Health Assessment of Urban Wetland Ecosystems: A Case Study

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***Abstract* — Wetlands form a significant ecological basic infrastructure in cities. The condition of ecosystem health will directly affect its ecological and social service function for citizens. The ecosystem health assessment of urban wetlands takes the Aixi Lake in Nanchang city of China as an example. The eco-health assessment of urban wetlands can help urban planning, comprehensive management and provide basis for decision-making. The results indicate that Aixi Lake has a median score of Ecological Health Comprehensive Index method (EHCI) according to the calculations. Based on these results, the specific damage of wetlands ecosystem were identified, which could provide scientific basis for the subsequent ecological restoration and optimizing measures.**

Keywords - urban wetlands; ecosystem health assessment; analytic hierarchy process; comprehensive health index

I. INTRODUCTION

Urban wetland is one of the significant ecosystems in cities (Chao et al, 2003), whose health condition will directly affect its ability to provide services to urban residents. Researches on urban wetland ecosystems have mostly focused on hydrological elements (Zhou et al, 2006; Li et al, 2010), soil or pollutants and sediment (Dimitriou, 2008; Trompa, 2012), biodiversity (Katha, 2009), environmental impact and protection (Li et al, 2009), planning and management (Yu et al, 2007; Li et al, 2010; Xie, 2010), etc., while health assessment system was rarely mentioned. Prior study on health evaluation of urban wetland ecosystems paid a lot of attention on chemical and biological indicators, while in recent years, scholars began to establish health evaluation system for wetland ecosystem from ecosystem structure and function, and landscape ecology perspectives (Norton & Pollock, 1998). Among those studies, index systems have been widely used, including ecological health comprehensive index method (EHCI) (Xu & Xu, 2008; Li et al, 2009; Li et al, 2012), blur comprehensive evaluation method (Zhang et al, 2005; Gao et al, 2009), pressure - state – response" (PSR) model (Li et al, 2008), and so on. After comparison, ecological health comprehensive index method (EHCI) is more suitable for quantitative evaluation and analysis of a specific lake at different time periods, since the principle is relatively simple, the calculation is convenient (Li et al, 2012), and the results are reliable and intuitive.

Located in the Hi-tech Development Zone, Aixi Lake is a typical urban wetland in Nanchang City((Figure 1). Dating back to 1990s, the water quality of Lake Anxi was deteriorated mainly resulted from man-made factors. Since September 2007, the Government has started to invest on Aixi Lake Wetland Park, which would be gradually combined with Tianxiangyuan Migratory Bird Park, and thus forming the Lake Poyang migratory bird channel.

Taking Lake Anxi as an example, the paper assesses the health status of this urban wetland ecosystem, with the purpose to set up a simple and feasible evaluation index system, improving the relevant evaluation methods. Meanwhile, it analyzes the main factors and the impact mechanism affecting the health condition of urban wetland ecosystems, providing the basis for dynamically monitoring, effectively protecting and scientifically managing urban wetlands. EHCI method is used to evaluate the health condition of Aixi Lake.

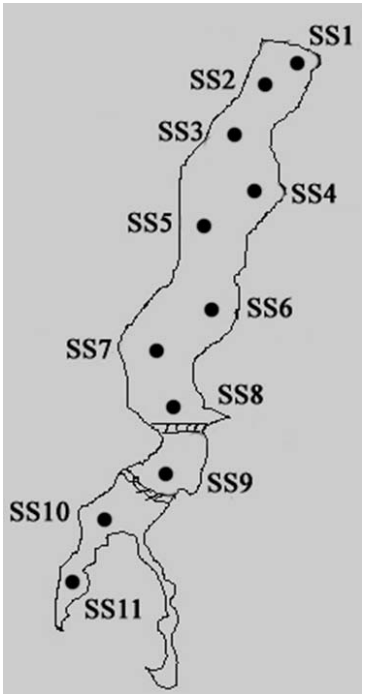

Figure 1. . The diagram of Aixi Lake and the location of sampling sites

II. Research Method

A. Index System

Referring to evaluation methods and concepts for urban lakes at home and abroad (Rapport et al, 1998; Rapport et al, 1999; Yuan et al, 2001; Zhao et al, 2005; Zhao & Yang, 2005), ecosystem health evaluation index system for Aixi Lake is divided into three levels based on the principle of selecting indicators:

(1) Target Level, namely the health status of Aixi Lake ecosystem, reflects its overall health condition.

(2) Factor Level, reflecting the attributes and levels of the ecosystem health from different aspects, sets up the foundation for determining the scope of the main key impact factors.

(3) Index Level, that is, each factor is demonstrated by certain indexes. Accordingly, there are ten indexes representing the four factors in Factor Tier (Figure 2).

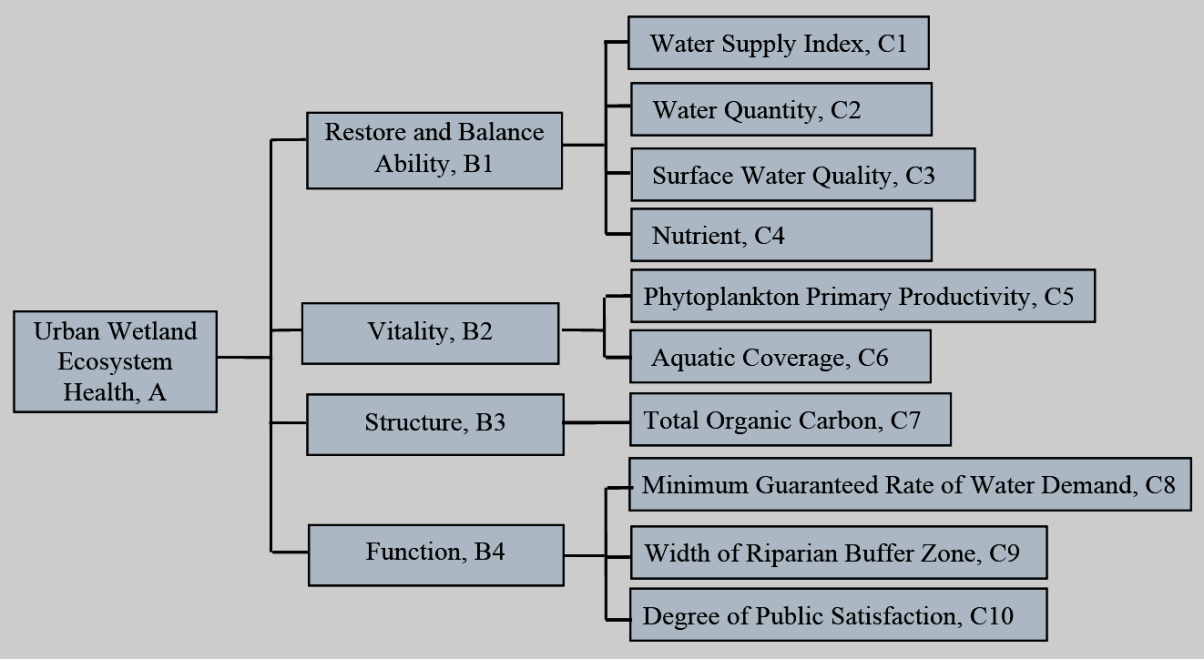

Figure 2. Ecological health comprehensive Index structure for urban wetlands.

B. Reference Standard

There are currently no unified and clear standards for urban wetland ecosystem health assessment. Such criteria vary by different latitudes, sizes, types of wetlands, and the needs of different study groups(Zhang et al, 2005). Hence, the methods to select reference standards in accordance with the uses of wetlands include: ① referring to a series of environmental standards developed by international environmental departments; ② drawing upon relevant foreign standards; ③ searching for recognized indicator ranges; ④ surveying the indicator settings for lakes at the same latitude; ⑤ using the average bottom values of the ecosystems within the surrounding area, trying to get the ideal value from surveys or the optimal value from actual indicators.

C. Data Collecting and Processing

In October and December 2015, the author, complying with all the national standards, conducted a comprehensive water quality survey at nine different locations in Lake Aixi (see Figure 1), aiming to investigate seven basic indicators including COD, BOD_5, ammonia, total nitrogen, total phosphorus, chlorophyll a, and TOC. Later in March 2013, additional surveys were carried out to examine the width of the riparian buffer zone, and to acquire public opinions on environmental quality. The experimental methods refer to the relevant national standards as well as domestic and international case studies.

Having obtained the basic data for assessing the health condition of Lake Aixi, the author quantified the various indicators using setter methods such as scoring by experts, so as to make a comparison between actual values and reference values (Table 1).

D. Index Weights

Analytical Hierarchy Process quantitatively analyzes each factor in terms of its importance, influence, and priority. With relatively low random consistency ratio, the deviations caused by human factors in AHP are smaller than those from other methods (Liu & Chen, 2008).

The variety of factors in the complex problem was separated into interrelated and ordered levels. Every two indicators were compared and scored based on their significance. Taking advantage of the feature vectors of the judgment matrix, the author determined the contribution of the lower-level indicators to those from the

upper level, and then calculated their weights via Matlab7.1, which resulted in the ranking of those indicators. This ranking generally presented the importance of the comprehensive evaluation index upon the overall target. In order to ensure scientific decision-making, the author also examined the consistency of the judgment matrix. Details are illustrated in Table II.

TABLE I. COMPARING ACTUAL VALUES AND REFERENCE VALUES

Target Level	Factor Level	Indicators	Reference Value	Actual Value	Index Value
Urban Wetland Ecosystem Health Index (A)	Restore and Balance Ability (B1)	Water Supply Index (C1)	75.56	3.50	0.05
		Water Quantity (C2)	3.05	2.53	0.83
		Surface Water Quality (C3)	0.8	0.2	0.25
		Nutrient (C4)	40	69	0.58
	Vitality (B2)	Phytoplankton Primary Productivity (C5)	5.60	6.25	0.90
	Structure (B3)	Aquatic Coverage (C6)	60%	21%	0.35
		Total Organic Carbon (C7)	10.14	17.41	0.58
	Function (B4)	Minimum Guaranteed Rate of Water Demand (C8)	100%	100%	1
		Width of Riparian Buffer Zone (C9)	16.30	27.45	1
		Degree of Public Satisfaction (C10)	100%	84%	0.84

TABLE II. INDEX WEIGHTS

Target Level	Factor Level	Weights (B on A)	Indicators	Weights (C on B)	Weights (C on A)
Urban Wetland Ecosystem Health Index (A)	Restore and Balance Ability (B1)	0.5823	Water Supply Index (C1)	0.1601	0.0932
			Water Quantity (C2)	0.0954	0.0556
			Surface Water Quality (C3)	0.4673	0.2721
			Nutrient (C4)	0.2772	0.1614
	Vitality (B2)	0.1627	Phytoplankton Primary Productivity (C5)	1.0000	0.1627
	Structure (B3)	0.1627	Aquatic Coverage (C6)	0.7500	0.1220
			Total Organic Carbon (C7)	0.2500	0.0407
	Function (B4)	0.0922	Minimum Guaranteed Rate of Water Demand (C8)	0.2970	0.0295
			Width of Riparian Buffer Zone (C9)	0.5396	0.0535
			Degree of Public Satisfaction (C10)	0.1634	0.0162

E. Assessment

After making the indicators dimensionless and identifying index weights, we put the figures into the EHCI formula, and assessed the health status of Lake Aixi during the survey period. The total value calculated from the formula was 52.1789. According to the ecological health comprehensive index method, the EHCI in the range of 40 to 60 shows that Lake Aixi's health status is moderate.

III. CONCLUSIONS AND DISCUSSIONS

The evaluation system that this paper has proposed can be used for assessing and comparing the health conditions of a specific urban wetland ecosystem from different time periods or wetland ecosystems in different locations. Standing upon the actual characteristics of such ecosystems, the method is easy to understand. Its advantages in data collection and reliable results make it worth promoting.

Due to the limited data, this paper hasn't take into account biodiversity and the diversity of benthic animals, nor has it studied another wetland ecosystem and made a comparison. The author suggests that future researches should pay additional attention to the vitality of urban wetlands. Knowing that urban wetlands are closely related to urban environment, the paper has tried to include indicators associated with urban landscape and tourism

while building up the evaluation system, with the intent to help urban wetland ecosystems remain healthy and functioning. Although Analytical Hierarchy Process can reduce the influence of subjective factors on determining index weights to some extent, there are still some inevitable impacts. Thus it is recommended to look for a more scientific and objective methods to define index weights in future studies.

Table 1 and Table 2 show that surface water quality C3 (0.2721), water nutritional status C4 (0.1614), phytoplankton primary productivity C5 (0.1627), and aquatic plant coverage C6 (0.1220) have relatively larger weights to urban wetland ecosystem health index (A) ($\geqslant$ 0.1). This means that the above indicators have a greater impact on the health status of urban wetland ecosystems. Since 1980s, Lake Aixi has had serious deterioration in its surface water quality, leading to high content of organic carbon and nitrogen, and water eutrophication as well. At the same time, because of the rapid urbanization of the surrounding area and the imperfect structure of aquatic ecosystems, the total amount of water in Lake Aixi has been gradually reduced. The shrinking in water supply enlarged the relative influence of other indicators. As a consequence, such indicators should be a priority when managing urban wetland ecosystems.

In the end, the author has proposed several ways to manage Lake Anxi wetland ecosystem, which are: to control point source and non-point source pollution, improving water quality from its source; to restore aquatic ecosystems, for example: as for eutrophic shallow wetlands, restoring vegetation, mainly submerged plants, can effectively slow down N and P circulation, and control excessive growth of phytoplankton (Wu et al, 2003); to develop a scientific and rational design and land use planning for urban wetland ecosystems; and to establish long-term and dynamic monitoring and management mechanisms so as to better restore and preserve urban wetland ecosystems.

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