A Study on the Coupling Coordination Between Tourism Economy and Ecological Environment

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Abstract

Tourism environment is the basis of sustainable development of tourism economy. Exploring the coupling relationship between tourism economy and ecological environment system can not only promote the construction of tourism ecological civilization, but also contribute to the sustainable development of tourism economy. Based on data from Nagasaki Prefecture, Japan, from 2010-2019, this paper aims to introduce an indicator system and develop an integrated approach to assess the coupling and coordination between the tourism economy and the environment. The indicator system consists of 2 levels, 6 aspects, and 18 indicators, weighted by Entropy method. Based on the development status of Nagasaki Prefecture in Japan the PSR model framework of the coupling and coordination mechanism of tourism economy and ecological environment is constructed. Then, the coupled coordination degree of its tourism economy and ecological environment is evaluated, and the comprehensive evaluation index of the system is derived. Finally, suggestions for promoting the sustainable development of tourism and environment in Nagasaki Prefecture, Japan, are proposed.

Keyword: PSR model/ Tourism development/ Ecological environment/ Coupled and coordinated development

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1. Introduction

As a resource-dependent and environment-dependent industry, tourism development and the ecological environment are inextricably linked. On the one hand, the ecological environment is the guarantee and source of the development of the tourism economy, which in turn will promote the improvement of the ecological environment. On the other hand, excessive pursuit of economic benefits will lead to the deterioration of the ecological environment, which in turn will affect the sustainability of tourism economic development. Therefore, the study of the coupled and coordinated development of tourism and the ecological environment has become a hot spot for academic research. This has important theoretical and guiding values.

Researchers have studied the relationship between the environment and tourism as far back as 1920 (Lutz, H. J.,1945). In this initial phase, scholars began to study the ecological impacts of tourism activities. Most of the studies are general observations and qualitative descriptions (Akoglu, T., 1971 and Budowski, G., 1976). With the rapid development of tourism, researchers have begun to pay attention to the issues of tourism capacity and tourism carrying capacity (Ovington, J. D., Groves, K. W., Stevens, P. R., & Tanton, M. T., 1974 and Sutcliffe, C. M., & Sinclair, M. T., 1980). In the 21st century, as research continues to intensify, researchers have gradually become more interested in studying the relationship between ecological environment and tourism. Studies of the relationship between tourism and the ecological environment have become more specific and diverse, especially in tourism ecological security (Nie, N., Wang, H., & Xiong, J. X., 2011 and Wang, Y., Wu, C., Wang, F., Sun, Q., Wang, X., & Guo, S., 2021), the development of tourism resources and the protection of the ecological environment (Bo, Q. I. N., 2007), and the impact of climate warming on tourism development (Wang, S., He, Y., & Song, X.,2010 and Shi-Jin, W., & Lan-Yue, Z., 2019). Researchers have introduced a large number of models and quantitative methods, which have provided new research ideas for the study of the coordinated development of tourism

and the environment. In the study of coupled and coordinated development, most scholars have conducted research on tourism and the environment (Tang, Z., 2015 and GENG, S., & XIE, Y.,2013). Many researchers have studied its coupling and coordination with tourism from the perspective of tourism traffic (Wang, Y. M., & MA, Y. F., 2011 and Zeng, J., Rong, Q., Yue, W., Dai, X., & Su, M.,2020, March), urbanization (Liu, J., Li, C., Tao, J., Ma, Y., & Wen, X., 2019 and Nan, C. A. O., Yaofeng, M., Tianshun, L., & Kai, B. A. I., 2013) and air environment (Geng, Y., Wei, Z., Zhang, H., & Maimaituerxun, M., 2020 and Geng, Y., Maimaituerxun, M., & Zhang, H., 2020).

In summary, research methods on the relationship between the ecological environment and the tourism economy have gradually changed from qualitative to quantitative research. Among them, coupled coordination models have been more widely applied (Geng, Y., Wang, R., Wei, Z., & Zhai, Q., 2021 and Li, Y., Li, Y., Zhou, Y., Shi, Y., & Zhu, X., 2012 and Chen, J., Li, Z., Dong, Y., Song, M., Shahbaz, M., & Xie, Q., 2020). However, existing studies are mainly limited to large cities with mature tourism development and the whole country, while small and medium-sized cities are neglected as the basic units of the interaction between ecological environment and tourism economy (Huang, J., Shen, J., & Miao, L. , 2021 and Cheng, X., Long, R., Chen, H., & Li, Q., 2019). Therefore, this research takes Nagasaki Prefecture in Japan as the research object and constructs an evaluation index system for ecological environment and tourism economy.

2. Methodology

2.1 Study area

The study area was Nagasaki Prefecture, which is located at the southernmost tip of Japan and the westernmost of Kyushu Island. Nagasaki Prefecture is located close to the Korean Peninsula and mainland China, making it the closest place in Japan to mainland Asia. There are 13 cities under Nagasaki Prefecture, and the seat of the prefectural office is Nagasaki City. The climate in Nagasaki Prefecture is typically maritime, with an average annual temperature of 18.0°C and an annual precipitation of 1,464 mm. Nagasaki Prefecture has the 2nd longest coastline in Japan at 4,203 km. Nagasaki Prefecture has the largest fishery resources in Japan, with a variety of natural fish species. The location of Nagasaki Prefecture is shown in Figure 1.

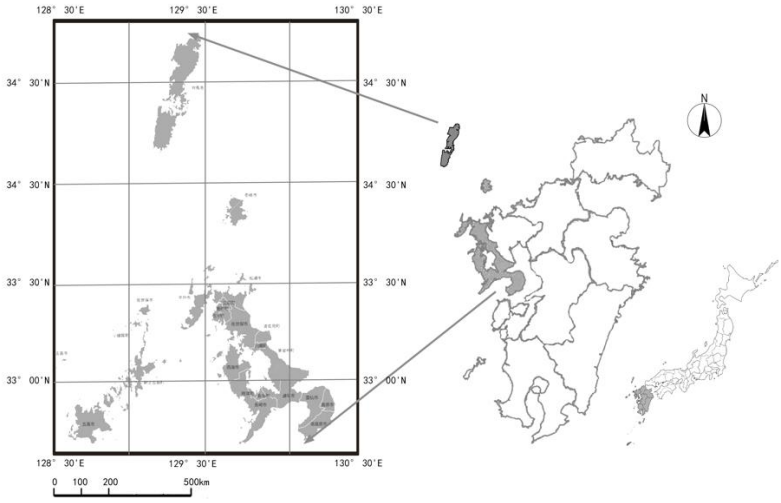

Figure 1. The location of Nagasaki Prefecture

2.2 Date resource

This paper used panel data (2010, 2013, 2016, and 2019) in Nagasaki Prefecture. Among them, tourism economic data was obtained from the Nagasaki Prefectural Tourism Trends Survey and Nagasaki Prefectural Tourism Statistics. The ecological environment data were derived from the Ministry of the Environment's official

website, the e-Stat statistics website and the website of the National Institute for Environmental Studies of Japan.

3. Methods

3.1 Assessment index system

At present, there is no uniform standard for the construction an evaluation index system of tourism economy and ecological environment system. Therefore, this research has selected the indicators that exist to study the relationship between tourism economy and ecological environment with high frequency of use. In order to analyze the coupling development process of tourism economy and ecological environment more objectively and systematically in Nagasaki Prefecture. This research combines the actual situation of Nagasaki Prefecture and constructs an evaluation index system for the tourism economy and ecological environment system (Table 1). Among them, the tourism economic system selects 9 indicators from the three dimensions of ecological resources, ecological environment and development potential to comprehensively evaluate the development level of the tourism economy. According to the "pressure (P)-state (S)-response (R)" model, the ecological environment system selects 10 indicators in three dimensions to comprehensively evaluate the development level of the ecological environment.

Table 1. Index system used for evaluation of the relationship between tourism economy and eco-environment

Subsystem	First-class index	Second-class index	Unit
Tourism economy	Economic benefit	Total tourism revenue	Billion yen/year
		The proportion of total tourism revenue in the tertiary industry	%
		Total tourism revenue as a proportion of GDP	%
	Scale of development	Total number of tourist reception	Ten thousand people
		Total number of foreign tourists received	Ten thousand people
		Total number of tourist reception accounts for the proportion of the permanent population	%
	Tourism supply	Number of main tourist facilities	place
		Number of places of interest	place
		Number of accommodation facilities	place
Eco-environment	Pressure	Discharge of domestic waste per person per day	g/person·day
		Water pollutant discharge	Thousand tons/year
		Waste discharge	Thousand tons/year
		Garbage discharge per person per day	g/person·day
	State	Dam impoundment rate	%
		Forestry rate	%
		Park green area per capita	Hectares
	Response	Waste treatment rate	%
		Population penetration rate of sewage treatment	%
		Waste recycling rate	%

3.2 data standardization

The tourism economy and eco-environmental system contains several index layers. The dimensions of each index are different, and the direction of the force is also different. Therefore, the value of each index needs to be standardized for comprehensive evaluation (Fan, Y., Fang, C., & Zhang, Q., 2019). Assuming that the m-th index value of the n-th year in a certain place is x_{nm}, the maximum value of index j is x_{max} and the minimum value is x_{min}. According to the positive and negative properties of the index, the normalized value of x_{nm} can be obtained.

Positive index (larger value for a useful parameter):

$$\chi'_{nm} = \frac{\chi_{nm} - \chi_{min}}{\chi_{max} - \chi_{min}} \quad (1)$$

Negative index (smaller value for a useful parameter):

$$\chi'_{nm} = \frac{\chi_{max} - \chi_{nm}}{\chi_{max} - \chi_{min}} \quad (2)$$

3.3 Index weight calculation

Since the entropy method is more objective than the subjective analysis method, this study uses the entropy method to determine the weight of the index and avoid the influence of subjective factors. This study follows the calculation process of the entropy method. First, calculate the normalized index proportion S_{nm} of index m (Equation 3); second, calculate the entropy value h_m of index m (Equation 4); third, calculate the difference coefficient α_m of index m (Equation 5); fourth, determine the weight of the indicator w_m (Equation 6).

$$S_{nm} = \chi'_{nm} / \sum_{n=1}^{p} \chi_{nm} \quad (3)$$

$$h_m = \frac{1}{In\, p} / \sum_{n=1}^{p} \chi_{nm} \quad (4)$$

$$\alpha_m = 1 - h_m \quad (5)$$

$$w_m = \alpha_m / \sum_{m=1}^{q} \alpha_m \quad (6)$$

3.4 Sub-system development index calculate on

This research uses the weighting method to calculate the development level index P_n of a certain subsystem in a certain place in the *i* year.

$$P_n = \sum_{m=1}^{q} w_m \chi'_{nm} \quad (7)$$

3.5 Development of the CCD model

The coupling degree can only reflect the degree of interaction between the birth tourism economic system and the ecological environment system, but cannot really measure the synergistic effect of their overall development. Therefore, this study builds a coupling coordination model between the two based on the coupling degree model. This can judge the coordinated development of tourism economy and ecological environment more scientifically. The calculation formula is:

$$D(P_{TE}, P_{EE}) = \sqrt{C \times T} \quad (8)$$

$$C = \sqrt{\frac{P_{TE} \times P_{EE}}{(P_{TE} + P_{EE})^2}} \quad (9)$$

$$T = \alpha P_{TE} + \beta P_{EE} \quad (10)$$

Where; D denotes degree of coupling coordination; C is the coupling degree of the two systems; T is the comprehensive coordination index of the two systems; P_{TE} and P_{EE} are the comprehensive evaluation indexes of the tourism economic system and the ecological environment system respectively; α and β are undetermined coefficients. Since the tourism economic system and the ecological environment system are of equal importance, the values of α and β are both 0.5 in the actual calculations of this research.

3.6 Grade division of the coordinated development

On the one hand, the calculation of the coupling coordination D for the two systems in 2010-2019 is mainly in the smaller range of 0.3-0.6. On the other hand, in order to more clearly distinguish the coupling and coordination relationship between tourism economy and ecological environment. Therefore, this research uses the tenth method of coupling coordination degree to classify the coordinated development level. The specific classification criteria are shown in Table 2.

Table 2. The classification of the coupling coordination degree

Category	Coupling coordination degree	Subclass
Disorder (zone of unacceptable)	0.00-0.09	Extreme disorder
	0.10-0.19	Serious disorder
	0.20-0.29	Moderate disorder
	0.30-0.39	Light disorder
Transition (zone of reluctantly accept)	0.40-0.49	Near disorder
	0.50-0.59	Reluctance coordination

Table 2. The classification of the coupling coordination degree (cont.)

Category	Coupling coordination degree	Subclass
Coordination (zone of tolerance)	0.60-0.69	Primary coordination
	0.70-0.79	Middle coordination
	0.80-0.89	Well coordination
	0.90-1.00	High coordination

4. Results and Discussion

4.1 The characteristics of comprehensive development of tourism economy and ecological environment

According to the coupling degree model and the coupling coordination degree model, this research obtained the comprehensive development index P_{TE} and P_{EE}, the coupling degree C, the integrated evaluation index T of tourism economic system and ecological environment system, and the coupling coordination degree D for Nagasaki County from 2010 to 2019. According to the classification basis in Table 2, the specific results of this study are shown in Table 3 and Figure 2. It can be seen from Table 3 and Figure 2:

Table 3. Coupling degree and coordination degree between tourism economy and ecological environment in Nagasaki Prefecture

	P_{TE}	P_{EE}	C	T	D
2010	0.084	0.245	0.436	0.164	0.268
2013	0.191	0.298	0.488	0.245	0.345
2016	0.301	0.083	0.412	0.192	0.282
2019	0.424	0.133	0.426	0.279	0.345

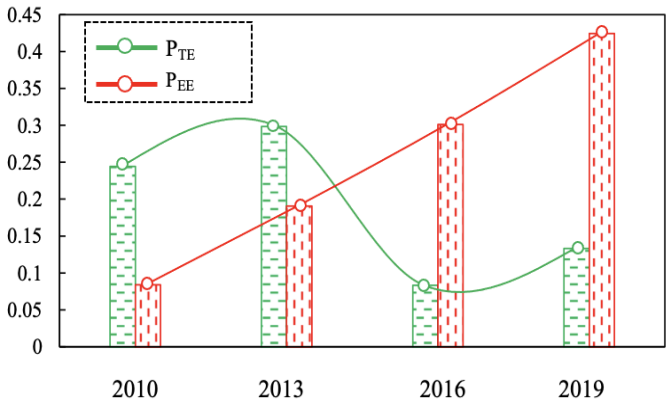

Figure 2. Comprehensive development index of tourism economy and eco-environment

(1) From the perspective of the comprehensive development index of the ecological environment, the ecological environment development index of Nagasaki Prefecture from 2010 to 2019 showed a fluctuating decline (0.245 to 0.133). Among them, 2013-2016 showed a sharp downward trend, with the remaining years showed a slight increase. This indicates that although the ecological status of Nagasaki Prefecture is good and the ecological pressure is decreasing year by year, the response to the ecological environment is insufficient. Obviously, the waste treatment rate, sewage treatment rate and waste recycling rate in Nagasaki Prefecture have all been greatly reduced, all of which have contributed to a negative increase in the overall ecological environment.

(2) From the perspective of the comprehensive tourism economic development index, the tourism economic development index of Nagasaki Prefecture from 2010 to 2019 has shown an increasing trend (from 0.084 to 0.424), and its rate of development has increased year by year. This is mainly due to the following three points:

- In 2013, Nagasaki Prefecture was certified as one of the world's three new night scenes, and night tourism is growing rapidly.

- In 2015, Nagasaki Prefecture was registered as a World Heritage Site for its "Industrial Revolution Heritage of Meiji Japan Steelmaking/Steelmaking, Shipbuilding and Coal Industry", and tourism in Nagasaki Prefecture is gaining attention.
- In 2018, Nagasaki Prefecture was affected by the world cultural heritage "Christian Hidden Heritage", and the number of cruise ship tourists and visitors to surrounding facilities increased significantly.

(3) From an overall perspective, Nagasaki Prefecture's P_{TE} was less than its P_{EE} from 2010 to 2013, meaning that Nagasaki Prefecture's the comprehensive development index of tourism economy is lower than the comprehensive development index of ecological environment at this stage, which belongs to the lagging development stage of tourism industry. This shows that, on the one hand, tourism activities are still within the controllable range of the ecological environment. On the other hand, there is also a relatively large room for progress in the development of tourism. The P_{TE} of Nagasaki Prefecture in 2016-2019 is greater than the P_{EE}. The tourism economic development index exceeds the ecological environment development index. This shows that the level of tourism economic development has been rapidly improved on the original basis, but the level of ecological environment has shown a significant downward trend. This also reflects that the development of tourism in Nagasaki Prefecture has brought a certain pressure or has begun to coerce the ecological environment.

4.2 The characteristics of the coordinated evolution of tourism economy and ecological environment coupling

According to the data obtained in Table 3 and formula 8-10, the coupling degree and coordinated development degree of the tourism economy and ecological environment system of Nagasaki Prefecture from 2010 to 2019 can be calculated. From the results in Figure 3 and the metric based on the coupling degree (Table 4), it can be seen that the coupling degree index of the tourism economy and eco-environment system of Nagasaki Prefecture has been developing steadily since 2010, a, with the coordination degree index showing an overall fluctuating upward trend. The degree of coupling between tourism economy and ecological environment in Nagasaki Prefecture was mainly in the antagonistic stage, i.e., C was between [0.3, 0.5].

Table 4. Coupling measurement standard (Li Shujuan, & Wang Tong., 2017)

C	Stage
[0,0.3]	Low-level coupling
[0.3,0.5]	Antagonistic stage
[0.5,0.8]	Run-in stage
[0.8,1]	High level of coupling

The above showed that the coordination effect of various factors between the tourism economy and ecological environment system of Nagasaki Prefecture was not obvious enough. The coupling between the tourism economy and the ecological environment was at a low level of coupling, and the negative effects of the growing tourism industry on the ecological system were becoming apparent. This was mainly due to the immature development of the tourism industry in Nagasaki Prefecture, and the structure of the tourism industry still needs to be optimized. This means that if tourism in Nagasaki Prefecture continues to develop at such a rapid pace, it is bound to have a negative impact on the ecological environment. For the entire study period, the coupling between tourism and the ecological environment in Nagasaki Prefecture was at an increasing stage (0.164 to 0.279), which indicated that the mutual influence and interaction between the two was gradually increasing. This showed not only that ecological conservation in Nagasaki Prefecture drives the development of tourism, but also that the development of tourism promoted ecological conservation.

4.3 Coupling and coordinated development

According to Figure 3 and the coordination degree measurement standard (Table 2), it can be seen that from 2010 to 2019, the coupling coordination degree of the tourism industry and the ecological environment in

Nagasaki Prefecture showed a fluctuating upward trend (0.268 to 0.345), from a moderate disorder to a light disorder. Among them, the coupling coordination degree was the worst in 2010, only 0.268, which was a moderate disorder. This was due to the lowest comprehensive development index of the tourism economic system of Nagasaki Prefecture in 2010, and the development of tourism is in its infancy. In addition, P_{EE} was much larger than P_{TE}, and the comprehensive development level of the tourism economic system and the ecological environment system itself was relatively low, resulting in poor coupling coordination. There was a slight downward trend in the coupling degree from 2013 to 2016, which was mainly due to the impact of the significant decrease in P_{EE}. From 2016 to 2019, the coupling coordination degree of the tourism economy and the ecological environment system of Nagasaki Prefecture has been continuously improved, and finally rose to the highest coordination degree during the research period in 2019, which was in the development stage of mild imbalance.

The above showed that although Nagasaki Prefecture has adopted a series of measures to make it develop in a good manner, the coordination between the tourism economic system and the ecological environment system of Nagasaki Prefecture was not high. With the emergence of other new tourism methods such as ecotourism, health tourism, and green tourism, the comprehensive development level of the tourism economy and ecological environment of Nagasaki Prefecture has been continuously improved. This has further promoted the improvement of the coupling and coordination between the tourism economic system and the ecological environment system in Nagasaki Prefecture.

5. Suggestions

(1) The level of tourism development in Nagasaki Prefecture has been growing year on year, and its tourism infrastructure development, tourism capital investment and tourism policies are relatively stable. Therefore, in the future, Nagasaki Prefecture's tourism industry should focus on optimising the structure of the tourism industry. Nagasaki Prefecture should not only pay attention to land use planning, environmental protection planning, urban and rural development planning, forest land protection planning, and cultural relics protection planning, but also strengthen the protection and management of tourism resources.

(2) The overall development level of the ecological environment system in Nagasaki Prefecture is in a declining stage. Therefore, Nagasaki Prefecture should pay more attention to the protection of the ecological environment while paying attention to the development of tourism economy. First of all, Nagasaki Prefecture should increase citizens' awareness of environmental protection and allow more citizens to receive environmental protection education. Secondly, Nagasaki Prefecture should reasonably control the discharge of waste gas, waste, and wastewater from enterprises, and promote the use of clean energy. Thirdly, Nagasaki Prefecture should strengthen the supervision and enforcement of environmental protection, and improve relevant laws on environmental protection.

(3) Nagasaki Prefecture maintains a good coordination between the development of tourism and the ecological environment, which is the key to the sustainable development of the tourism economic system and the ecological environment system. Therefore, Nagasaki Prefecture should vigorously develop eco-tourism. On the one hand, Nagasaki County should increase its support for the eco-tourism industry and provide it with some preferential policies and tax reduction and exemption policies. On the other hand, Nagasaki Prefecture should strictly implement environmental protection measures to achieve the coordinated and sustainable development of tourism and the ecological environment.

6. Conclusions

Based on the pressure-state-correspondence framework and taking into account the characteristics of the ecological environment of Nagasaki Prefecture, this research constructs a PSR model of the direct coupling and coordination extremes between the tourism economy and the ecological environment. In this

research, the coupling degree model and the coupling coordination degree model were introduced to measure the comprehensive development index of the tourism economic system and the ecological environment system in Nagasaki Prefecture. Then, this research analyses the state of coupled and coordinated development of the tourism economy and the ecosystem in Nagasaki Prefecture and the evolution of the trend. The results show that:

(1) Nagasaki Prefecture's tourism economic development index showed an increasing trend from 2010 to 2019, but the Nagasaki Prefecture's ecological environment development index showed a fluctuating decline;

(2) From 2010 to 2019, the coupling degree between the tourism economic system and the ecological environment system of Nagasaki Prefecture is mainly in the antagonistic stage, and the coupling degree between the two needs to be improved;

(3) From 2010 to 2019, the coupling coordination degree of the tourism economy and ecological environment system of Nagasaki Prefecture has changed from a moderate disorder to a light disorder.

(4) This research covers the period from 2010 to 2019, and the statistical data are all from official Japanese websites. As some indicator data cannot be obtained continuously, this research only selects data for 2010, 2013, 2016, and 2019. This leads to certain limitations in the research results. If the research timeline can be extended, and the spatial dimension analysis based on the data of each city in Nagasaki Prefecture, the research will more clearly reflect the evolution process of the coupling and coordination of the tourism industry and the ecological environment system in Nagasaki Prefecture.

Acknowledgement

This research was funded by Nagasaki University “Doctoral Program for World-leading Innovative and Smart Education” for Global Health, KENKYU SHIDO KEIHI (“the Research Grant”)

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