin issued *Tianjin Energy-Saving and New Energy Vehicle Demonstration and Promotion and Industry Development Plan*, *Conservation and Restoration Planning of Tianjin Ancient Coast and Wetlands National Nature Reserve Qilihai Wetland* and *Duliujian River Green Project Plan*, proposing to implement at a high level, the planning and construction of key projects to effectively accelerate the pace of construction of the eco city.

On January 4, 2013, the Ministry of Land and Resources announced the "three rates" of development and utilization of the three kinds of mineral resource—Kaolin, gold and phosphorus. This is another important standard released after the "three rates" index of coal and Panxi vanadium titanium magnetite. The release of the standard is of great significance to the promotion of resource conservation and improving the level of the utilization of resources.

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On January 4, 2013, the Ministry of Water Resources of the People's Republic of China issued *Opinions on Accelerating the Construction of Water Ecological Civilization* in order to implement the important idea of strengthening the construction of the ecological civilization put forward by the 18th National Congress of the Party. *Opinions* proposed that the Ministry of Water Resources will choose a number of representative and typical cities with sound basic conditions to carry out the pilot work of the construction of the water ecological civilization, explore the construction model of the water ecological civilization fit for the water resources and water environment condition of China.

On January 21, 2013, the Ministry of Environmental Protection and the China Insurance Regulatory Commission jointly formulated *The Guidance on Carrying Out the Pilot Work of Environmental Pollution Compulsory Liability Insurance* which clearly stipulates that three types of business (including businesses related to heavy metals, companies incorporated into the range of insurance according to local regulations and other businesses with a high environmental risk) must be forced to obtain social and environmental pollution liability insurance or they will be affected in the EIA and through access to credit etc.

On January 23, 2013, *The 12th Five-Year Plan for Energy Development* was officially announced, putting forward three binding targets. In 2015 "the total energy consumption was of 4 billion tons of standard coal. Energy consumption per unit of GDP fell by 16 % compared to 2010 and the proportion of non-fossil energy consumption increased to 11.4 %".

On February 7, 2013, the State Council issued China's first recycling economy development strategy plan—"recycling economy development strategy and the recent action plan", determining the short-term development goals of the recycling economy. These were that by the end of "the 12th five-year plan", China's major resource productivity will have increased by 15 % and the output value of the resource recycling industry will have reached 1.8 trillion Yuan. The core of the recycling economy lies in an efficient use and recycling of resources, which is the fundamental change from the traditional growth pattern of "mass production, mass consumption and mass waste".

On February 27, 2013, the Ministry of Environmental Protection issued an announcement deciding to implement special emission limits on air pollutants in the six major industries of thermal power, iron and steel, petrochemicals, cement, nonferrous metals and chemical industries as well as coal-fired boiler projects in the key control areas. Altogether, 47 cities at or above the prefecture-level in 19 provinces (autonomous regions and municipalities) are involved in the key control areas, such as Beijing, Tianjin, the Yangtze River Delta, Pearl River Delta and other cities belonging to the "three District 10 group". This is by far the most severe measure taken in the history of pollution control in China, and the implementation of special emission limits will strictly control the amount of air pollutants newly emerging from sources as well as providing effective means of controlling air pollution and being conducive to accelerating industrial restructuring and industrial upgrading as well.

On March 1, 2013, the only mandatory national standards for pesticide residues in China's food regulations—*The Maximum Residue Limits of Pesticide Residues in Food* (GB2763—2012) was implemented, providing a legal and technical basis for regulating the scientific and rational use of drugs, supervising the quality and safety of agricultural products and cracking down on the illegal use and abuse of pesticides.

On March 18, 2013, in order to respond actively to the new changes in production and consumption patterns of energy in the third industrial revolution, Tianjin electric power company started "the demonstration project construction of the smart city innovation supported by a smart grid" in the Sino-Singaporean Tianjin eco city. The project contains construction plans for the five pillar fields such as an efficient use of renewable energy, access to widely distributed energy, convenient energy storage, efficient clean travel and the interconnection and sharing of energy.

On March 21, 2013, the scientist alliance of the international ecological civilization compact was established in Beijing and nearly a hundred scientists from more than 70 countries signed in agreement.

On March 28, 2013, "The Tenth International Green Building and Building Energy Conservation Conference and New Technologies and Products Expo" opened at Beijing International Convention Center, the theme of which was to "popularize green building and promote energy-saving and emissions reduction". The Low-Carbon Experiencing Center of the Sino-Singaporean Tianjin Eco City was awarded "The China Green Building Three-Star Design Logo".

On March 29, 2013, the China Green Foundation Artist special fund was launched in Beijing. The purpose of the special fund is to "raise social funds and promote the sound development of art". The funds raised will be widely used in the dissemination of ecology culture and the promotion of ecological civilization, by the compilation of supporting literature and data, gathering published works and holding arts forums, etc. in order to make a positive contribution to the prosperity of the social ecological culture.

On March 29, 2013, funded by the British Foreign Affairs and Commonwealth Office Prosperity Fund, *The Low-Carbon Eco City Planning Method* compiled by Atkins and the China Urban Scientific Research Institute was officially released. *The Method* is intended to provide a high standard of reference and a benchmark for China's future low-carbon eco city planning.

On April 1, 2013, the State Council General Office issued a notice requiring the construction of urban drainage and flood protection facilities. Before the flood season in 2013, each region should seriously investigate the hidden danger spots and effectively solve the problem of severe waterlogging influencing larger areas. Before the end of 2014, the compilation of the city drainage and flood protection facility construction plan will be finished. Every effort should be made to complete the transformation of the drainage pipe network to diversify rain and sewage water within 5 years. It will take 10 years or so to build a more perfect city drainage and waterlogging engineering system.

On April 8, 2013, the National Development and Reform Commission released a more systematic annual report of comprehensive utilization of resources for the first time—*China Annual Report of Comprehensive Utilization Resources (2012)*, marking the beginning of the formation of a complete set of systems, supporting ideas of the comprehensive utilization of resources and management in China.

On May 10, 2013, "2013 China—Jinzhou World Garden Expo" opened, the theme of which was "the city and the sea and the harmonious future" with "the blue sea moistening the green home" as its central idea. The Expo was co-sponsored by the Ministry of Housing and Urban–Rural Development of the People's Republic of China, National Tourism Administration, State Oceanic Administration, the Council for the Promotion of International Trade of China, the Liaoning Provincial People's Government and the Chinese Society of Landscape and Garden Architecture.

On May 14, 2013, the Ministry of Environmental Protection announced the nationwide annual verification and punishment for the reduction of total emissions of the main pollutants in 2012. Two companies in Panzhihua (the Huadian Sichuan Panzhihua Three-Dimensional Power Plant and the Panzhihua Steel Company) were supervised and monitored as they attempted to rectify and reform within a deadline and were ordered to pay a pollutant discharge fee due to their abnormal operation of desulfurization facilities and falsification of monitoring data.

On June 13, 2013, the Ministry of Agriculture approved and issued the safety certificate for the herbicide resistant soybean CU127 applied for by BASF Agrochemical Co. Ltd. and the Insect-Resistant Soybean MON87701 and Insect-Herbicide Tolerant Soybean MON87701 × MON89788 applied for by Monsanto Far East Co. Ltd.—the three agricultural transgenic biological organisms which can be imported as raw materials for processing. This announcement has caused public concern and discussion about the safety of genetically modified food.

On June 14, 2013, Chinese Premier Li Keqiang chaired a State Council executive meeting which formulated ten measures for the control of air pollution, including vigorously promoting clean production, developing public transport, accelerating the adjustment of energy structures, increasing the supply of clean energies such as natural gas and coal methane, strengthening constraints of energy-saving environmental indicators, and those projects which fail the energy evaluation and environmental evaluation will not be approved for construction and cannot be provided with land, loans, power supply, water supply and so forth.

On June 17, 2013, the Supreme People's Court and the Supreme People's Procuratorate issued *The Interpretation of Several Issue*s *Concerning Laws Applicable to Handle Criminal Cases of Environmental Pollution* which determined new standards for environmental pollution offences, reduced the threshold of the offences and paid more attention to environmental pollution infringements.

On June 18, 2013, the Shenzhen carbon emission trading platform went live. Shenzhen became China's first pilot city for the official start of carbon emission trading. Subsequently, carbon emissions trading in Shanghai and Beijing opened one after the other and 2013 officially became the first year of China's carbon trading.

On June 20, 2013, the Chinese Academy of Social Sciences published *The Eco City Green Paper: China's Eco City Construction Development Report (2013)* (co-edited by Sun Weiping and Liu Juke), which was co-compiled by the social development research center of the Chinese Academy of Social Sciences, Gansu Urban Development Research Institute and Lanzhou City University. *The Report* pointed out that ecological urban construction is the only way to further develop urbanization and analyzed the current main problems of eco city construction in China from five aspects.

On July 22, 2013, "The Ecological Civilization Guiyang International Forum 2013 Annual Conference" opened in Guiyang, the theme of which was "the construction of the ecological civilization: the green revolution and transformation—sustainable development led by green industry, green towns and green consumption". Xi Jinping wrote a congratulatory letter to the forum, pointing out that moving towards a new era of ecological civilization and building a beautiful China is an important part of the Chinese dream of realizing the great rejuvenation of the Chinese nation.

On August 2, 2013, the Ministry of Environmental Protection issued *Procedure Regulations of Pollution Damage Assessment at the Emergency Disposal Stage of Emergent Environmental Accidents*. The assessment of the pollution damage at the emergency disposal stage refers to the quantitative assessment of the direct economic losses caused by sudden environmental incidents during the disposal of the emergency and the activity to evaluate the extent of the damage.

On August 9, 2013, the Ministry of Water Resources categorized 45 cities as pilot cities of national water ecological civilization construction, including Jilin.

On August 11, 2013, the State Council released *The Opinions about Speeding up the Development of Energy-saving and Environmental Protection Industry*, predicting that the output value of the energy conservation and environmental protection industry would reach 4.5 trillion by 2015 with an average annual growth rate of more than 15 %. According to *The Opinions*, four big industries, namely key areas in the energy-saving industry, key areas in the resources recycling industry, key areas in the environmental protection industry and the energy conservation service industry etc. will be key to development during the "12th five-year plan".

On August 29, 2013, the Ministry of Environmental Protection announced the nationwide assessment results of reducing the total emissions of main pollutants in 2012. Because Petrochina and Sinopec did not complete the task of COD and NOx emission reduction respectively, the examination and approval of the environmental assessment of new refining projects, changes to refining projects and expansion of refining projects of the two companies were suspended, except for projects relating to the upgrading of products and energy conservation and emission reduction. These measures have accelerated the formation and spread of investors' environmental thinking and further eliminated doubts about the degree of realization of cash investment growth in the environmental protection industry.

On August 29, 2013, the China Disabled Peoples' Federation website released *The Opinion about Promoting Employment for the Disabled in Proportion Put Forward by the Seven Departments Including the Central Committee Organization*

Department of the Communist Party of China. The Opinion pointed out that by 2020 the main member units of all the provincial party and government organs at prefecture-level and the Municipal Working Committees of the disabled, will arrange for at least one disabled person to work there. The proportion of disabled cadres in the provincial CDPF cadre ranks should reach more than 15 %. Party and government organs at all levels should, for the positions the disabled are qualified for, encourage and give priority to disabled persons under the same conditions, sticking to the premise of their physical condition fit for performing normally their duties.

On August 30, 2013, the second council session of "Wisdom City (Nansha) High-End Forum and Guangdong smart city Industrial Technology Innovation Alliance in 2013" was held in the Software Application Technology Research Institute of the Chinese Academy of Sciences of Guangzhou. The term "Wisdom city" refers to the full use of the Internet of Things, sensor networks, cloud computing and other technologies in order to put forward specific technical solutions in all areas relating to urban life, including transportation, medical care, finance, industry, energy, environmental protection and public safety etc. representing a new approach in the construction of the eco city.

On September 12, 2013, the State Council officially announced *The Air Pollution Prevention Action Plan*. It planned to reduce the overall level of concentration of fine particulate matters in all regions by 2017, of which the concentration of PM2.5 in the Beijing–Tianjin–Hebei region will be reduced by 25 %. In the surrounding areas of three cities—Beijing, Shanghai and Guangzhou, new coal-fired power plants will be banned and the use of clean fuel by vehicles should be encouraged. The plan is considered to be the most stringent air control action plan in the history of China.

On September 16, 2013, the State Council issued *The Opinions on Strengthening the Construction of Urban Infrastructure Put Forward by the State Council. The Opinions* pointed out that China should ensure the safety of urban operations, improve the urban ecological environment, promote energy conservation and emissions reduction in cities, and promote the sustainable and healthy development of the economy and society.

On September 24, 2013, 13 units were awarded the title of "National Ecological Civilization Education Base". In the China Symposium in Urban Forest Construction in 2013, the State Forestry Administration, the Ministry of Education, and the CYL Central Committee awarded 13 units including the Capital University of Economics the title of "National Ecological Civilization Education Base". The construction of the "National Ecological Civilization Education Base" set up the ecological civilization concept of respecting nature, complying with nature and protecting nature throughout society.

On September 26–27, 2013, innovation-driven eco city construction—the 2013 Eurasian Economic Forum was held in the ancient city of Xi'an.

On October 12, 2013, the international *Minamata Convention* was signed. This is an agreement signed by China and 140 other countries on the issue of controlling mercury pollution. The Convention requires that products such as mercury thermometers be withdrawn from the market in every country by 2020, and mercury emissions from coal-fired power stations, industrial boilers, cement and other industries, should be limited and all mercury mines should be closed within 15 years. This agreement has brought about a serious challenge to China as it is the world's largest mercury producing, using and emitting country.

On October 14, 2013, *Beijing Emergency Environmental Accidents Emergency Plan* (revised in 2013) made substantial adjustments to the classification of environmental emergencies, and atmospheric pollution incidents were first included in the classification factors of environmental emergencies. If environmental pollution leads directly to the death of more than 10 people, it is a "particularly serious environmental emergency".

On October 16, 2013, the State Council promulgated *Regulations on Urban Drainage and Wastewater Treatment*, stipulating that provisions of the people's governments at or above the county level shall incorporate urban drainage and sewage treatment work into the national economic and social development planning. The regulations will come into force on January 1, 2014.

On October 22, 2013, "the 2013 Contaminated Sites Remediation International Forum (China Beijing)" was held in Beijing, jointly sponsored by the China Ecological Restoration Network, the Chinese Academy of Environmental Sciences, the Ecological Environment Research Center of the Chinese Academy of Sciences and Beijing Environmental Protection Science Research Institute.

On November 12, 2013, the third plenary session of the eighteenth NPC (National People's Congress) scrutinized and subsequently passed *Decisions Made Up by CPC Central Committee on Several Major Issues of Deepening Overall Reform*. The announcement proposed the building of a complete system of ecological civilization institutions, and a sound system of property rights to natural resources and the control institution of the use of natural resources to be at the center of comprehensive reform in China over the next 10 years.

On November 28, 2013, the "2013 International Eco City Construction High-End Forum", jointly organized by the Chinese Academy of Engineering and the International Council of Eco City Construction, was held in Beijing. The theme of the forum was "urban ecological infrastructure engineering technology and management of the new type of urbanization". Urban ecological infrastructure includes urban wetlands (kidney), urban green space (lungs), urban surface (skin), waste discharge points (mouth) and transportation and river corridors (pulse).

On December 3, 2013, the general office of the State Council issued *The Sustainable Development Planning for Nationwide Resource-Based Cities (2013–2020)*, which identified 262 resource-based cities in China for the first time, and required that the problems of resource-exhausted cities be addressed and solved basically by 2020, and a long-term sound mechanism be established to promote the sustainable development of resource-based cities.

On December 12, 2013, the working conference of urbanization of the Central Committee of the Communist Party of China was held in Beijing for the first time. The meeting required that China should focus on improving the quality of urbanization, attach greater importance to ecological security, continually improve environmental quality, reduce the total amount of discharge of major pollutants, control the rate of development and enhance its ability to resist and slow natural disasters.

On December 18, 2013, the State Council Premier Li Keqiang chaired a state council executive meeting which deployed a group of major ecological engineering projects, such as Qinghai Sanjiangyuan ecological protection, the construction of a comprehensive experimental national ecological security barrier in Gansu province, the control of sandstorm sources in Beijing and Tianjin and environmental governance of water in the five great lakes of China etc.

On December 19, 2013, the first national forum relating to juvenile education in ecological ethics was held in Beijing. The forum discussed ideas about the theory of exploration, the exchange of practical experiences and the demonstration of outstanding cases in the ecological moral education of juveniles, and deepened discussion of new forms, new thoughts and new measures on the theory and practice of juvenile education in ecological ethics.

On December 20, 2013, the Court of Hebei Province passed sentenced in four environmental pollution cases. Four defendants were sentenced to three-year terms of imprisonment and fines ranging from 30,000 to 50,000 yuan, for having committed environmental pollution crimes. This is the first time China has really focused on the sentence for environmental pollution offences.

On January 7, 2014, the Ministry of Environmental Protection and the 31 provinces (autonomous regions and municipalities) signed *The Objective Responsibility Book of the Prevention and Control of Air Pollution,* clearly defining the air quality improvement goals and key tasks for every province.

On January 2014, Ali and Tencent, two Internet giants, launched two network taxi software applications—Fast taxi and Didi. The software is used widely by a large number and in a blowout type, displays the potential of the innovative use of Internet resources by both businesses and the public and enhances the smart city's development through the market and by innovation.

On February 26, 2014, the General Secretary Xi Jinping hosted a symposium in Beijing on the report of the coordinated development of Beijing–Tianjin–Hebei area. Integration of the Beijing–Tianjin–Hebei region was seen for the first time as part of a national strategy. The implementation of this major national strategy is of far-reaching significance and has a very significant impact on getting rid of restrictions on various institutional obstacles to the free flow and optimized allocation of capital, technology, property, personnel, labor and other production factors, and to the overall improvement of international competitiveness of urban agglomerations, carrying capacity, content development level and ecological governance level, thereby creating a large, modern metropolitan economy with a global influence, driving the construction of "one belt, one road", and promoting the collaborative development of metropolitan areas worldwide.

On March 5, 2014, the second session of the Twelfth National People's Congress opened in the Great Hall of the People. Premier Li Keqiang pointed out in *the Government Work Report* that we want to fight resolutely against pollution as well as poverty. *The Report* took an important decision to strengthen pollution prevention and control, promote the change of energy production and consumption patterns and advance ecological protection and construction.

On March 16, 2014, *The National New Urbanization Planning (2014–2020)* was officially announced. *The Planning* stressed that we should improve institutional mechanisms to promote the green cycle and low-carbon development of urbanization, implement the most stringent environmental protection systems, limit the red line of ecological protection, accelerate price reforms of natural resources and their products and form the spatial pattern, industrial structure, production modes and way of life to conserve resources and protect the environment.

On April 17, 2014, the Ministry of Environmental Protection and the Ministry of Land and Resources issued the *National Soil Pollution Survey Bulletin.* The results of the survey showed that the overall situation of the national soil environment was not good, that soil pollution in some areas was serious, and the environmental quality of cultivated land was worrying and soil environmental issues connected to mining and industrial wasteland were still in need of addressing.

On April 24, 2014, *The Amendment Draft of the Environmental Protection Law* was passed in the 8th meeting of the 12th session of the standing committee of the National People's Congress, which was announced by the 9th presidential order signed by President Xi Jinping. The draft included "promoting the construction of ecological civilization, and accelerating sustainable economic and social development" in the legislative purpose, established "environmental protection" as basic state policy, regarded "protection priority" as the first basic principle, wrote the "ecological red line" into laws for the first time, and clearly proposed that businesses illegally discharging pollutants should be continuously fined by the day—without limitation on the sum of fines. New environmental protection law will come into force on January 1, 2015.

On May 20, 2014, the Ministry of Environmental Protection held an on-the-spot meeting at a national ecological civilization construction in Huzhou, Zhejiang Province. At the meeting 37 cities (counties and districts) were awarded the title of "national ecological civilization construction demonstration zone". Six ministries and commissions, including the National Development and Reform Commission launched 57 demonstration areas of ecological civilization construction. The Ministry of Water Resources identified 59 cities as pilots in the second batch of national water ecological civilization city construction. The Ministry of Agriculture issued ten modes of "a beautiful rural area". The National Afforestation Committee and the State Forestry Bureau awarded 17 cities the title of "National Forest City".

On June 26, 2014, the Chinese Academy of Social Sciences published *The Green Paper of the Eco City: The Development Report of China's Eco City Construction (2014)* (Liu Juke, Sun Weiping, Hu Wenzhen, Eds.). *The Report* pointed out that there were problems in five aspects of China's eco city construction: Cities with a high health index have been in leading positions overall, but their key individual indices such as air quality and water quality etc., are still not up to standard; the problem of causing damage to the ecological environment in order to advance personal and local interests has not been fundamentally changed; the construction of areas for production and habitation still need specifying; the construction of the natural belt, the agricultural belt and the humanity belt both inside and outside the city is not being harmoniously developed and the assessment of the environmental impact is not transparent etc.

On July 2, 2014, the coordination group in charge of recognizing those reaching the required standards in their national appraisals through comparison gave an official written reply to the Ministry of Environmental Protection agreeing to set up the "China Ecological Civilization Award" as part of the "Ecological Civilization Construction Demonstration Zone" project. The "China Ecological Civilization Award" is the first special award for ecological civilization in China, and its selection and recognition is open to basic level and frontline work, focusing on the award of the unit and the individual making a significant contribution to the practice of creative construction of the ecological civilization, theoretical research and publicity, and education. At the annual meeting of the ecological civilization forum of China held on November 1st in Chengdu, the Chinese ecological civilization award was started.

On July 15, 2014, the Supreme Court issued opinions requiring the Higher People's Court to rationalize institutional functions, rationally allocate judicial resources and set up a special trial institution for environmental resources in accordance with the idea of professional judgment.

On August 1, 2014, the first comprehensive standard covering all the industrial businesses emitting volatile organic compounds—Tianjin *Standard of Controlling the Emission of Volatile Organic Compounds by Industrial Enterprises* was formally promulgated. *The Standard* stipulated the organized emission concentration of volatile organic compounds, the concentration limit at monitored spots within the factory, management regulations and monitoring requirements, etc., for the industries producing volatile organic compounds, for example, the 11 kinds of key industries and other industries such as oil refining and petrochemicals, and pharmaceutical manufacturing. The introduction of "the standard" by the industrial businesses will be of great significance for the control of the volatile organic compound pollution, the reduction of emissions amounts, and the improvement of environmental air quality.

On August 11, 2014, the World Health Organization defined the outbreak of Ebola in West Africa as an international health emergency. The cross-regional, global spread of Ebola shows that the world city network based on air transport can become a major channel by which diseases spread, and the perfection of the aviation hub and disease control system should become an important issue to be considered by eco cities and especially by international eco cities.

On September 11, 2014, according to *The Plan for Coordinated Development of Water Conservancy in Beijing, Tianjin and Hebe* compiled by the Ministry of Water Resources, Beijing, Tianjin and Hebei will build a unified deployment of a water resources management platform and carry out the joint scheduling of water. By 2030, the Beijing–Tianjin–Hebei region will be the first to finish building a water-saving society and will begin to see the benefits of a modern approach to water conservation.

On September 13, 2014, according to the report from *The Voice of China Global Chinese Radio Network*, China currently has 33 established cities including Nanchang and Zhengzhou, as the first batch of pilot projects to carry out the resource utilization and harmless treatment of kitchen wastes. Food waste recycling can not only cut off the black market in the production of waste oil and reduce the threat to food safety, but can also help to avoid environmental pollution while recycling waste products or even turning them into useful products.

On September 19, 2014, Chinese officials released the first national special planning in the field of climate change. China will achieve all its goals of controlling greenhouse gas emissions from 2020, including decreasing unit GDP carbon dioxide emissions to 40 from 45 %, compared to that of 2005. The consumption of non-fossil energy will be reduced to around 15 % of the proportion of primary energy consumption. Compared to 2005, carbon dioxide emissions in the Chinese unit of industrial increase value decreased by 50 %. Compared with 2010, carbon dioxide emission of the railway unit decreased 15 % and carbon dioxide emissions in the civil aviation unit decreased 11 %.

On October 23, 2014, *The Decision on Certain Major Issues to Advance the Law-Based Governance Comprehensively*, passed by the Fourth Plenary Session of the 18th Central Committee of the Communist Party of China, proposed to protect the ecological environment through strict legal measures, to accelerate the establishment of the legal system of ecological civilization to effect development behavior and promote green development, cycle development and low-carbon development, strengthen the producer's legal responsibility towards environmental protection and greatly raise the cost of illegal behaviors, establish and perfect the system of property laws relating to natural resources, improve the legal system of the development and protection of national land and space, formulate and perfect the laws and regulations regarding ecological compensation, the prevention and control of soil pollution, water pollution, air pollution and the protection of the Marine ecological environment in order to promote the construction of ecological civilization.

On October 26, 2014, the expert from CMA National Climate Center said that the phenomenon of fog-locked cities in autumn and winter in China will be normalized, and the skylines of the four big "haze regions"—the Beijing–Tianji–Hebei region, the Yangtze River Delta, the Pearl River Delta and Chuan-Yu region (Chengdu and Chongqing), will become clear.

On October 31, 2014, a series of activities on the first "World Urban Day" set up by the UN General Assembly were held in Shanghai, the theme of which was "urban transformation and development". The World Standardization Organization set up the first international standard of cities—ISO37120. Shanghai became one of the 20 global pilot cities.

During the period of APEC in November 2014, Beijing took such methods as limiting the quantity of vehicles on the road according to whether the number on the car license plate was odd or even, created the "APEC blue" and reduced PM2.5 concentration by 55 %. The emergence of the "APEC blue" illustrates that the haze can be controlled through people's efforts.

On November 12, 2014, the United States and China published *The Sino-US Joint Statement on Climate Change* in Beijing. Chinese President Xi Jinping and US President Barack Obama announced the respective actions to be taken by the two countries on climate change after 2020. The United States plans, on the basis of 2005, to achieve the target of reducing emissions by 26 % down to 28 % in the nationwide economy by 2025, and will try to reduce emissions to 28 %. China plans to reach the peak of carbon dioxide emissions in 2030 or so, and is working towards that peak being early. China also plans to increase the rate of the non-fossil energy consumption to 20 % or so in the total proportion of energy consumption. UN Secretary General Ban Ki-moon said in a statement, the leadership exhibited by the world's two largest economic countries would bring an unprecedented opportunity to the international community.

On November 26, 2014, State Council Premier Li Keqiang chaired a state council executive meeting, at which *The Air Pollution Prevention and Control Act of the People's Republic of China (Revised Draft)* was passed after discussion. The draft stressed the governance of the sources, the participation of all people and strengthening the control of the amount of pollution emissions and concentration, increased special provisions for carrying out the cooperative governance and regional joint defense and control of the spread of pollution in key areas and in such key fields as coal, industry, motor vehicles and dust. The revision of the Chinese law relating to the prevention and control of atmospheric pollution after 14 years shows that China will control pollution with severe laws.

On November 30, 2014, the large-scale public welfare activity "Forest China—2014 China Ecological Hero" started in Beijing. The theme of the activity is "feelings for forest, China dream", to publicize ecological heroes who make a special contribution to the protection of forest resources, raise public awareness of and participation in the protection of forest resources, practice the socialist ecological civilization view and implement the green China dream. The specific criteria are as follows: guidance, demonstration, public welfare and journalism.

On December 5, 2014, Lukang Pharmaceuticals Company, a business in Shandong, secretly discharged antibiotics sewage at a concentration 10,000 times that of natural water, and the Nanjing Water Supply even detected amoxicillin from its sewage. Antibiotics were detected in major Chinese rivers such as the Huangpu River, the Yangtze River estuary and the Pearl River etc. Bacterial drug resistance caused by the persistent antibiotic pollution of urban soil, water and food is now a big threat to urban development and urban life.

On December 9–11, 2014, the central economic work conference was held in Beijing. It described resources and environment with some severe words: "from the perspective of the resources and environment constraints, in the past the amount of energy resources and the size of the ecological environment was relatively large, but the environmental carrying capacity has now reached or is close to its upper limit. We must comply with the people's expectations of a sound ecological environment and promote the formation of new ways of green low-carbon cycle development", which highlights the importance and priority of ecological problems in the development of the national economy.

On December 16, 2014, the second court session was opened to hear the case that Taizhou Environmental Federation in Jiangsu sued 6 chemical businesses because of their illegal disposal of waste acid. The first court session received much attention and the 6 chemical businesses were sentenced to pay 1.6 billion yuan. This is the largest amount of environmental public welfare litigation in the country so far. In the future, through the use of environmental public interest litigation, the curbing of environmental damage caused by businesses will be normalized and the promotion of environmental protection by means of the legal system will be a very important direction of development.

On December 23, 2014, the largest pneumatic garbage conveying system, the standard type according to environmental protection criterion in the latest model at the highest level of informatization, was recently put into use in the Sino-Singaporean eco city of Tianjin. In the future, integrating the garbage collection system with modern technology will become an important task of smart city construction.

On December 25, 2014, an important part of the comprehensive bilateral strategic partnership between China and Germany—Sino-German Low-Carbon Eco City Pilot Demonstration Work began in Beijing. Yantai city in Shandong Province, Zhangjiakou city (including Huailai) in Hebei Province, Haimen city and Yixing city in Jiangsu Province and Urumqi in Xinjiang Autonomous Region were all chosen to be in the first batch of pilot demonstration cities of the "Sino-German Low-Carbon Eco City Cooperation Project".

On December 26, 2014, the implementation plan of the Qiannan water ecological civilization city construction pilot was approved by the Ministry of Water Resources. The water-control ideas of Qiannan were "priority of water conservation, the balance of space and systematic management with no expense or effort spared", implementing the integrated water project of "strict water management, enhancing water security, improving the water environment, repairing water ecology and revealing water culture", and balancing the relationship between regional ecological environment protection and the development of the economy and society.

On December 28, 2014, Beijing Gardening and Greening Bureau declared that they would focus on creating 10 urban forest ecological areas with distinct characteristics in 2015, including the construction of a green corridor south-to-north along the water diversion project, planting a 5103 mu forest in Fangshan, Huairou, Miyun, and planting a 5000 mu forest on both sides of the Jingkun highway etc. The plan includes the planting of 11.6 million mu of forest in 2015.

On December 28, 2014, the Asia Pacific City Construction and Development Summit Meeting in 2014 was successfully held in Beijing, the theme of which was to "focus on livable cities, show the elegant appearance of Asia and the Pacific, extol the virtues of industry models and discuss urban development". The meeting selected the top 10 Chinese "Ecologically Livable Model Cities in 2014". They were Xiamen, Guilin, Nanjing, Kunming, Dalian, Linyi, Guiyang, Lanzhou, Urumqi and Dazhou.

On May 6, 2015, China issued *The Opinions on Accelerating the Construction of Ecological Civilizations*, on behalf of the CPC Central Committee and the State Council. This was the first document of a comprehensive special deployment that the country made on ecological civilization construction. *The Opinions* explicitly put forward for the first time the collaborative development of the new type of industrialization, informationization, urbanization, agricultural modernization and greening.

On September 21, 2015, the top-level design of Chinese reform in the field of ecological civilization—*The Overall Scheme of System Reform of Ecological Civilization* was announced, which clearly stated the commitments and the road map of system reform of ecological civilization. *The Scheme* focused on the direction of the concept and the basic framework, clearly proposed the construction of the institutional system and consolidated the institutional foundation of accelerating of the construction of ecological civilizations in China.

Appendix B
Cases of Eco City

Introduction to the Ecological City Construction Experience of Zhuhai

Zhuhai is located on the west bank of the Pearl River Delta in Guangdong province, adjacent to Hong Kong and Macao, with a total area of 7653 km^2, of which the land covers 1724 km^2. It has a permanent population of 1.65 million. There are 217 islands of various sizes in Zhuhai and it known as "the city of a hundred islands." Zhuhai ranked first in "the list of livable cities in China" in 2014 and 2015, and was called "the experimental field of ecological civilization" in a CCTV news broadcast. The main methods Zhuhai has employed are:

One: To improve ecological nomocracy through the exploration of system innovation. Zhuhai has built the legal system of ecological civilization with *The Ordinance Promoting Ecological Civilization Construction in Zhuhai Special Economic Zone* at its core and has formulated 17 local laws and regulations related to the ecological environment, along with 12 government regulations. In May 2015, the experience of regulation of the construction of ecological civilization in Zhuhai got "the Best Example Award for the National Ecological Environment Nomocracy Security System Innovation."

Two: To lead scientific development by adhering to advance planning. Zhuhai has worked out the planning for the implementation of ecological civilization construction and integrated it with the five plans including overall planning, the national economic and social development plan, the main functional area plan and land use planning and will achieve, "everything subject to a single blueprint." Meanwhile, Zhuhai has designated the ecological control line in the urban area with a total area of about 1053 km^2, accounting for 58.54 % of the total land area and has laid a sound ecological security pattern for the city's scientific development.

Three: To drive ecological development by the "three high and one special" industries. Zhuhai has focused on the development of the "three high and one special" industries (high-end manufacturing, high-end services, high-tech industries, special marine economy and ecological agriculture), and achieved remarkable

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results. By 2015, the output value of the city's high-tech products accounted for 55 % of the total industrial output value across the scale and the added value of the modern service industry as a proportion of the service industry rose to 57.6 %.

Four: To strengthen the ecological basis by promoting cell engineering. Zhuhai has implemented joint creation of the ecological "city, district, town and village" and an ecological demonstration effect has been gradually revealed. Zhuhai received little publicity before it was named "the National Ecological City", all the administrative areas received little publicity before they were named "the National Ecological District" and Xiangzhou District was named "the National Ecological District" in 2014. Zhuhai has built 13 national ecological towns (villages), 25 ecological demonstration towns (villages, communities) in Guangdong Province, 271 ecological demonstration villages (communities) at the municipal level, 165 "green schools", 61 "green communities" and 12 environmental protection education bases, reinforcing the foundation of ecological civilization construction.

Mobilization meeting for the creation of national eco cities in 2012 in Zhuhai

The city's living room

The *lush green*—RuanYaolin

A Brief Introduction to the Experience of Ecological Civilization Construction in Chongming Island in Shanghai

As Chongming Island is an organic part of the ecological demonstration area in a metropolis circle and the sustainable development of Shanghai as well as being an important strategic space and ecological service function area, the construction of Chongming ecological island has attracted widespread attention at home and abroad. In January 2010, Shanghai promulgated *The Outline of Chongming Ecological Island Construction (2010–2020)*, which put forward the index system and the target at every stage of Chongming ecological island construction, making every effort to form the basic pattern of sustainable development of the island in terms of natural ecological health, living ecological harmony, high-end industrial ecology, strong international competitiveness and an outstanding leading exemplary role by the year 2020.

In March 2014, the United Nations Environment Program issued *The International Assessment Report on Chongming Ecological Island*. *The Report* pointed out that the core values of the ecological construction of Chongming Island reflect the green economic philosophy of the United Nations Environment Program. In terms of natural ecological construction, Chongming Island has fulfilled the protection of biodiversity and the ecosystem of wetlands through such ways as the management of invasive species, restrictions on reclaimed wetlands, ecological habitat protection and management and comprehensive control of pests. In terms of its human settlement ecology, Chongming Island has created a new model of decentralized rural sewage treatment and through accelerating the construction of sewage interception and centralized treatment of urban sewage, the quality of the water and environment have been significantly improved. For the comprehensive management of solid waste, Chongming Island is trying to achieve "quantity reduction, innocuousness and resource recovery". In terms of industrial ecology, Chongming Island has begun to transform fragmented agricultural management into the establishment of a green, organic brand system and under the guidance and support of science and technology the low-carbon development strategy and pattern has been preliminarily established. *The Report* also suggests establishing "the ecological civilization DC" in Chongming and points out that "compared to the construction of special economic zones, the core of the construction of the Chongming ecological zone should be the ecological civilization, in order to play the demonstration role for the construction of ecological civilization in other similar areas".

The ecological office building of Chenjiazhen company on Chongming Island in Shanghai

Dongtan national nature reserve for birds on Chongming Island in Shanghai

Brief Introduction to the Construction Experience of Chanba National Wetland Ecological Park in Xi'an

In recent years, Xi'an has proposed a development goal of "building a beautiful Xi'an". To this end Xi'an integrates ecological construction into its overall economic, political, cultural and social development. Targeting "the purification of air, the development of the hydro ecological environment, the increase of green areas and the comprehensive construction of the rural ecological environment and urban landscape", Xi'an has accelerated the implementation of a series of major ecological projects. In 2014 alone, the government invested 3.13 billion RMB, 2.1 times more than in 2013. 480 coal-fired boilers were demolished and 42,000 "yellow label" vehicles were eliminated. The project of clean energy transformation for 34,000 households was completed. Artificial weather modification has been a routine practice. By all measures, in 2014 there were 71 more days that were even better than the provincial AQI standard and the public satisfaction index improved to stand at 17.7 % higher than the previous year. Every effort was made to protect the ecological environment of Mount Qinling and 8 ecological squares and 17 km-long green paths in the mountains were built to a high standard. The urban green area increased to 4.5 million square meters and afforestation amounted to 7666.67 hectares in 2014. "Hydro projects on 8 rivers" were accelerated and the construction of "two rivers, five lakes and six wetlands" was completed. The ecological water area increased by 207 hectares and wetlands by 434 hectares. Through unremitting efforts to coordinate economic and social development and ecological construction, Xi'an, the ancient city with more than two thousand years of history now takes on a beautiful appearance with a splendid urban landscape and achieves harmony between man and nature.

Xi’an Chanba National Wetland Park—a new look of ecological Xi’an

An aerial view of Xi’an Chanba National Wetland Park

Appendix C
Cases of New Energy Development

The first phase of a 3.8 million kilowatt wind power project of the ten million kilowatt level wind power base of Huaneng Jiuquan Wind Power Co., Ltd. In 2015 the wind power grid in the Hexi Corridor broke through the 10 million kilowatt figure

China is one of the countries with the most abundant wind energy resources on Earth. The theoretical resource reserve of wind energy in the nation is 3.226 billion kilowatts, of which the economic exploitable amount is 253 million kilowatts. At present, the national total installed capacity is more than 600 million kilowatts and 158 wind power plants and 6582 wind turbine generators have been built distributed across 20 provinces (cities and districts) including Inner Mongolia, Xinjiang, Gansu, Liaoning, Hebei and Shandong.

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The photovoltaic industrial park in the deserts of Zhongwei, Ningxia is the largest desert photovoltaic power station in China with an estimated total investment of 20 billion Yuan, and a photovoltaic power generation capacity of about 1500 mw. At present there are 26 businesses involvbed in it. There is an increase of 2.8 billion degrees of electricity into the grid every year, realizing an output value of more than 7 billion Yuan and saving more than 1.1 million tons of standard coal every year

By the end of 2014, the cumulative installed capacity of China's photovoltaic power generation was 28.05 million kilowatts, ranking second in the world with an annual power generation of about 25 billion kWh.

In 2014, the installed capacity of hydropower in China was more than 300 million kilowatts, and the hydropower generating capacity exceeded 1 trillion kilowatts, ranking first in the world.

26 hydroelectric generating sets have been installed in the Three Gorges hydropower station of the Yangtze River Three Gorges Project with an installed single machine capacity of 0.7 million kilowatts hydroelectric generating units, the total installed capacity of which is 18.2 million kilowatts, generating an average amount of 84.68 billion kWh. It is the largest hydropower station in the world

Appendix D
Case Studies of Ecological Engineering

To Construct and Protect the Dunhuang "Desert Dujiangyan" and Create a New Model of Desert and Flood Control through Business Partnerships
Dunhuang is a bright pearl on "the Silk Road Economic Belt" and is globally seen as an historical and cultural city embedded in the Gobi Desert at the western end of the Danghe River Basin in the Hexi Corridor in Gansu. However, Dunhuang is surrounded by the Kumtag Desert on three sides. The Kumtag Desert is moving eastwards at an annual speed of 5–10 m. Because Dunhuang is close to the Qilian Mountains in the South and is threatened by floods from Subei and Aksai at the northern slope of the Qilian Mountains during the annual flood season, Dunhuang has long faced environmental problems such as "sand damage" and floods. In order to preserve Dunhuang, we must preserve Yangguan, and to preserve Yangguan we must control sand invasion and floods. The business led by He Yanzhong of the Gansu Yangguan Bibo Company provides us with a successful example of a business that shoulders social responsibility, has persevered for ten years in its treatment of sand and floods and industrial development and carries out scientific research unswervingly—the Yangguan Bibo mode.

In order to realize the "Chinese Dream" of protecting Dunhuang and constructing "the green silk road", the people of Bibo have invested 0.28 billion Yuan and built the ecological management project "Desert Dujiangyan" at the desert eroding forefront in Yangguanzhen by moving more than 500 dunes and rocky mountains and more than 100 million cubic stones in more than ten years. They have set more than 100 sand barriers, built more than 150 km of the comb dam water conservation project, 21 km of desert osmosis filtration engineering and 13 multi-level flood combing rivers with a total length of 90 km. They have stored floods to save windbreaks through filtration and purification turning "water damage" into "useful water", areas of sand invasion into sand retreats, ecologically governing 30 thousand mu of land and controlling 56 km^2 of desertified land. They have built the hub water injection project including Moon Lake, Jiulian Lake, the Dunhuang Science and Technology Demonstration Park of Desert Grapes, the desert alpine cold water fish production base, the trout deep processing workshop, research and training center and Dunhuang Palace etc. They have also explored the "flood flow control" mode, namely "the system engineering of dividing, saving,

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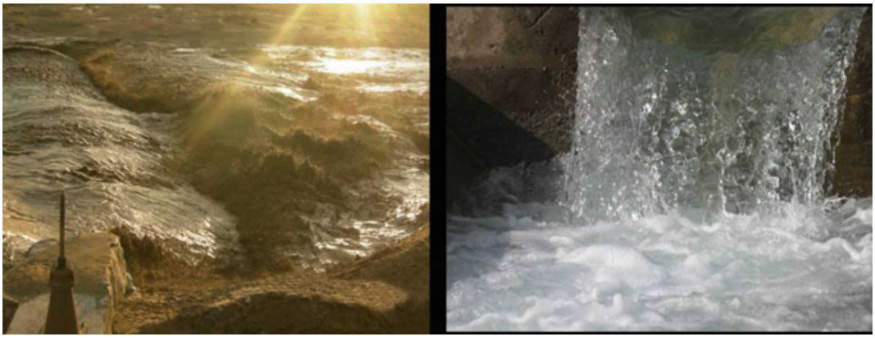
filtering, building and constructing". "Dividing" refers to splitting a flood and diversifying its flow. "Saving" refers to water conservation. "Filtering" refers to desert osmosis filtration. "Building" refers to building a dam as a windbreak while sand fixation and "constructing" refers to the construction of the ecological agricultural industry chain. Experts believe that the project is smartly designed and its new mode of ecological governance by managing harmful things with harmful things, and turning harmful things into useful things through absorbing the philosophy of "the integration of heaven and man" is very creative and inspiring. To protect Yangguan and keep a watch on Dunhuang, a green ecological barrier has been erected and this has promoted the development of agriculture with special local characteristics and has highlighted the economic and social benefits of desertification control, the taming of floods, family protection and enriching people.

At the same time, Yanggan Bibo Company established a workstation for academic experts in Dunhuang Feitian Ecological Science and Technology Park in cooperation with the Chinese Academy of Sciences, engaging in research and development on flood and desertification control and the technology of ecological

On the left Before treatment the soil erosion is serious and landslides and debris flow happen frequently. *On the right* After treatment the erosion on both sides of the river channel has been effectively controlled and clear water always flows

On the left Sand dunes in the Kumtag Desert before treatment. *On the right* Vegetation growing on the surface of the dunes after treatment



Pictures of the separation of clean water from floods

restoration in Dunhuang. This is helpful to the construction of “the green silk road” and provides intellectual support for the protection of Dunhuang, the Pearl of Mogao. The project has aroused great interest in the international scientific community and there have been experts and academicians from Canada, Japan, Israel, the United States, Germany and Australia etc. coming to Dunhuang to visit and study.