Research on the Evaluation Index System for Urban Sustainable Development

Wang Hongyue1, Inna Koblianska2

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Abstract: With the rapid development of industrialisation and urbanisation, many problems and challenges are encountered in urban development. Constructing a scientific and reasonable index system to evaluate the performance of urban sustainability is of great significance to comprehensively improving urban life and growth. This study innovatively built the theoretical framework for the “four-dimensional interactive structure” of sustainable urban development and, combined with the principle of index system construction, established the evaluation index system with four subsystems: environment, economy, society, and science and technology. This lays a foundation for the follow-up empirical analysis and research.

1. INTRODUCTION

Since the reform and opening-up, China’s urbanisation construction has made remarkable achievements, and the urbanisation rate has been advancing rapidly at an average rate of 1% per year. In 2021, the urbanisation rate will be as high as 64.72% (Peng et al., 2021). Although urbanisation plays a positive role in the transformation and upgrading of economic structure, the transformation and upgrading of consumption structure, and the alleviation of overcapacity, the rapid urbanisation process also exposes a series of problems, such as the deterioration of the urban environment and ecology, traffic congestion, housing shortage, and social stability (Ding et al., 2020). The sustainable development of cities has gradually become a new challenge in urban development. In recent years, China has been increasing investment in sustainable urban development. However, due to the lack of systematic and scientific urban sustainable development index systems and evaluation methods, the construction of the index system is not reasonable. Therefore, it isn’t easy to theoretically evaluate the status of sustainable urban development in China, whether the measures taken are valid and effective, and whether the expected sustainable urban development goals can be achieved.

2. LITERATURE REVIEW

Many studies have focused on evaluating sustainable urban development (Chen, 2019). Great efforts have been exerted to study urban sustainability at urban, regional, national, and international scales. A list of evaluation systems for urban sustainability composed of various sets of indicators was proposed by global and regional organisations at an early stage, such as the “Driving force-State-Response (DSR)” model developed by The United Nations Commission on Sustainable Development (UNCSD) (Dantas et al., 2021), “Pressure-State-Response (PRS)”
model employed by the Organization for Economic Cooperation and Development (OCED), “Society-economy-environment” framework proposed by United Nations Environment Programme (UNEP) (Chopin et al., 2021) and “Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development” developed by the World Bank (Chebaeva et al., 2021). However, these index systems pay more attention to constructing theoretical frameworks of sustainable development and do not meet the actual demands of different countries. Later, these frameworks were used as references for many countries and communities to develop their systems at a national scale, such as member states of the European Union (Karjalainen & Juhola, 2021), the UK (Michalina et al., 2021), and Singapore (Hegazy et al., 2021). Based on its actual situation, China also built index systems with Chinese characteristics by different governmental agencies. For example, the Sustainable development index system of China organised by the Ministry of Science and Technology, the sustainable development evaluation index system of experimental areas of the State Science and Technology Commission, and the sustainable development Index system of the Sustainable Development Strategy Research Group of the Chinese Academy of Sciences (Yi et al., 2021).

Meanwhile, many scholars began to study sustainable development on an urban scale. Researcher Mao Hanying created the sustainable development index system framework in Shandong Province in the Preliminary Study on the Index System of Sustainable Development (Mao, 1996). The index system established includes four subsystems, including the economic growth subsystem, social subsystem, resource environment subsystem, and sustainable development ability subsystem, with one subject layer and 90 essential index factors. Xiong Xuezhen et al., for example, according to the nature of environmental bearing capacity, the structure and function of the external environment system, and performance, believed that the index system of environmental carrying capacity should reflect the exchange of material, energy, and information between the environment and the social and economic system, the indicators are divided into natural resources supply, support social conditions and pollution capacity indexes from three categories (Xiong et al., 2022). Sun Jiuxia et al. summarised the indicators for evaluating sustainable urban development into economic, social, and environmental indices. Finally, they integrated them into the “coordination degree” index (Sun & Wang, 2022).

By systematically combing the domestic literature, we can find that the existing research work on the sustainable development index system in China reflects a good level of administrative divisions and industry divisions; these index systems are based on different modes of creation, absorb the strategic idea of sustainable development, and show good systematicity and hierarchy. It has laid a good foundation for the research and comparative analysis of China’s sustainable development index system.

At the same time, the domestic and foreign sustainable development indicator system also has many problems. The index system is complex, and the number of indicators is too large, making it difficult to operate.

3. RESULTS AND DISCUSSION

Theoretical analysis of the evaluation index system of sustainable urban development. From the perspective of system theory, sustainable urban development is a scientific system that reflects the overall development of human society. It is not only related to the development of each subsystem of environment, economy, society, and science and technology but also the relationship
and interaction between each subsystem (Han et al., 2021; Hongyue & Koblianska, 2021). Urban sustainable development is a complex and systematic problem. Therefore, this study first discusses the system structure of sustainable urban development and the division mechanism of a four-dimensional complex system from the perspective of system theory and then establishes a scientific evaluation index system of sustainable urban development.

The system is composed of many interrelated and interdependent elements. According to the complex system theory, the subject of this study is treated as a complex system problem. Then it meets the three necessary conditions that the system should have: first, it is composed of the main elements such as environment, economy, society and science and technology; Secondly, the aspects of the environment, economy, society and science and technology are interrelated and interacted with each other, and there are cross-vertical and horizontal structures and orders among them. Third, this complex system has its specific functions and roles. The process of sustainable urban development depends on the elements of the environment, economy, society and science and technology and their reciprocal links and structures. So, suppose we want to evaluate the urban sustainable development ability. In that case, we must use the thought of the system, from the perspective of the system, clear the component elements of sustainable urban development of this system and its specific content and function, and use the scientific method of concise evaluation of urban sustainable development system the various components of the underlying index, eventually forming a complete set of index system (Hongyue et al., 2022).

According to the urban sustainable development system framework analysed in this study, the theoretical framework for the establishment of the urban sustainable development evaluation index system can be obtained, as shown in Fig. 1.

**Figure 1.** The theoretical framework of “four-dimensional interactive structure” for regional sustainable development

*Source:* authors’ development

Figure 1 shows four core carriers of sustainable urban development: policy, talent, capital, and science and technology. Regardless of system and dimension, if we want to promote sustainable development, we must start from the four aspects of policy, talent, capital, and science and technology. From the point of view of each subsystem of sustainable urban development, the most direct and vital way is through capital investment to realise the sustainable economic
development of the economic subsystem. To realise the sustainable innovation of the science and technology subsystem, the most intuitive and core is to rely on science and technology development; To realise the sustainable ecological environment of an environmental subsystem, the most critical and universal way is to rely on the guidance and norms of relevant policies. The most effective and scientific way to achieve sustainable social well-being of social subsystems is through the wisdom, ability, and relationships of talents. Because society is a collection of people, people are the main body of scientific and technological development, science and technology is the carrier to promote social progress and economic development, a policy is a bridge to achieve the goal of sustainable development of the economy, society, environment, science, and technology, so policy, talent, capital and science, and technology are interrelated with the four subsystems of sustainable urban development and cannot be separated.

Furthermore, looking at the intuitive performance of the four subsystems to achieve sustainable development, the functioning of a sustainable ecological environment is the effective implementation of laws and regulations on energy conservation and environmental protection. When society changes from labour-intensive to knowledge-intensive and talent-intensive, it meets the requirements of social well-being and sustainable development. Sustainable economic growth is mainly manifested in the advocacy of a low-carbon economy, green industry, green enterprises, and other similar entities occupying a dominant position, and so on.

The intuitive manifestation of sustainable development of science and technology is the organic combination of the Internet and renewable energy. The research and development of energy-saving and environmental protection science and technology have made adequate progress (Hongyue et al., 2022). The four subsystems’ sustainable development goals and performances are different, but they can be effectively connected and interact with each other. For example, the sustainable macroscopic performance of science and technology and social subsystems is establishing and developing “science and technology think tanks”. The sustainability of the environment and society can be achieved by building a two-oriented society: a resource-saving society and an environment-friendly society. The sustainability of the economy and environment can be realised by entering the post-carbon era of new energy. The sustainability of technology and the economy needs to be implemented by adhering to the essence of the third industrial revolution.

Construction of urban sustainable development evaluation index system. Combined with the theoretical connotation of sustainable urban development, according to the principles of scientific, systematic, practical significance, and data availability, this study condensed the index system including environment, economy, society, science, and technology, four dimensions of 20 sub-indicators (Table 1).

An environmental subsystem is the essence of sustainable development. Development without ecological protection, pollution control, and new energy development and utilisation can never be called “sustainable development”. Therefore, there is no doubt that the environmental subsystem is a subsystem of sustainable urban development. The indicators of the environmental subsystem include the daily treatment capacity of urban sewage (A1) and the harmless treatment rate of domestic waste (A5), which reflect environmental pollution control capacity. Total sulfur dioxide emission (A3) and Discharge amount of industrial wastewater (A4) reflect environmental pollution degree, and green coverage in built-up areas (A2) reflects the achievements of ecological environment construction.
Table 1. Urban sustainable development evaluation index system

<table>
<thead>
<tr>
<th>Criterion Layer</th>
<th>Index Layer</th>
<th>Index Unit</th>
<th>Index attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological environment (A)</td>
<td>Daily treatment capacity of urban sewage (A1)</td>
<td>Million cubic meters</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Green coverage in built-up areas (A2)</td>
<td>%</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Total sulfur dioxide emission (A3)</td>
<td>Ten thousand tons</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Discharge amount of industrial wastewater (A4)</td>
<td>Ton</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Harmless treatment rate of domestic waste (A5)</td>
<td>%</td>
<td>Positive</td>
</tr>
<tr>
<td>Economic development (B)</td>
<td>Per capita gross regional product (B1)</td>
<td>Yuan</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Total retail sales of consumer goods (B2)</td>
<td>Billion yuan</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Water consumption per ten thousand yuan of GDP (B3)</td>
<td>Cubic meter million</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Power consumption per ten thousand yuan of GDP (B4)</td>
<td>KWh/ billion yuan</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Proportion of tertiary industry (B5)</td>
<td>%</td>
<td>Positive</td>
</tr>
<tr>
<td>Social well-being (C)</td>
<td>Health technicians per 10,000 people (C1)</td>
<td>Person</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Social security and employment expenditure (C2)</td>
<td>Billion yuan</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Urban population density (C3)</td>
<td>Person/km2</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Urban green space area (C4)</td>
<td>Ten thousand hectares</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Urban registered unemployment rate (C5)</td>
<td>%</td>
<td>Negative</td>
</tr>
<tr>
<td>Science and technology innovation (D)</td>
<td>The R&amp;D expenditure of industrial enterprises (D1)</td>
<td>Ten Thousand Yuan</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>The turnover of technology market (D2)</td>
<td>Billion yuan</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>The financial expenditure on science and technology (D3)</td>
<td>Billion yuan</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>The amount of domestic patent application authorization (D4)</td>
<td>Term</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>The full-time equivalent of R&amp;D personnel of industrial enterprises (D5)</td>
<td>Person/year</td>
<td>Positive</td>
</tr>
</tbody>
</table>

Source: authors’ development

On the issue of sustainable urban development, economic factors are the basis for realising social well-being, technological innovation, and resource protection. The economic subsystem indicators include per capita gross regional product (B1) and proportion of tertiary industry (B5), which reflect the economic scale, measure the economic development status and examine the comprehensive strength of the city. Water consumption per ten thousand yuan of GDP (B3) and power consumption per ten thousand yuan of GDP (B4) reflect resource consumption in economic activities. Total retail sales of Consumer Goods (B2) reflect people’s consumption level and purchasing power of social goods and indirectly reflect a city’s economic development level.

Social subsystems are the root of sustainable urban development, and social well-being is the fundamental criterion for measuring sustainable development. Social subsystem indicators include health technicians per 10,000 people (C1) and social security and employment expenditure (C2), which reflect the government’s ability to provide public goods and services. Urban population density (C3) and urban green space area (C4) reflect residents’ quality of life. The urban registered unemployment rate (C5) reflects the basic level of urban social development.

The science and technology subsystem is the driving force for the city’s sustainable development. The science and technology subsystem indexes include the R&D expenditure of industrial enterprises (D1) and the financial expenditure of science and technology (D3), which reflect the importance and investment of the government and enterprises in innovation. The turnover of the technology market (D2) and the amount of domestic patent application authorisation (D4) reflect a city’s technological innovation achievements. The full-time equivalent of R&D personnel of industrial enterprises (D5) reflects the number of urban talents.
4. CONCLUSION

This research innovatively constructs the theoretical framework of the “four-dimensional interactive structure” of urban sustainability from multiple perspectives and disciplines. Based on this theoretical framework, combined with scientificity, systematisation, practical significance, and data availability, an urban sustainable development evaluation index structure system with 20 underlying indicators in four subsystems is finally established. It lays a foundation for the follow-up empirical analysis and research.

REFERENCES


