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Ecological Security Evaluation of Zhalong Wetland Nature Reserve based Composite Index Evaluation Method

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Abstract

According to "Pressure - State – Response" model, an eco-security assessment system was built which contains 32 indictors such as human activities, regional development index, etc. The results showed that: ecological security index of Zhalong Wetland Nature Reserve, appeared upward trend after the first drop in overall, but were all in warning category from 2007 to 2012. As for subsystem level, since 2007, pressure subsystem showed worsening trend, while the state and response subsystem appeared signs of improvement.

***Keywords**: Zhalong wetland; composite index; eco-security*

1. Introduction

In recent years, with more frequent human activities, ecosystem vulnerability of Zhalong Wetland Nature Reserve appeared constantly: ecological water demand gap continues to increase, biodiversity sharp decrease, the degree of eutrophication grows. Series of environmental problems gives a red light to Zhalong Wetland ecological security. What level is Zhalong Wetland ecological security? Which environmental factors are the most prominent in Zhalong Wetland ecological security? These questions have become urgent problems to be revealed.

2. Site and Methods

2.1. Site Description

Zhalong National Nature Reserve (46 ° 48 '~ 47 ° 31'5 N, 123 ° 51' 5 "-124 ° 37'5" E) is located in western part of Heilongjiang Province, the junction of Qiqihar city, Lindian, Dumont and Tailai County. It is wetland ecosystem nature reserves with a total area of 2100k m^2, the average years of wetland area of 1240km^2 [1]. It is the largest wetland ecological type national Nature Reserve to protect the cranes and other large water birds as the main rare bird sanctuary which plays an extremely important role in rare waterfowl protection and breeding in the world [2].

Zhalong wetland takes Zhalong National Nature Reserve as the main body with the population of about 5.8-6 million people. The total area is 2100km^2, of which the core area of 500km^2, buffer 1480km^2, experimental area 120km^2 [3]. Zhalong Nature Reserve is mainly composed of reed wetlands, river lake bubble water, marsh meadows, and agricultural land.

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2.2. Methods

2.2.1 Evaluation System: Based on the "Pressure - State - Response" (PSR) model, Analytic Hierarchy Process (AHP) was adopted and experts opinions were extensively selected from various fields of wetlands, water resources, wildlife and ecological environment. Evaluation index system for ecological security was built which consists of three subsystems. They were pressure subsystem, state subsystem and response subsystem respectively which contain 32 indexes, as described below:

Pressure subsystem (B1) contains 12 indexes: human activities C1, demographic change C2, poverty rate C3, regional development index C4, beach area degradation C5, the urbanization rate C6, road density C7, habitat C8, pesticide utilization C9, fertilizer utilization C10, disaster frequency C11, ecotourism number C12.

State subsystem (B2) contains 11 indexes: primary productivity C13, system resiliency of ecological C14, C15 biological diversity, air pollution index C16, land pollution index C17, water quality index C18, biomass C19, food production C20, wetlands degradation C21, landscape fragmentation C22, wetlands threatened status C23.

Response Subsystem (B3) contains 9 indexes: Water Control C24, hydrology adjust C25, sewage treatment rate of C26, water supply guarantee rate C27, wetland conservation awareness C28, efforts to implement the policies and regulations of the C29, wetland management level C30, the surrounding population quality C31, Nature Reserve investment C32.

2.2.2 Evaluation classification: On the basis of AHP, comprehensive index was conducted to assess system security of Zhalong Wetland Nature Reserves. The index values of AHP were put into formula of comprehensive evaluation index:

$$S = \sum_{i=1}^{m} W_i C_i$$

Where: S for evaluation score; W_i for index weight; C_i for standardized value of index.

Criteria and grading of assessment can be confirmed according SI values getting from the formula. Finally, the SI value will be compared with assessed criteria to get levels of ecological security (Table 1).

Table 1. The Value of SI Evaluation Grades and Significance

Grade	Score	Safe state	Meaning
Ⅰ	≤0.25	Dangerous	Ecological system function almost collapsed and difficult to be reversed. Ecological environment has been severely damaged and ecological disaster occurred frequently.
Ⅱ	0.5～0.25	More dangerous	Ecological systems function degradation, ecological environment has been greatly damaged. Ecological and environmental problems are outstanding.
Ⅲ	0.75～0.5	Warning	Ecological environment is suffering a certain damage, but can still maintain the basic functions, disasters have occurred.
Ⅳ	0.9～0.75	Safer	Ecological service function is better. Ecological environment rarely damage and can generally recover after disturbance. Ecological problems are not significant.
Ⅴ	≥0.9	Safe	Ecological service function is basically complete. Ecological environment was not destroyed and the system has high regeneration ability. Fewer environmental problems have happened.

3. Results and Discuss

According to composite index, ecological safety evaluation results for Zhalong wetland nature reserve were obtained from 2007 to 2012 (Figure1 and Table 2). The results showed that evaluation index of ecological security appeared trends for the better after the first fall.

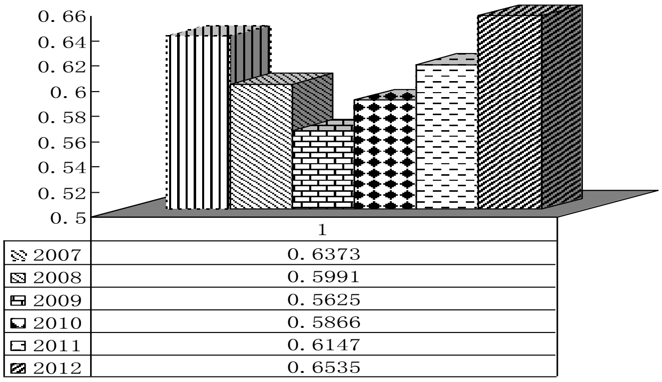

Figure 1. Trends for Safety Index of Ecological Security Evaluation in Zhalong Wetland Nature Reserve

Table 2. Results of Ecosystems Safety Evaluation of Zhalong Wetland

Name of indexes		Values of index evaluation					
		2009	2010	2011	2012	2013	2014
human activities	C1	0.0374	0.0315	0.0354	0.0298	0.0297	0.0341
demographic change	C2	0.0071	0.0063	0.0073	0.0064	0.0081	0.0072
poverty rate	C3	0.0035	0.0028	0.0015	0.0033	0.0031	0.0042
regional development index	C4	0.0524	0.0437	0.0434	0.0513	0.0513	0.0489
beach area degradation	C5	0.0214	0.0182	0.0181	0.0241	0.0219	0.0269
the urbanization rate	C6	0.0047	0.0038	0.0033	0.0032	0.0042	0.0049
road density	C7	0.0184	0.0176	0.0171	0.0195	0.0193	0.0121
habitat	C8	0.0181	0.0182	0.0178	0.0193	0.0176	0.0183
pesticide utilization	C9	0.0337	0.0289	0.0329	0.0371	0.0315	0.0356
fertilizer utilization	C10	0.0285	0.0273	0.0265	0.0291	0.0289	0.0273
disaster frequency	C11	0.0032	0.0029	0.0039	0.0021	0.0034	0.0024
ecotourism number	C12	0.0063	0.0052	0.0061	0.0059	0.0056	0.0061
primary productivity	C13	0.0354	0.0312	0.0299	0.0234	0.0213	0.0317
system resiliency of ecological	C14	0.0137	0.0131	0.0142	0.0121	0.0157	0.0145
biological diversity	C15	0.0094	0.0089	0.0079	0.0073	0.0083	0.0078
air pollution index	C16	0.0119	0.0191	0.0163	0.0124	0.0149	0.0156
land pollution index	C17	0.0116	0.0108	0.0105	0.0132	0.0157	0.0145
water quality index	C18	0.0215	0.0257	0.0213	0.0215	0.0267	0.0259
biomass	C19	0.0312	0.0306	0.0224	0.0241	0.0214	0.0317
food production	C20	0.0061	0.0051	0.0033	0.0069	0.0073	0.0053
wetlands degradation	C21	0.0154	0.0143	0.0135	0.0159	0.0163	0.0134
landscape fragmentation	C22	0.0122	0.0119	0.0104	0.0113	0.0156	0.0127
wetlands threatened status	C23	0.0137	0.0115	0.0132	0.0136	0.0145	
Water Control	C24	0.0245	0.0216	0.0209	0.0213	0.0217	0.0213
hydrology adjust	C25	0.0195	0.0192	0.0184	0.0172	0.0197	0.0144
sewage treatment	C26	0.0651	0.0678	0.0631	0.0546	0.0631	0.0647

rate							
water supply guarantee rate	C27	0.0191	0.0183	0.0173	0.0135	0.0157	0.0187
wetland conservation awareness	C28	0.0093	0.0032	0.0035	0.0048	0.0091	0.0071
policies and regulations	C29	0.0285	0.0258	0.0201	0.0311	0.0272	0.0319
wetland management level	C30	0.0276	0.0251	0.0217	0.0215	0.0261	0.0356
surrounding population quality	C31	0.0019	0.0013	0.0012	0.0015	0.0012	0.0123
Nature Reserve investment	C32	0.0248	0.0254	0.0218	0.0287	0.0295	0.0319
SI values		0.6373	0.5991	0.5625	0.5866	0.6147	0.6535
Safety degree		warning	warning	warning	warning	warning	warning

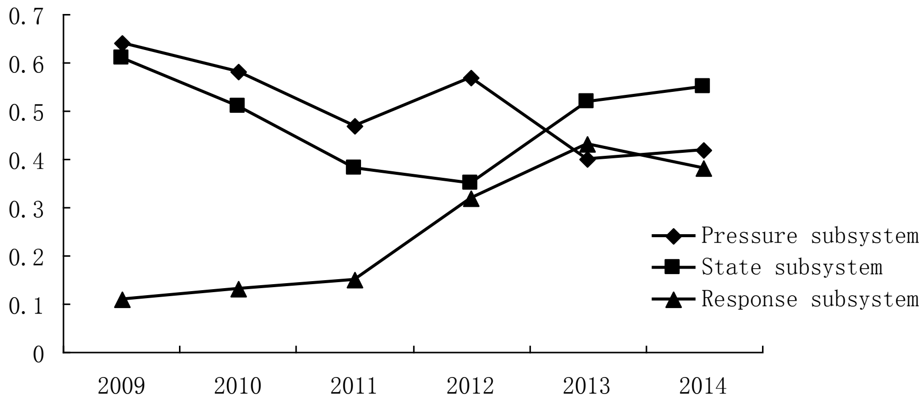

Figure 2. The Trends of Subsystems of Comprehensive Evaluation Index

Figure 2 shows the trend of three subsystems of “pressure - state – response” from 2007 to 2012. It is clear that the pressure subsystem was downward trend overall which security was warning level.

It illustrated that the pressure that the ecosystems faced was more and more severe. In recent years water quality was serious deterioration nature reserve. And the self-purification capacity of wetlands was greatly reduced due to the source of natural recharge—Wuyu'er river was closured by Shuangyang and Dongsheng reservoirs. On the other hand, a large number of domestic sewage and industrial waste input to the wetlands along with the runoff of Wuyu'er river. The ecosystems which were already fragile faced greater threats. According to the water quality analysis of Zhalong Wetland Nature Reserve, Ye Yajie found a higher water alkalinity (pH = 9.3) in Zhalong, the majority of reservoirs were IV or V class, large gap comparing with Ⅱ class standards made by state for wetlands.

Especially in 2009 and 2010, eutrophication of water was very serious with amount of TN, TP index out of 15 times than V-class standards limit [4]. This could be one of the reasons that the minimum values of evaluation index appeared in the 2009. In addition severe water shortages in a large number of reed wetland left potential problems for fire. Such as the severe drought (rainfall is only 160mm) in 2001, it led to a major fire with the burned area of 400 km^2, accounting more than half of the core area, burned reed was near 13500t. If effective measures do not take to control, the Zhalong wetland area will be further reduced [5].

The trends of state subsystem were fall first and then rise gradually. As we can see from Figure 2, in 2007 with less environment pressure, ecological environment of

Zhalong wetland was more favorable (0.6054). But the performance was very sensitive to the state of the subsystem along with the surrounding disturbance factors increased which indicated that ecological security of wetland had reached a critical point threshold. Especially in recent years, owing to the water shortage in Zhalong wetland in successive years, the wetland areas were severely reduced for the natural water could not meet the water requirement of Zhalong itself [6]. It is worth noting that by comparison we found that although the status of a subsystem had strong and fast response to pressure subsystem, but feedback to the response subsystem was not the case [7]. Response subsystem index increased from 2009, indicating that all parties had begun to take the appropriate measures, but the state subsystem did not appear to improve and continued to decline, indicating that there was a certain lag for the latter to response subsystem. It also reminded policy makers and protectors should pay attention to prevent and control the possible disturbance factors threatening ecological security [8].

The change of response subsystem was dramatic, and were all under danger class from 2007 to 2009 (mean of 0.1101). It fully indicated the disregard of protected managers for environmental change in the past few years and also showed that harm of multiple management style to ecological safety in nature reserve [9]. Zhalong Nature Reserve crosses two administrative cities (Qiqihar and Daqing). Qiqihar has the power to equip persons of management office but no land ownership of the wetlands. Uneven regional interests make Zhalong wetland management in a very awkward position, and seriously dampen the enthusiasm of local residents. The phenomenon of drainage and reclamation in Zhalong wetland were very serious just because the lack of publicity for wetland conservation and use coupled with weak environmental awareness of residents. Zhalong wetland meets their water needs through Nen engineering over the years, but due to its geographical location, water gap still exists [10]. In view of the actual needs of wetland, Water Conservancy Department in Heilongjiang Province should establish long-term replenishment mechanism to alleviate water shortage in Zhalong wetlands so as to restore ecosystems effectively.

4. Conclusion

Zhalong Wetland has good natural conditions and relatively stable ecosystem. But under the larger socioeconomic development pressures, individual indicators were more vulnerable and were in Ⅲ stage "warning" status which would endanger the overall ecosystems security. The protection for wetlands should be combined with the humanity, social, economic and coordinated development. The measures must be taken by means of funding and policy preferences and regulatory development and international exchanges of technical measures to reduce human stress and wetland degradation trend. The key point is governing the pollution generated by surrounding economic development to improve resource utilization and protection effectively in Zhalong wetland.

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