Assessment and optimization for regional sustainable development base on the human-land system

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Abstract. The human-land system is a complex and open giant system composed of two subsystems of geographical environment and human activities. Though the optimization of the relationship between two subsystems, we could realize the regional sustainable development. The regional sustainable development is the embodiment of the most optimization of human-land system. This paper revealed human-land system, in terms of connotation, structure, relation, mechanism and function. Based on the theory of human-land system, the paper proposed the regional sustainable development assessment model and carried out the empirical analysis in the township scale. We chose Haiyong Town as the study area. The results show that the study area is in a good level of regional sustainable development, but in a primary stage. The economic sub-system and the society sub-system have reached the good level of sustainable development, but the environment subsystem is always at a low level. The study area should put forward optimization strategies within the economic, social and environmental subsystems, such as ecological agriculture strategy, circular economy strategy, modern service industry strategy, environmental protection system strategy and so on, in order to promoting regional sustainable development. The research results can provide scientific reference for the assessment of regional sustainable development and the formulation of regional sustainable development strategy.

1. Introduction
The human-land system is a complex and open giant system composed of two subsystems of geographical environment and human activities, which has specific internal composition, interaction mechanism and function. In this giant system, the interdependence and interaction between human activities and geographical environment make the whole system develop and change constantly. Coordination between human and land, the study of the internal mechanism of the human-land system is the philosophical essence of exploring the sustainable and coordinated development of regions and the rational evolution of space and time. Any regional development, regional planning and regional management are aimed at improving the structure of human and land interaction, developing the potential of human interaction and coordinating human interaction. Taking villages and towns as regional units, the study on the mechanism of human-land system and the assessment and optimization
of sustainable development from a micro perspective will provide theoretical basis for effectively evaluating the level of regional sustainable development, guiding regional development and regional management.

The human-land system is a complex and open giant system composed of two subsystems of geographical environment and human activities. The regional human-land system is a human-land system based on a certain region of the earth's surface, and a dynamic structure formed by the mutual contact and interaction between human and land in a specific region [1-3], has been the core of geography and related scientific research [4-5].

The objective relationship between human and land should be recognized in the study of human-land system. People rely on their place for survival activities, actively understand, use, change, so as to make the better service to people. With the continuous improvement of human culture, technology and productivity, the human-land relationship has become increasingly close, and the interference degree of human activities to the land has been significantly enhanced, which has become the leading factor of the regional system evolution of human-land relationship on the earth surface [6]. Due to unreasonable human activities, a series of major issues such as resources, environment and social economy have been triggered globally, making the study of the regional human-land system become the research hotspot of various related disciplines recently, attracting the attention of many scholars all over the word [7-9]. In order to solve these problems, it is necessary to study the human-land system as a whole, and study its internal composition, interaction mechanism, structure, function and regulation approaches and countermeasures.

The relationship between human and land is closely related to the sustainable development of the region, and the essence of sustainable development is an embodiment of the optimization of the human-land system [10]. Regional sustainable development is a dynamic and open complex system involving three sub-systems of environment, economy and society. The interaction between the human-land system development and the sustainable development is the geographical and spatial-temporal coupling [11]. The key lies in the collection of various factors of the spatial-temporal coupling point group and the divergent geographical response process. The optimization of human-land system exists simultaneously at multiple levels. To achieve the goal of regional sustainable development, it is required to achieve the optimization of human-earth relationship in the three subsystems of environment, economy and society [12-13].

2. Models and methods

Based on the theory of human-land system, we constructed the regional sustainable development assessment model. The assessment system includes I subsystem (I=1,2..., n), and set the order parameter in the system development process as $C_i$, $C_i = (C_{i1}, C_{i2}..., C_{in})$, the actual performance value of the subsystem order parameter $C_{il}$ is $x_{ij} (i=1,2..., n, j=1,2..., m)$.

Suppose the efficiency coefficient is expressed by $U$, and U is required to be between 0 and 1. When the evaluation is the most satisfactory, $U=1$; when the evaluation is the worst, $U=0$. If the order parameter is expressed as $x_{ij}$, then

$$U(x_{ij}) = \begin{cases} \log x_{ij} - \log \beta_{ij} & (x_{ij} \text{ is positive indicators}) \\ \log \alpha_{ij} - \log \beta_{ij} & (x_{ij} \text{ is negative indicators}) \end{cases}$$

In the formula, $\alpha_{ij}$ and $\beta_{ij}$ are satisfactory and basic values of $x_{ij}$, a time-sequence parameter of system stability.

Based on the theory of human-land system, we constructed the regional sustainable development assessment indicator system. The indicator system is composed of target layer, system layer and indicator layer (table 1).
Table 1. Sustainable development assessment indicator system

| Target layer | System layer | Indicator layer |
|--------------|--------------|-----------------|
| Economic (U₁) | Per capita net income of farmers \((u₁₁)\) |
|              | Per capita GDP \((u₁₂)\) |
|              | Proportion of output value of secondary and tertiary industries \((u₁₃)\) |
|              | Engel coefficient \((u₁₄)\) |
|              | Urban population rate \((u₂₁)\) |
| Society (U₂) | Proportion of expenditure on science education in the fiscal expenditure \((u₂₂)\) |
|              | Participation proportion of cooperative medical treatment \((u₂₃)\) |
|              | Road density \((u₂₄)\) |
|              | Waste water treatment proportion \((u₃₁)\) |
| Environment (U₃) | Garbage treatment proportion \((u₃₂)\) |
|              | Per capita public green area\((u₃₃)\) |
|              | Vegetation coverage proportion\((u₃₄)\) |

According to the assessment result, we divided the regional sustainable development level to five levels (table 2).

Table 2. The standards of regional sustainable development assessment

| Assessment result | Regional development level |
|-------------------|---------------------------|
| 0.0\(\leq U < 0.2\) | Worst level |
| 0.2\(\leq U < 0.4\) | Bad level |
| 0.4\(\leq U < 0.6\) | Middle level |
| 0.6\(\leq U < 0.8\) | Good level |
| 0.8\(\leq U < 1.0\) | Best level |

3. Results and discussion

Haiyong Town is located in 121°09'30"~121°54'00"E, 31°27'00"~37°51'15"N. It is an alluvial plain with flat terrain and no hills and hills. It is slightly higher in the northwest and lower in the southwest and east. More than 90% of the land elevation is between 3.21m and 4.20m. It is a typical subtropical climate, the four seasons change obviously, the annual average temperature 15.2°C, sunshine, abundant rain. Haiyong Town, with a total area of 12.5km², is an "enclave" on Chongming island, the third largest island in China (figure 1).

Based on the regional sustainable development assessment model, we assess the regional sustainable development level for Haiyong Town. From 2015 to 2018, the score of regional sustainable development has continued rising, the score is 0.2677 in 2015, and 0.6293 in 2018. The regional sustainable development level has changed from bad level in 2015 to middle level in 2016, then to the good level in 2017 and 2018 (table 3).

Table 3. The regional sustainable development assessment result of Haiyong Town

|         | 2015   | 2016   | 2017   | 2018   |
|---------|--------|--------|--------|--------|
| Regional sustainable development | 0.2677 | 0.5337 | 0.6642 | 0.6293 |
| Regional sustainable development level | Bad level | Middle level | Good level | Good level |

The score of economic subsystem keeps rising, indicating that the economic sub-system has reached the good level of sustainable development. The score of society subsystem increased slightly, and the urban population rate was the main factor restricting its improvement. The score of
environment subsystem is always at a low level, so the whole environment sub-system should be improved (table 4).

![Figure 1. The location of Haiyong Town](image)

The purpose of system optimization is to achieve an ideal combination of regional economic development, social progress, resource and environment support and sustainable development ability, so as to improve regional sustainable development ability.

Table 4. The regional sustainable development assessment result of subsystems

|          | 2015  | 2016  | 2017  | 2018  |
|----------|-------|-------|-------|-------|
| Economic (U₁) | 0.0985 | 0.2562 | 0.2930 | 0.2931 |
| Society (U₂)   | 0.1601 | 0.1797 | 0.1797 | 0.1686 |
| Environment (U₃) | 0.0091 | 0.0978 | 0.1916 | 0.1677 |

For economic optimization, firstly, Haiyong Town will build 100 km<sup>2</sup> high-quality planting base, develop the flower industry, fruit industry, vegetable industry and aquaculture industry, as well as construct the comprehensive agricultural network. Secondly, relying on the advantages of agriculture, Haiyong Town should develop the agricultural creative processing industry, construct the agricultural creative industrial zone, and improve the infrastructure and industrial information network. Thirdly, Haiyong Town should promote the development of cultural industry and creative industry, focusing on the leisure industry, modern tourism industry, health industry and high-quality old-age care industry, so as to create a new economic zone of modern services industry.

For society subsystem optimization, firstly, Haiyong Town should control development to east and south, moderate development to the north and mainly development to the west, and form a spatial development structure that is “one development core, two development belts and four development zoons”. Secondly, Haiyong Town should optimization the tertiary urban-rural development structure of town-community-village, and put forward different development strategies for different areas. Thirdly, Haiyong Town should provide convenient living conditions, such as transportation, electricity, water supply, heating supply, waste disposal and so on.
For environment subsystem optimization, firstly, Haiyong Town should carry out the landscape design for the "Pigeon River", and construct the green space system for the whole region with central park, coastal wetland, landscape farmland, and so on. Secondly, Haiyong Town should construct the environmental protection system with atmospheric environmental quality monitoring system, water quality monitoring system, industrial zones protective forest network, environmental sanitation system, and so on.

4. Conclusion
The optimization of human-land system is the essence of regional sustainable development. The human-land system optimization at multiple levels exist at the same time, to achieve the purpose of the regional sustainable development, the requirements on environment, economy and society in the three subsystems are to reach the optimization of human-land system, namely the requirements within the system the proportion of the various elements to form an ideal combination, and various indexes reach the ideal value. Based on the coordination mechanism of human-land system, a regional sustainable development assessment model is constructed, and the optimization of regional sustainable development in Haiyong Town, Haimen City, Jiangsu Province are analyzed. Research has shown the case area is in a good level of regional sustainable development, but in a primary stage with larger development space. The optimization of the economic subsystem is mainly to give play to the strategic position of connecting with Shanghai and continue to optimize the industrial structure. The optimization of the society subsystem is mainly to improve the urbanization level, improve the planning of the rural system, enhance the awareness of sustainable development, and establish the social security system. The optimization of environment subsystem is mainly to strengthen pollution prevention and control, improve per capita green space area, improve per capita environment, and improve the market economic system.

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