Analysis of Degree of Coupling and Coordination Between Ecological Resources and Economic Development in Sanjiang Region

Yi Liu, **Mingrui Zhang***, **Zheng Zhang**

Departments of economics and management, Harbin university of science and technology, 150080, China

Email: 13313666558@163.com, 565777793@qq.com, 1782705087@qq.com
TEL: 13199568696

Abstract: This paper constructs an evaluation index system based on the economic and environmental statistics of the counties (cities) in the Sanjiang Region from 2010 to 2016, and calculates the weights of economic development and the ecological resources of each year using the improved entropy method. This paper applies the coupling and coordination degree function to the statistics of 17 counties (cities) in the Sanjiang Region for the abovementioned 7 years and makes a chart of changing trend and data tables and heat maps of each region so as to present the result in a clearer manner. From 2010 to 2016, the coupling and coordination degree of the Sanjiang Region is $D \in [0.4, 0.6]$, which is at an intermediate high stage. Suggestions also are proposed to provide reference for the formulation of regional development plans based on the study result, the ecological resources and environmental status of the Sanjiang Region.

1. Introduction

The reform and opening up in 1978 has witnessed the rapid development of economy and living standard in China. However, problems such as the over-consumption of environmental resources and ecological damage have also emerged. The Sanjiang Region, located in the northeastern part of Heilongjiang Province, has an ever-growing economy since the founding of PRC. In order to meet the growing needs of the population, there has been continuous land reclamation with a purpose of gaining more cultivated land, which leads to a sharp decline of wetland and forest, thus posing greater threats including desertification and soil erosion [1]. Inappropriate occupation of the vast vegetation, wetlands, woodlands, pastures and improper mining [2] have caused various ecological problems, which are detrimental to the stable and healthy development of the regional economy. Against this backdrop, the study on the coupling and coordination between ecological resources and economic development in the Sanjiang Region has become more important because it is of practical significance for the future sustainable development of the region. "Coupling" refers to the phenomenon that two or more systems influence each other through interaction [3]. The coupling between economic development and ecological resources is the interaction between the two subsystems, during which they can achieve mutual development. Coupling can be used to measure the coordination degree between economic development and ecological resources in a region while reflecting the stage characteristics to some extent. However, it is not enough to evaluate regional development by only relying on the degree of coupling. Therefore, this paper proposes a coupling and coordination degree analysis method. After

the analysis, this paper also puts forwards corresponding optimization suggestions.

2. Overview of research region

2.1. Definition

The Sanjiang Region, lying in the northeastern of Heilongjiang Province, is located at the confluence of Amur River, Songhua River, and Wusuli River. It covers the Sanjiang Plain and surrounding counties and cities. The administrative area of this region covers five municipalities directly under the central government, including Jiamusi City, Hegang City, Shuangyashan City, Qitaihe City and Jixi City, and counties such as Luobei, Suibin, Jixian, Tangyuan, Yilan, Boli, Huanan, Huachuan, Baoqing, Raohe, Fujin, Tongjiang, Fuyuan, Jidong, Muling, Mishan and Hulin. There are also 52 state-owned farms and 8 forestry bureaus in this region [4].

2.2. Social and economic development status in Sanjiang Region

From 2015 to 2016, the total population of Sanjiang Region dropped from 7,465,100 to 7,381,400, while the total production value increased from 223.652 billion yuan to 228.162 billion yuan, accounting for 14.34% of GDP in Heilongjiang Province. In 2016, the added value of the primary, secondary and tertiary industries in the Sanjiang Region was 72.963 billion yuan, 56.217 billion yuan, 98.894 billion yuan, respectively, and the completed investment in fixed assets reached 113.272 billion yuan. The per capita disposable income of urban and rural residents is 22086 yuan, an increase of 6.1% over 2015. Since the founding of the PRC, the region has been improving its basic public facilities, carrying out municipal planning and constructing water conservancy facilities. This region also boasts geographical advantages. It is a window open to Russia with ever expanding convenient road, railway, waterway, and air transportation networks, which can meet the requirements of domestic and international transportation [5].

2.3. Ecological and resources status in Sanjiang Region

Sanjiang Region is located in the plain, with vast and open black lands suitable for large-scale mechanized operation, making it an important grain production base in China [6]. It has rich forest resources and mineral resources, such as natural gas, petroleum, gold, graphite, and sillimanite, especially in cities of Hegang, Shuangyashan, Qitaihe and Jixi. The area is also home to the biggest wetland in the northeast with beautiful scenery and a variety of animals and plants. The wetland also has multiple functions, including water conservation, flood control, and climate adjustment [7].

3. Analysis of coupling and coordination degree between ecological resources and economic development in Sanjiang Region

3.1. Evaluation model of coordination degree

The ecological resource subsystem, providing abundant material resources and a stable production environment for economic development, is regarded as a guarantee for the economic subsystem. In the meantime, economic development affects the attention of individuals and organizations paid to resource stability and regeneration, which can be reflected in the sustainable development strategy advocated by China [8]. In this way, the two co-related subsystems form a more complex system, making it difficult to measure the coordination degree using only one indicator. In order to solve this and make a reasonable judgment of the development of the region, it is necessary to establish a relevant model for making evaluations by using various indicators. Higher degree of coupling and coordination indicates better system development. Based on domestic and foreign literature [9-11], this paper proposes the following model for measuring the two-dimensional economic and ecological resource systems, so as to evaluate the inter-connection and development of the two subsystems.

$$C = \left[\frac{f(x) \cdot g(x)}{(f(x) + g(x))^2}\right]^k \quad (1)$$

$$P = \alpha f(x) + \beta g(x) \quad (2)$$

$$D = \sqrt{C \cdot P} \quad (3)$$

$f(x)$ represents the comprehensive score of the economic subsystem; $g(x)$ indicates the comprehensive score of the ecological resource subsystem; α and β are the relative weights of the two subsystems (generally 0.5, indicating that the two subsystems are equally important); k is the adjustment coefficient. Based on the literature [12], k equals 2 in the two subsystems. $D \in [0,1]$ characterizes the degree of coupling and coordination, and can be used to reflect the actual development level. Larger D value indicates higher coupling and coordination degree and better development. Based on the D values, the system is divided into four phases, as shown in Table 1.

Table 1. Ranking of Coupling and Coordinating Degree.

Interval	Coordination degree
[0.0，0.3]	Low coupling coordination
[0.3，0.5]	Moderate coupling coordination
[0.5，0.8]	Highly coupled coordination
[0.8，1.0]	Extreme coupling coordination

3.2. Indicator selection and data source

The selection of indicators should take into account many factors so as to meet the requirements for characterizing subsystems, and the data must be reliable and authentic. Due to the scarcity of data in some areas and data loss before 2010, this paper selects 17 major counties (cities) in the Sanjiang Plain area from 2010 to 2016 as the object for coordination analysis. The original data is shown in Table 2 ("+" represents the positive indicator, while "-" represents the negative indicator).

Table 2. Subsystem indicators.

Indicators / The subsystem	Per capita GDP	GDP per capita index	The average salary	Land average forestry output value	Every village USES electricity	Proportion of arable land
Economic	+	+	+			
Ecological resources				+	−	+

Per capita GDP and per capita GDP index are calculated by dividing the regional GDP and GDP index by the end-of-year population. The average wage means the average wage of the jobholders. Average forestry output and proportion of cultivated land are calculated by dividing the forestry output value and cultivated land area by the total land area. Average village electricity consumption is calculated by dividing the rural electricity consumption by the number of village committees, or the number of villages. Obviously, per capita GDP, per capita DGP index, and average wage can represent the level of the local economic subsystem, which are all positive indicators. The average forestry output and the proportion of cultivated land characterize the development of local forestry and agriculture, which are also positive indicators. Electricity consumption represents the regional resource consumption, so it is a negative indicator.

3.3. Analysis of system coordination degree

This paper obtains coupling and coordination degree by putting the weights of each index and the comprehensive scores of each subsystem in the model based on the data gained from preprocessing.

Due to limit of space, this procedure will not be described in detail in the paper. Among the six indicators, per capita GDP index has the highest weight in the economic subsystem, while the average forestry output has the highest weight in the ecological resource subsystem, which shows that the per capita GDP growth and forestry development is important to coupling and coordination in the Sanjiang Plain. For the development stages of coupling and coordination, see Table 3. For the thermal map of the coupling and coordination degree of each region, see Figure 1 (Darker colors represent larger values). It can be seen that the coupling and coordination degree maintains stable, indicating no significant progress in this aspect during this period.

Table 3.The coordinated development stage of the Sanjiang region from 2010 to 2016.

Year / Region	2010	2011	2012	2013	2014	2015	2016
Luobei County	Altitude	Altitude	Altitude	Altitude	Altitude	Altitude	Altitude
Suibin County	Moderate	Altitude	Altitude	Moderate	Altitude	Altitude	Altitude
Jixian County	Altitude	Altitude	Altitude	Altitude	Minuent	Moderate	Moderate
Tangyuan County	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Yilan County	Altitude	Altitude	Moderate	Altitude	Altitude	Moderate	Altitude
Boli County	Moderate	Moderate	Moderate	Minuent	Moderate	Minuent	Moderate
Huanan County	Minuent	Minuent	Minuent	Moderate	Moderate	Minuent	Minuent
Huachuan County	Altitude	Altitude	Moderate	Altitude	Altitude	Altitude	Altitude
Baoqing County	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Raohe County	Minuent	Moderate	Moderate	Moderate	Moderate	Altitude	Moderate
Fujin City	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Tongjiang City	Moderate	Moderate	Moderate	Moderate	Altitude	Altitude	Moderate
Fuyuan County	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Minuent
Jidong County	Altitude	Altitude	Altitude	Altitude	Altitude	Altitude	Altitude
MuLeng City	Altitude	Altitude	Altitude	Altitude	Altitude	Altitude	Moderate
Mishan City	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Hulin City	Altitude	Altitude	Altitude	Altitude	Moderate	Moderate	Altitude

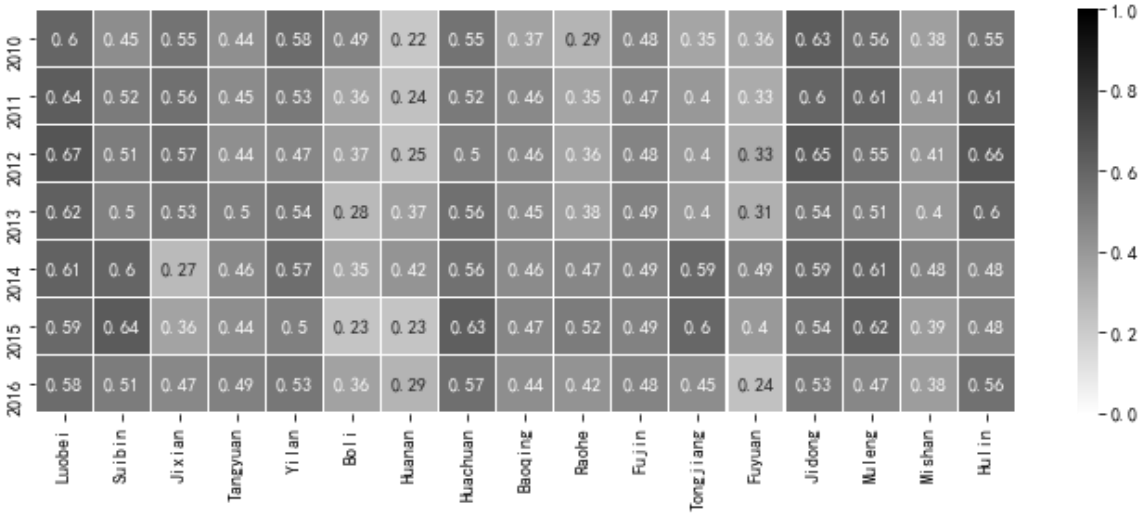

Figure 1. Thermal diagram of coupling coordination degree of Sanjiang region from 2010 to 2016.

Based on Figure 1, which shows the specific values of the coordination degree of each region, and Table 3, which shows the coordinated development stages of the regions in the Sanjiang Region, it can be seen that most area in the Sanjiang Region is at a lower level of the moderate-to-high coupling and coordination stages while counties such as Boli, Huanan, Raohe and Fuyuan have long been stuck in a low or medium stage. In Huanan, Raohe and Fuyuan Counties, both the coordination and coupling degrees are low, showing that the two subsystems are not closely linked or coordinated in development. In some other areas, high coupling and low coordination indicate that the two subsystems are highly correlated but not coordinated in development, which is unfavorable for the regional economy and the utilization of ecological resources.

4. Suggestions and countermeasures for coordinated development of Sanjiang Region

The above analysis shows that the coordination degree between the economic development and the ecological resources are low in some counties and cities. This paper proposes the following suggestions, with the aim to better protect the ecological environment, scientifically utilize existing resources, and promote healthy economic development.

4.1. Developing the industry of the deep processing of agricultural and sideline products

The Sanjiang Region has rich agricultural resources and available enterprises for processing grain products. However, the absence of coordinated planning and reasonable layout makes the production output overwhelming for the region, for example, rice cultivation. In addition, there is no uniform specification for the varieties and standards for processing. Therefore, it is necessary to develop a variety of products based on field investigation and vigorously promote agricultural and sideline products with the characteristics of Sanjiang Region. By leveraging the abundant agricultural resources of the province and developing the economic model of agricultural industrial parks, the modern service industry, including the transnational free trade industrial park, can be gradually transformed into the modern ecological service industry in the future.

4.2. Extending the industrial chain by integrating mineral resources

We need to further develop the advantages of resource-based cities in the Sanjiang Region so as to develop fine and deep processing. For example, it is possible to implement an integrated coal mine power generation project in the area rich in coal resources. At the same time, it is feasible to develop a variety of extension products by making full use of existing resources. Pilot activities can be carried out in large enterprises so as to effectively coordinate personnel, technology, products and equipment

[13]. Rational integration of production capacity and resources shall be performed within a reasonable radius of the economic scale of the Sanjiang Region.

4.3. Developing transnational trade economy by utilizing the geographical advantage

The Sanjiang Region has a long history of trade with Russia because they are close to each other. However, the trading companies in this region are relatively small with low level of operation, making them difficult to compete with other enterprises in the market. This problem can be solved by putting more efforts to the improvement of the quality of trade products and expanding cross-border trade based on the geographical advantage. It is also necessary to train more compound talents who master both the Russian language and professional skills, so as to strengthen communication. In addition, infrastructure, such as traffic lines, should also be improved step by step.

4.4. Developing ecotourism industry

Tourism plays an important role in adjusting and optimizing the industrial structure, relieving employment pressure, promoting infrastructure and developing new economic growth points. It is also an important sustainable model under the background of reverting cultivated land to wetland and an industry crucial to the transformation of the Sanjiang Region[14]. The Sanjiang Region boasts abundant eco-tourism resources, which can be used to formulate tourist routes and products with unique local ecological characteristics. For example, abundant forests, wetlands, and agricultural resources can be appropriately used to develop an ecological tourism economy.

4.4.1. Forest tourism products

The Sanjiang Region, rich in forest resources, has a good natural landscape. The development of forest tourism aims to protect the ecologic environment [15] by integrating, investigating, and rationally developing forest resources. For example, it is possible to carry out activities like mountaineering, camping, and forest skiing based on the existing resources of mountains and forests.

4.4.2. Wetland tourism products

Sanjiang Region boasts rich wetland resources, making it suitable to develop a new form of wetland tourism without harming the environment or the wetland ecosystem [16]. The local government can carry out different ecotourism activities, such as sightseeing and fishing, based on the condition of wetlands. Areas with hot springs can also build sanatoriums and develop characteristic eco-hot-spring resorts based on the local conditions, so as to attract more tourists from South China.

4.4.3. Agricultural tourism products

With the vast farmland resource, the Sanjiang Region should not only develop agritainment in the traditional sense, but also build a new image of modern scientific agricultural tourism by leveraging the agricultural technology. For example, urban visitors can experience modern farming by spraying pesticides on a tractor or a plane. In this way, they can feel the charm, freshness and entertainment provided by the new agricultural industry.

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