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ORIGINAL RESEARCH ARTICLE

References and enlightenment of city biodiversity index in Singapore and Japan

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ABSTRACT

City biodiversity is an important part of global biodiversity conservation, and city biodiversity conservation needs to start with measurement and criteria. This paper introduces the Singapore index and Japanese index, and also introduces city biodiversity index conceptual framework which is developed based on the "driving force pressure status impact response model". The trend of city biodiversity index development is pointed out to build a city biodiversity index of different scales, to build cooperative and shared information infrastructure and to evaluate city biodiversity index itself. At the end, in view of the status quo of city biodiversity index in China and the requirements of urban development, this paper proposes the conception of city biodiversity index development in China from the perspectives of local urban biodiversity, ecosystem service functions and urban management measures.

Keywords: city; biodiversity; index; enlightenment; development conception

1. Introduction

According to the world urbanization outlook, the global population is expected to increase to 9.2 billion by 2050, of which 6.4 billion will live in cities. Cities need to respond to the increase of urban population in the future[1]. Biodiversity can provide safe and economic material and cultural supply for mankind through ecosystem services. The biodiversity widely existing in cities is also an important part of global biodiversity protection. It is necessary to rethink the future urban development from the perspective of biodiversity[2].

Internationally, the Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity (COP10) in 2010 adopted the resolution X/22 "on the Biodiversity Action Plan of sub national governments, cities and other local authorities", encouraging the use of urban biodiversity indicators as a monitoring tool to help local governments assess their progress in urban biodiversity protection[3].

In China, since joining the Convention on Biological Diversity in 1992, urban planning and biodiversity protection in scenic spots have beenincluded in China's biodiversity protection action plan in 1993. In 2002, the notice on strengthening urban biodiversity protection was issued. In 2005, the measures for the application and evaluation of national garden cities clearly required the applicant city to prepare the biodiversity (plant) planning within the urban planning area. the

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evaluation standard for urban landscaping issued in 2010 included the protection of urban biodiversity in the evaluation content and attached great importance to the protection of urban biodiversity, but did not discuss and formulate the indicators of urban biodiversity, and the measurement standard should be considered first in the protection of urban biodiversity.

2. Urban biodiversity indicators in Singapore and Japan

2.1. Overview of urban biodiversity indicators

The proposal of Singapore's urban biodiversity index was put forward by Singapore's Minister of National Development, Ma Baoshan, at the high-level chapter of the Ninth Meeting of the Conference of the Parties to the Convention on Biological Diversity (COP9). After development and optimization of a series of expert discussion meetings, it was officially published at COP10 and adopted by the parties. The urban biodiversity index of Singapore consists of two parts. The first part "urban overview" provides the background information of the city. The second part consists of 23 indicators[4]. The Ministry of land and transportation of Japan released the simplified version of urban biodiversity indicators in 2016, which is composed of three parts and seven indicators: the diversity of urban ecosystems and habitats, the ecosystem services that urban residents can enjoy and the action of cities[5] (**Table 1**).

Table 1. Contents of urban biodiversity indicators[4,5]

Core components	Indicator	Indicator type	Japan/Singapore/common
Urban indigenous biological or ecosystem diversity	Proportion of natural areas of the city (sustainable green space)	Status	Common indicators
	Status of green space (proportion of green space with potential to ensure urban biodiversity)	Status	Japan indicators
	Proportion of protected natural areas (guaranteed by law)	Status	Common indicators
	Connection measures or ecological networks to inhibit fragmentation	Status	Common indicators
	Native biodiversity in built-up areas (bird species)	Status	Singapore indicators
	Changes in the number of local species and investigation on the number of animal and plant species	Impact	Common indicators
	Proportion of invasive alien species	Impact	Singapore indicators
Ecosystem services provided by biodiversity	Water management (water regulation (pervious effect of green space))	Status	Common indicators
	Climate regulation: the carbon storage and cooling effect of vegetation or the absorption of greenhouse gases by urban greening, leisure and education services	Status	Common indicators
		Impact	Singapore indicators
Biodiversity management and action	Budget for biodiversity	Response	Singapore indicators
	Number of biodiversity projects implemented in cities each year	Response	Singapore indicators
	Does the city have a biodiversity strategy and action plan	Response	Common indicators
	Institutional capacity, participation and partnerships	Response	Common indicators
	Education and awareness	Response	Singapore indicators

2.2. Characteristics and use of indicators

It is not easy to use the same standard to evaluate the biodiversity of cities in different climate zones. Therefore, the biodiversity index of Singapore is only used as a tool for self-evaluation to grasp the current situation information, guide conservation practice and test practice results. It can be scored, but not used as a city ranking. The three core components of the indicators respectively represent the stock of local biodiversity in the city, whether the services provided by natural resources are sound, and the relevant contents of the city's response capacity and policy implementation. By 2019, a total of 54 cities in the world have used Singapore's urban

biodiversity index[6].

Japan's urban biodiversity indicators refer to the "Singapore urban biodiversity indicators" and are improved based on three perspectives. The need to serve as an indicator for evaluating the status of actions related to biodiversity and biodiversity conservation. The simplicity of data and calculation method in urban use index evaluation. Wide applicability that can be used in cities all over Japan[7]. In the ranking of excellent cities with biodiversity in Japan[8] released in November 2016, based on the simplified version of urban biodiversity indicators in Japan, 665 cities in Japan were evaluated.

2.3. Improvement points of indicators

In Singapore's biodiversity index "proportion of natural areas (sustainable green space)of the city", in addition to the natural areas of the city, there is no evaluation of the green space affected by human factors, such as parks, open spaces, farmland, etc., and there is no mention of the distinction between urban and suburban areas. It is suggested to consider the distinction between urban and suburban areas, classify the green space therein, and then evaluate the biodiversity of various green spaces. In addition, the indicator "local biodiversity in densely built areas" only considers the total number of urban species and ecosystem, which is greatly affected by the region of the city. The increase or decrease of the total number of species can be replaced by the increase or decrease of protected species. In addition, in the part of ecosystem services, in addition to the existing indicators, cities should adjust appropriately according to the actual situation, such as increasing the evaluation of biodiversity on alleviating urban flood and heat island effect.

Firstly, there is a positive correlation between the indicator "current situation of green space" and the indicator "current situation of urban ecological network", so it is necessary to sort out the relationship between the indicators. Secondly, the relevant indicators of urban action are mainly the evaluation of time series. For example, the evaluation of urban action is higher than that of cities that have made progress in the past, and there is a lack of evaluation of action level. Thirdly, it is necessary to carry out graded evaluation on cities. Only by graded evaluation according to the action status of cities can we effectively promote the action of urban biodiversity protection. Fourthly, it is suggested to increase the number of full-time personnel engaged in urban biodiversity protection and the evaluation of cooperation between administrative departments. In the ranking of Japan's excellent biodiversity cities, it is found that some small and medium-sized cities have excellent scores for biodiversity action because they have set up relevant full-time personnel[9]. Therefore, the important factor affecting biodiversity protection action is likely to be the number of full-time personnel. In addition, the cooperation between departments can be evaluated in terms of whether a multi compliance green space system planning has been formulated.

3. Analysis of urban biodiversity indicators in Singapore and Japan based on the DPSIR framework

3.1. DPSIR framework

The "driving forces-pressures-state impact responses model" (DPSIR) framework is a framework for analyzing society, environment and their causality, because its attention to causality can further clarify problems and solutions, and there are many use cases[10]. The framework for setting and analyzing urban biodiversity indicators[11] includes the following five contents population, economic, social activities and other factors (driving force), environmental change and pollution load (pressure), biodiversity and ecosystem status (status), biodiversity loss caused by environmental change (impact)on human and ecosystem integrity, and the response of government or non-governmental organizations.

3.2. Comparison of indicators between Singapore and Japan

By comparing the framework of Singapore indicators with that of Japan indicators (**Figure 1**). Singapore indicators include not only indicators of natural environment stock and ecosystem service

circulation reflecting the state of biodiversity itself, but also indicators such as habitat fragmentation and the change dynamics of animal and plant species. They are roughly the evaluation tool of the "state impact responses model" (SIR) framework. In Japan, the SR version has two limitations. To sum up, for the future development of indicators, compared with Singapore indicators as a self-evaluation tool, the simple version of Japanese indicators that can be compared between cities also has its exploratory significance.

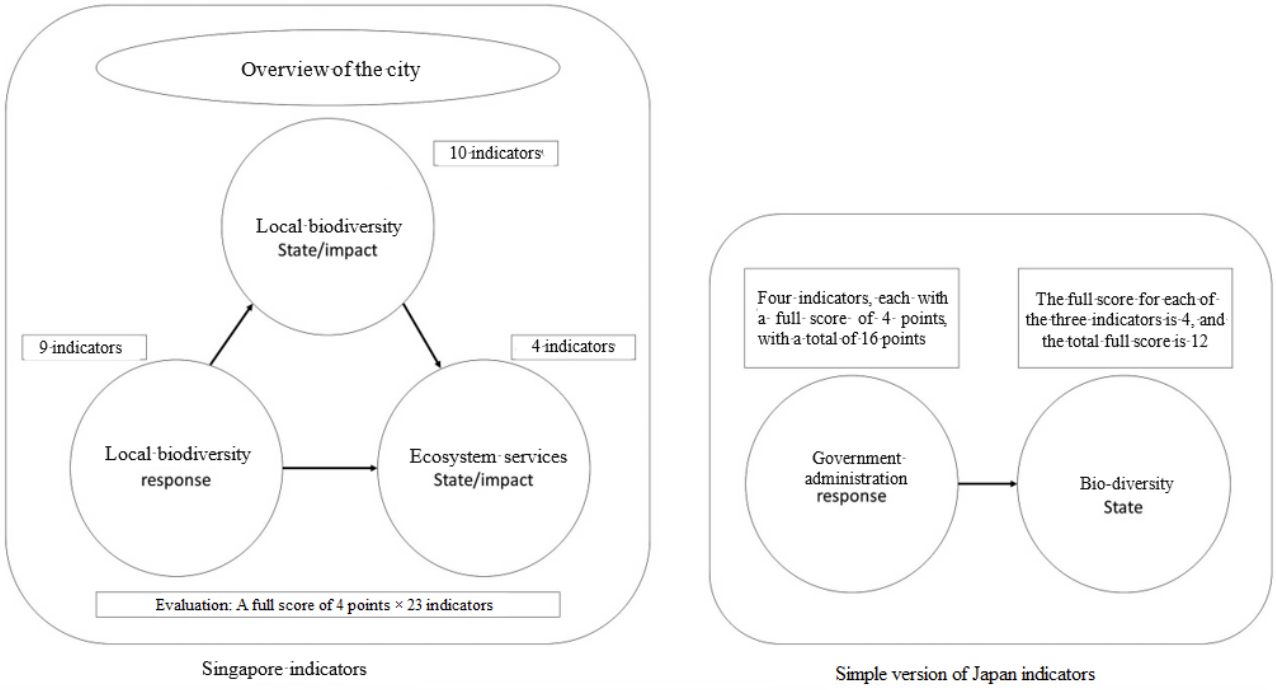

Figure 1. Comparison of evaluation frameworks of Singapore indicators and Japan indicators in simplified version[11].

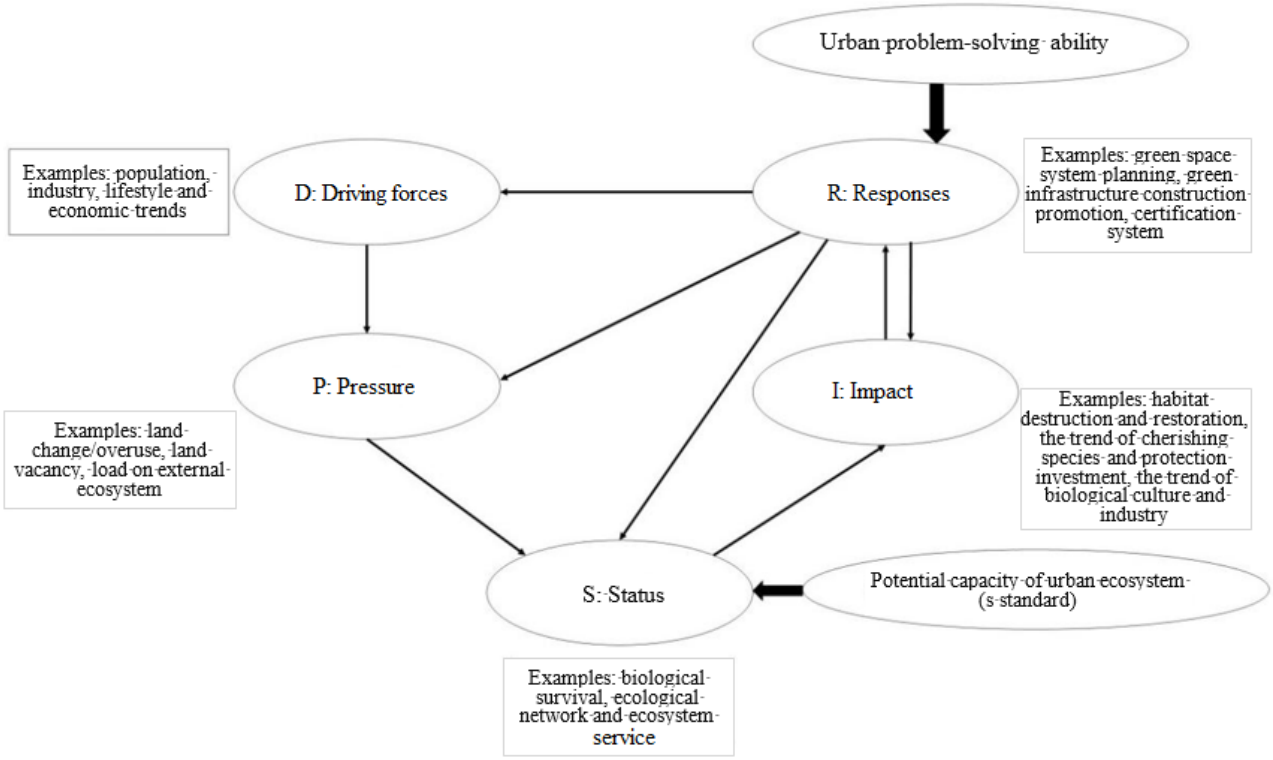

Figure 2. Urban biodiversity index framework based on DPSIR framework[11].

3.3. Urban biodiversity indicator framework

In order to further optimize the urban biodiversity index, this paper uses the thinking method of DPSIR to explore the framework of urban biodiversity index (**Figure 2**). First, it is necessary to add indicators that reflect environmental changes and pollution loads (Pressure). Secondly, regarding the indicators of biodiversity and ecosystem status (Status), set the indicators based on the potential capacity of the urban ecosystem, in addition to adding its soundness. In addition to the score, the evaluation of the status quo relative to the original biodiversity status should also be added; thirdly, the sensitivity of the number of animal and plant species indicators is low. For formulating appropriate protection policies, it is more important to have information on rare species and their habitats. Important, these should be reflected in the indicators of adverse impacts on people and ecosystem health (Impact). Finally, the government response (Response) indicators should reflect the latest international trends, such as biodiversity-related strategies, targets, certification Institutions, ecosystem management policies, and the participation of citizens and companies in biodiversity, etc.

4. Future development and enlightenment of urban biodiversity indicators

4.1. Development trend of urban biodiversity indicators

Build a full-scale urban biodiversity indicator

Establish a full-scale index system based on urban biodiversity protection. At present, the index system of city and urban block scale has been available, but there is a lack of indicators to evaluate the relationship between city and region, including suburban areas that have a direct impact on the city and remote areas indirectly affected by urban consumption activities. For example, as an ecological footprint evaluation index included in consumption activities, it has been widely used in the evaluation of cities, but it is not involved in the relationship between city and region. Regional system has a profound impact on urban ecosystem, which must be considered for urban biodiversity protection in the future. Therefore, it is necessary to build an index of urban regional relationship.

Build information infrastructure for cooperation and sharing

With the extensive and in-depth evaluation of urban biodiversity, in order to form a positive response mechanism between evaluation indicators and improvement measures, it is necessary to share knowledge and experience related to evaluation methods and policy judgment. Taking Japan as an example, 2 prefectures and 5 counties in Kansai (Shiga, Kyoto, Osaka, Hyogo, Wakayama, Tottori and Tokushima) map various types of ecological services with the goal of biodiversity information sharing in regional environmental protection planning. Share all information including storage indicators, supply indicators (supply and adjustment services) of ecosystem, corresponding demand indicators (ecological footprint) and management indicators (measures and countermeasures related to demand and supply of ecosystem services)[11,12]. In addition, cities with similar environmental characteristics should also share knowledge and experience related to evaluation. Such cooperation and sharing needs to be supported by national and even world-class information infrastructure.

Evaluate the urban biodiversity indicator itself

The main purpose of using urban biodiversity indicators is to pay attention to whether the measures related to urban biodiversity protection have been implemented and how the implementation effect is related to management practice. Compared with the evaluation results, whether the measures related to urban biodiversity protection operate effectively needs more attention. In the process of using urban biodiversity indicators in the future, whether the indicators have formed effective practical countermeasures and promoted the derivation of biodiversity protection in emerging fields, industries and culture is the key issue to be paid attention to[13]. To answer these questions, it is necessary to evaluate

the indicators themselves and strive to develop indicators that are closely combined with the concepts of green infrastructure and compact city and have strong practical guidance.

4.2. Current situation and development conception of urban biodiversity indicators in China

China lacks comprehensive and systematic urban biodiversity indicators

China issued GB/T 50563-2010 Urban Landscaping Evaluation Standard in 2010, HJ 623-2011 Regional Biodiversity Evaluation Standard in 2011, LY/T 2004–2012 National Forest City Evaluation Index in 2012 and National Ecological Garden City Standard in 2016. The above standards have more detailed index evaluation of urban local biodiversity, but have not yet involved the evaluation of ecosystem services. The evaluation of urban management measures is only whether to formulate protection plans, and there is still a lack of urban biodiversity indicators covering the whole scale, perfect infrastructure and paying attention to the evaluation indicators themselves.

Development concept of urban biodiversity indicators in China

The 2015 central urban work conference pointed out that China's urban development has entered a new era of development, and put forward the requirements of coordinating the three major layouts of production, life and ecology to improve the livability of urban development, which is highly related to the contents of urban local biodiversity, ecosystem services and urban management measures in the urban biodiversity indicators. Therefore, it is urgent to build a set of biodiversity indicators suitable for Chinese cities to adapt to the development of cities in the future Referring to the internationally recommended Singapore indicators and the widely used Japanese indicators in Japan, the indicators that can reflect the characteristics of urban biodiversity and meet the needs, simplicity and wide applicability are selected from the perspectives of urban local biodiversity, ecosystem service function and urban management measures, Establish urban biodiversity indicators (**Table 2**)[14–16] for quantitative evaluation of biodiversity performance at three scales, including city–region, city and urban block.

Table 2. Urban biodiversity index framework of China's development concept

Spatial scale	Indigenous biodiversity	Ecosystem services	Management measures	International experience	Indicator screening criteria
City–region	Including the landform, water system, soil, landscape type and species status of the city region	Reflect ecosystem support, supply, regulation and cultural services, such as water volume, climate regulation, greenhouse gas absorption, cooling effect, culture and education, etc.	Including the formulation of regional biodiversity planning and the construction of information infrastructure	Singapore indicators Japan indicators	Necessity Simplicity Applicability
City	Including the current situation of urban green space, species and ecological network		Including input, education, awareness and other biodiversity actions and participation		
City block	Including species status, population type, and habitat type		Including the evaluation of maintenance management system and investment		

5. Conclusions

Urban biodiversity indicators can be used to evaluate different urban land planning schemes, and

bring together urban managers, urban residents, eco technology experts and other stakeholders to jointly make suggestions for the protection of urban biodiversity. At present, urban biodiversity indicators pursue two aspects of development. On the one hand, simplicity is the main pursuit to make it easy for the government, citizens, non-profit organizations and enterprises to understand. At the same time, we also pay attention to the ease of obtaining the data required for evaluation. On the other hand, it pursues to promote the optimization of urban biodiversity, correctly and carefully evaluate the urban local biodiversity, ecosystem services and urban management measures in each stage of the process of "investigation evaluation planning implementation" of urban biodiversity, and make continuous improvement. In the future, it is also necessary to improve the index content based on the DPSIR model framework.

At present, the indicators related to urban biodiversity in China's current standards are not comprehensive enough. It is necessary to establish China's urban biodiversity indicators and apply their monitoring results to land and space planning, to meet the development requirements of optimizing biological habitat function, maximizing ecosystem services and optimizing management measures in cities.

Conflict of interest

The authors declare no conflict of interest.

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