Ecological security evaluation of Panjin city on town scale

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Abstract. With the double pressure of rapid economic development and ecosystem degradation, the ecosystem of Panjin wetland has been damaged to different degrees. Early warning research on ecological security in this region can provide decision-making basis for the ecosystem protection and management. Taking Panjin as the study area, the ecological security level of all towns in Panjin was evaluated by establishing the warning system of Panjin ecological security. The results showed that on the town scale, there were 20 towns or regions in the warning level of grade III or grade IV, indicating that the ecosystems in these areas were in general and good situation with the integrated value of ecological security from 0.41 to 0.71. Other 11 towns or regions, most of which were located in the northeast of Panjin had ecological security warning level of grade II, with the integrated value of ecological security from 0.28 to 0.39. These towns often have higher economic development level and less ecological protection measures. Therefore, when the government makes policies in these towns, more wetland ecological protection plans should be fully taken into account.

1. Introduction
Ecological security generally refers to a state in which the ecosystems and resources of a country or region can continuously satisfy the needs of social and economic development [1]. Regional ecological security is not only the foundation of national stability and development, but also an important guarantee of national defense security, and of great significance to regional sustainable development [2]. Wetland ecosystem is the most important ecosystem in Panjin city with an area more than 70%. With the urbanization process and petrochemical industry activities in recent years, Panjin wetland ecosystem is facing lots of ecological pressure. Taking Panjin city as the research area, this paper made a comparative analysis of the ecological security situation of each township in Panjin city, so as to provide decision-making basis for the ecosystem management.

2. Study area and data sources

2.1. Study area
Panjin (40° 39′ - 41° 27′ N, 121° 25′ - 122° 31′ E) is located at the central of Liaohe River Delta of Liaodong Bay with the area about 4084 km². There is a temperate continental climate in Panjin area,
with hot rainy season. The annual average temperature and frost-free period are 8.4 °C and 170d. And the rainfall is 623.2mm. In this area, the alluvial plain and tidal flat are the main land types. The main advantage community is reed wetland with the area about 800 km². In the intertidal belt, suaeda heteroptera spreads widely. Seashore saline soil is the main soil media in the region.

2.2. Data sources
Ecosystem classification data were mainly derived from Landsat ETM remote sensing images in 2017 and determined by visual interpretation method. The social and economic statistics are from the 2018 Panjin social and economic statistics yearbook. The index values of each town and city are calculated based on Fragstats 4.2 and ArcGIS 10.1 software.

3. Research Method

3.1. Construction of ecological security evaluation index system in Panjin city
For the study of ecosystem evaluation, evaluation index establishment is mostly based on PSR (pressure-state-response) model [3]. Based on the analysis of Panjin ecosystem characteristics and PSR model, combined with previous studies, 11 evaluation indicators of Panjin ecological security were taking account, as shown in Table 1.

| Ecological security evaluation index system of Panjin |
|-----------------------------------------------------|
| **Object layer A**                                  |
| **Criterion layer B**                                |
| **Indicator layer C**                                |
| **Pressure**                                         |
| The population density                               |
| The density of GDP                                   |
| The added value density of the primary industry      |
| **State**                                            |
| Number of patches                                    |
| Mean patch area                                      |
| Boundary density                                     |
| Diversity index                                      |
| Uniformity index                                     |
| Dominance index                                      |
| **Response**                                         |
| Degree of fragmentation index                        |
| Aggregation index                                    |

3.2. Determination of index weight
Index weight indicates the relative importance of the selected index for the multi-index evaluation result of ecological security. In this paper, under the guidance of PSR model, the analytic hierarchy process (AHP) is selected to determine an index system of 1 target, 3 preparation indexes and 11 measurement indexes. After that, the hierarchical structure of the index system is established. Through the establishment of hierarchical analysis structure, the pair-wise comparison of each index layer evaluation questionnaire was constructed, and then the pair-wise comparison and scoring of the index were conducted through the expert questionnaire method. The correlation and importance of the evaluation index was gradually analyzed, and then the qualitative problem was transformed into a quantitative calculation problem, so as to determine the weight values of the ecological security evaluation index. The weights determined are shown in the Single weight Column of Table 2.

3.3. Assessment value of single indicator
The measure values of each index in the ecological security evaluation are not linear to reflect the level of ecological security. There logistic model which had been applied in some cases successfully was used
to obtain single indicator value. [Lin maochang and li]. The single indicator values were computed as the follow table.

| Table 2. Panjin Assessment value of single indicator |
|-----------------------------------------------|
| Indicators                                      | 2017 Measure values | Single indicator values | Single weight |
| The population density                          | 322 0.017860        | 0.988236                | 0.069         |
| The density of GDP                              | 2154.04 0.30328     | 0.982773                | 0.139         |
| The added value density of the primary industry | 315.03 0.861329     | 0.034871                | 0.116         |
| Number of patches                               | 6225 0.001931       | 0.010178                | 0.047         |
| Mean patch area                                 | 32.95 0.034862      | 0.013726                | 0.176         |
| Boundary density                                | 55.32 0.019523      | 0.988057                | 0.166         |
| Diversity index                                 | 1.3816 0.009425     | 0.010896                | 0.048         |
| Uniformity index                                | 0.5109 0.010882     | 0.011042                | 0.054         |
| Dominance index                                 | 3.1341 0.003893     | 0.010362                | 0.085         |
| Degree of fragmentation index                   | 0.6951 0.009063     | 0.98914                 | 0.067         |
| Aggregation index                               | 0.0016 0.066667     | 0.018301                | 0.033         |

3.4. Comprehensive evaluation of ecological security

According to the index weights and the assessment value of each indicator above calculation, this paper adopted the comprehensive evaluation method to calculate the ecological security value of Panjin. The formula is as follows:

$$I = \sum _{j=1} ^n W_j \times X_j$$  \hspace{1cm} (1)

Where $I$ is the integrated value of ecological security; $W_j$ is the weight of each indicator ; $X_j$ is the single indicator value; $N$ is the number of indicators.

With the intergrated value, the ecological security early warning criteria (Table 3) for Panjin was set to five levels to determine the ecological security degree. The higher I value is, the lower the ecological security warning level is.

| Table 3. Ecological security warning level |
|-------------------------------------------|
| Integrated value of ecological security   | Ecological safety level | Warning level          |
| 0. 0≤I<0.2                               | I                       | Severe Warning (Worst State) |
| 0. 2≤I<0.4                               | II                      | Moderate Warning (Poor State) |
| 0. 4≤I<0.6                               | III                     | Waring (Common State)      |
| 0. 6≤I<0.8                               | IV                      | Relatively Safe (Well State) |
| 0. 8≤I<1.0                               | V                       | Safe (Perfect State)       |

When the integrated warning value between 0 and 0.2, namely the ecological safety level I , the state of ecological security warning level was severe alerts. In this state, the wetland ecological structure has defects, and the wetland ecosystem may be seriously deteriorated. When the integrated warning value between 0.2 and 0.4, namely the ecological safety level II, the state of ecological security warning level was moderate warning. In this case, although there is no obvious defect in the wetland ecological structure, some damage points have appeared, and the wetland ecological system may begin to degenerate or have already degraded. When the integrated warning value between 0.4 and 0.6, namely the ecological safety level III, the state of ecological security warning level was early warning. This indicates that the wetland ecosystem structure was relatively intact, close to but not up to the threshold of wetland ecological security, and the system was generally stable. When the ecological security level
is IV (the integrated value of ecological security between 0.6 to 0.8), the wetland ecological security status was in good condition. At this time, the wetland ecological structure is relatively stable, as the the ecological function was more stable. When the integrated warning value was greater than 0.8, the warning level of ecological security status was safe. This indicated that the ecological security of the wetland was in an ideal state with the ecological structure of the wetland very reasonable, and the function of the wetland ecosystem is perfect.

4. Result

According to the administrative division and ecological security evaluation system of Panjin city, the warning level of ecological security of Panjin city and its 31 towns or regions was evaluated. The evaluation results are shown in Table 4 and Figure 1.

| Area              | Panjin Ecological Security Warning Level in 2017 | Area               | Panjin Ecological Security Warning Level in 2017 |
|-------------------|------------------------------------------------|--------------------|--------------------------------------------------|
|                  | Value   | Warning level |                      | Value   | Warning level |
| Panjin City       | 0.46    | III           | Baqiangzi Town       | 0.32    | II           |
| Gaosheng Town     | 0.35    | II            | Xinxing Town         | 0.39    | II           |
| Lujia Town        | 0.45    | III           | Zhaokuanhe Town      | 0.57    | III          |
| Hujia Town        | 0.58    | III           | Xinkai Town          | 0.38    | II           |
| Desheng Town      | 0.53    | III           | Xinli Town           | 0.43    | III          |
| Taiping Town      | 0.3     | II            | Dongfeng Town        | 0.41    | III          |
| Tianshui Town     | 0.51    | III           | Tianjia Town         | 0.51    | III          |
| Yanguanzi Town    | 0.66    | IV            | Qingshui Town        | 0.61    | IV           |
| Shixin Town       | 0.57    | IV            | Dawa Town            | 0.34    | II           |
| Dongguo Town      | 0.71    | IV            | Wangjia Town         | 0.61    | IV           |
| Chenjia Town      | 0.34    | II            | Tangjia Town         | 0.47    | III          |
| Shuangtaizi Zone  | 0.31    | II            | Xi’an Town           | 0.46    | III          |
| Xinglongtai Zone  | 0.42    | III           | Ping’an Town         | 0.55    | III          |
| Wujia Town        | 0.28    | II            | Tianzhuangtai Town   | 0.49    | III          |
| Shaling Town      | 0.36    | II            | Yushu Town           | 0.65    | IV           |
| Guochengzi Town   | 0.36    | II            | Liaobin Zone         | 0.53    | III          |

In 2017, panjin ecological security warning value in Panjin City was 0.46, which was in the early warning state of grade III. This shows that, on the whole, although the ecological security of Panjin City was damaged to a certain extent, the overall ecological function was relatively perfect and had better self-recovery ability. But on the town scale, the situation is different. Among these townships, 11 towns or regions, most of which were located in the northeast of Panjin had ecological security warning level of grade II. These towns often have higher economic development level and less ecological protection measures. The ecological security warning level in other towns was grade III or grade IV, indicating that the ecological environment in these areas was in general and good situation. Although the ecosystem structure and ecological service function had been partially degraded, the overall security situation is good and some ecological functions are relatively perfect.
5. Conclusion

With Panjin ecological security as the objective, this study evaluated the ecological security level of the study area on the town scale by establishing the wetland ecological security early warning system of Panjin city. Through the analysis of the towns in Panjin, it can be seen that the towns in northeast and central Panjin are under a certain threat. Therefore, more ecological protection strategies in these regions should be incorporated into government decision-making or urban planning in order to realize the coordinated development of ecological protection and economy.

Acknowledgments

This work was financially supported by the Natural Science Foundation of Liaoning Province (Grants No. 2020-MS-351) and the Project of Regular Survey and Evaluation of Ecosystems in Liaoning Province.

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