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Integrated Interaction between Tourism, Economy, and Ecology in Indonesia: Coupling Coordination Degree Method

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ABSTRACT: Indonesian tourism sector becomes an important part of national development planning over the past decade. However, the development of the tourism sector stimulates many negative ecological issues. Tourism has a complex relationship with the economy and ecological quality. it is essential to investigate progress of tourism-economy-ecology system. An integrated study of this system can be analyzed using coupling coordination degree method (CCDM) that provides overview of interaction and level of coordination in systems. The findings show that coupling degree between tourism-economy-ecology systems increases from run-in to high-phases. This condition indicates that there was strong connection between systems during observation. Meanwhile, the coupling coordination degree constitutes an ever-increasing evolution from approaching-disorder to well-coordination. It shows that the systems are increasingly supportive of each other. Conversely, higher level of coordination is accompanied by decline in environmental system. Promoting ecological quality becomes critical policy for sustainable tourism growth.

Keywords: Tourism Development, Ecological Environment, Economic Progress, Coupling Coordination.

ABSTRAK: *Sektor pariwisata Indonesia menjadi bagian penting dalam perencanaan pembangunan nasional selama dekade terakhir. Namun, perkembangan sektor pariwisata terbukti menimbulkan banyak permasalahan ekologi yang negatif. Pariwisata memiliki hubungan yang komplek dengan perekonomian dan kualitas lingkungan, sehingga penting menganalisis perkembangan ketiganya secara bersamaan dalam sebuah sistem pariwisata-ekonomi-lingkungan. Studi terintegrasi ketiga sistem ini bisa dilakukan dengan metode* coupling coordination degree method *(CCDM) yang mampu menggambarkan interaksi dan tingkat koordinasi dalam sistem. Hasil menunjukkan derajat* coupling *antara sistem pariwisata-ekonomi-lingkungan meningkat dari* run-in phase *menjadi* high phase*, menunjukkan interaksi kuat antara ketiga sistem selama periode observasi. Sementara itu, derajat* coupling coordination *mengalami perkembangan yang terus meningkat dari tahap* approaching-disorder *menjadi* well-coordination*. Hal ini menunjukkan sistem semakin saling mendukung satu sama lain. Hanya saja, peningkatan level koordinasi ini diiringi dengan penurunan sistem lingkungan. Hal ini memerlukan perhatian lebih untuk mengedepankan peningkatan kualitas lingkungan sebagai pijakan penting bagi pembangunan pariwisata berkelanjutan.*

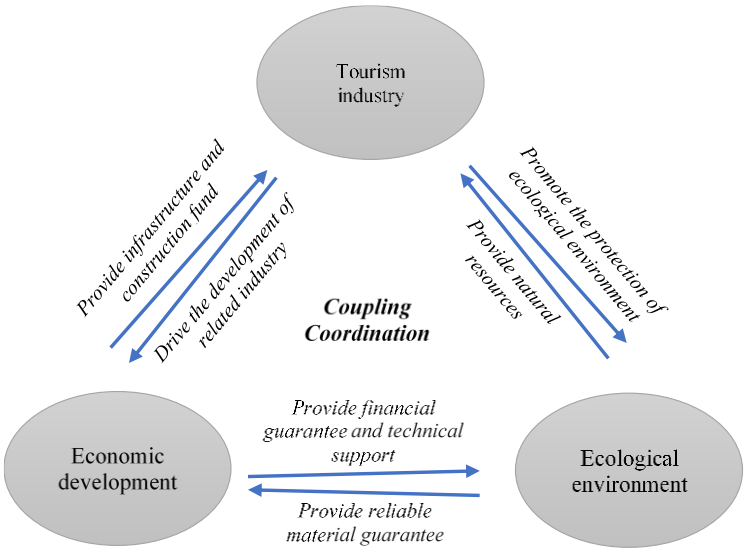
Kata Kunci: *Pembangunan Pariwisata, Lingkungan Ekologi, Kemajuan Ekonomi,* Coupling Coordination.

INTRODUCTION

Indonesia is one of the ten largest tourist arrival countries in Asia Pacific. Indonesia has a wide range of potential tourist destinations, hosting 5,8 billion foreign tourists in 2023. Indonesian tourism recorded the highest ranking increase in The Travel & Tourism Development Index (TTDI) 2021, rising from 44th in 2019 to 32nd (World Economic Forum, 2022). On the domestic scale, Indonesia recorded 626 million tourist trips in 2023 (BPS, 2023). Indonesia has made tourism an important element in national development planning to promote cultural diversity and boost economic growth. However, this sector ^{is} also seen as one of the causes of environmental degradation (Ahmad et al., 2019) and resource exploitation (Moslehpour et al., 2023). Ahmad et al. (2019) demonstrated the negative impact of international tourists on the environment through emissions caused by transport and energy. Cordova et al. (2021) added that there was a decrease in the environmental quality of poorly managed garbage deposits in coastal tourist areas. There is a long-term link between the arrival of tourists, ecological degradation, and economic growth in Indonesia (Lee & Syah, 2018). The development of the tourism sector has made many regions make it a major strategic pillar in improving economic performance and regional development. Nevertheless, the environmental impact of this sector is becoming increasingly highlighted (Xuan, 2013; Li et al., 2021; dan Pang et al., 2023).

Apart from being proven to harm the environment, tourism also has the other side of improving environmental quality in significant tourist destination countries, proving the concern of tourist destination countries for the environmental quality of their region in attracting tourists (Katircioglu et al., 2018). The tourism industry and economic growth are causal and interrelated (Rasool & Maqbool, 2021). Tourism can encourage overall economic growth (Tourism-Led Economic Growth-TLEG) through a direct and indirect multiplier effect (Rusu, 2011). Meanwhile, the economic climate is also a driving factor for tourism (Economic-Driven Tourism Growth-EDTG) (Antonakakis et al., 2015). On the other hand, a significant economic downturn and uncertain business climate could have a negative domino effect on the development of tourism activities, as happened during the crisis (Obradovic et al., 2013; U & So, 2020).

The tourism industry is heavily dependent on the quality of the ecological environment, which makes the analysis of the relationship between the tourism industry and the ecological environment essential to encourage the development of sustainable tourism industries (Duan et al., 2020). The integrated study of tourism-economy-environment plays an important role in quality regional development (B. Tang & Luo, 2022). Tourism is the key to the three systems that coordinate the regional economy and the ecological environment (Fei et al., 2021). Tourism can stimulate economic development, indirectly regulate and improve the quality of life, and give impetus to protect the natural environment (Zhang et al., 2021). Developing a harmonious tourism system and living environment is a dynamic process, not a static one. Understanding the coordinating relationship between tourism and the environment becomes essential because of the complex interactions and environmental impacts caused by tourism (Tang, 2015). Therefore, only when the tourism and environmental sectors are combined and coordinated can sustainable development mechanisms be formed (Zhang et al., 2021). Pang et al. (2023) state the coupling coordination relationship between this system and Figure 1.



Source: Pang et al (2023)

Figure 1. *Coupling Coordination* mechanism of the tourism-economy-ecology system

The coupling coordination degree method (CCDM) is a method that has been widely used to analyze interactions and coordination between tourism-economy-environment systems, as Fei et al. (2021). Tang & Luo (2022) and Pang et al. (2023) use this method in cities in China stated that the coordination relationship developed from unbalanced to balanced; Lai et al. (2020) also studied using the same method for provinces in China with unbalanced coordination results for 15 years; Wang & Zhang (2022) obtained results from unbalanced to transitional coordination in China over 20 years; Liu & Suk (2021) analyzed the environmental and tourism subsystem in Japan with unbalanced results.

The concept of CCDM comes from physics, which refers to dynamic relationships between interdependent and interactive systems. It reveals that different systems influence each other and even work together through various interconnections (Lai et al., 2020). Cao (2014) stated that the interactions described by coupling covered all forms of relationships, such as coincidences, dependencies, linkages, correlations, and causality. The interacting units can also include many things, whether units, elements, or groups of parts, so they can be used to analyze at various levels, national, regional, and local. This method is widely used for conducting analysis of climate change and diverse research on the ecological environment (Li et al., 2021; Tang, 2015).

Research on the interaction between economic tourism and ecology using coupling coordination in Indonesia has never been done. How to coordinate tourism performance with the quality of the ecological environment while continuing to boost the regional economy to sustainable development has been an important issue to be studied (Lai et al., 2020). Many studies analyze the relationship between the tourism industry, economic growth, and the ecological environment in Indonesia. Still, these studies are mostly limited to impact and causality relationships and are carried out partially. The relationship between tourism, the economy, and the ecology is a system with complex structures and coupling characteristics (Fei et al., 2021). To this end, the objective of this study is (1) to identify the most influential indicators in the tourism-economy-ecological system and (2) to analyze the interaction and the level of coordination between the tourism-economic-ecological system in Indonesia using the coupling coordination degree method.

METHODS

This study describes the interaction between tourism, economy, and environment. These interactions are expressed in a system organized in indexes based on various indicators representing each system. This research uses secondary data sourced from websites and publications of authorized agencies. Details of the data, such as variables, units, and data sources, can be seen in the Table 1 below.

Table 1. Indicators, Unit, Data Source of Variables

Primary Indicator	Code	Secondary Indicator	Unit	Data Source	Type
(1)	(2)	(3)	(4)	(5)	(6)
TOURISM SUBSYSTEM					
Tourism Scale	P11	Number of foreign tourist visits	Visit	BPS	+
	P12	Average tourist expenditure per visit	USD	BPS	+
	P13	Number of foreign guests at the star hotel	Thousand people	BPS	+
	P14	Number of foreign guests at non-star hotels	People	BPS	+
	P15	Number of domestic tourists at the star hotel	Thousand people	BPS	+
	P16	Number of domestic tourists at non-star hotels	People	BPS	+
	P17	GDP of Accommodation and food service activities category (I)	Million rupiah	BPS	+
Tourism Instrument	P21	Number of accommodations available at star hotel	Unit	BPS	+
	P22	Number of accommodations available at non-star hotel	Unit	BPS	+
	P23	Government expenditure on tourism function	Million rupiah	Kemenkeu	+
	P24	FDI of Accommodation and food service activities category (I)	Thousands USD	BKPM	+
	P25	Private domestic investment of Accommodation and food service activities category (I)	Billion rupiah	BKPM	+
ECONOMY SUBSYSTEM					
Economic scale	E11	GDP per capita	Billion rupiah	BPS	+
	E12	GDP primary sector	Million rupiah	BPS	+
	E13	GDP secondary sector	Million rupiah	BPS	+
	E14	GDP tertiary sector	Million rupiah	BPS	+
	E15	Export plus import/GDP (*degree of openness*)	Percent	WDI, World Bank	+
Economic benefit	E21	Unemployment level	People	BPS	-
	E22	Labor force participation level	Percent	BPS	+
	E23	Household consumption per capita	Billion rupiah	BPS	+
	E24	Labor compensation	% of expense	WDI, World Bank	+
Economic instrument	E31	Individuals using the internet	% of population	WDI, World Bank	+
	E32	Gross fixed capital formation	Million rupiah	BPS	+
	E33	Electricity distributed to customers	GWh	BPS	+
	E34	Foreign direct investment	Thousand USD	BKPM	+
	E35	Private domestic investment	Billion rupiah	BKPM	+
ECOLOGY SUBSYSTEM					
Ecological support	L11	Government expenditure on environmental function	Million rupiah	Kemenkeu	+
	L12	Arable land	% of land area	WDI, World Bank	+
	L13	Forest area	sq. Km	WDI, World Bank	+
	L14	Access to clean fuel and technology for cooking	% of population	WDI, World Bank	+
Ecological pressure	L21	Fertilizer Consumption	km/ha of arable land	WDI, World Bank	-
	L22	Agricultural land	% of land area	WDI, World Bank	-
	L23	The amount of clean water channeled by the pure water company	Thousand m^3	BPS	-
	L24	CO_2 emission	Kiloton (kt)	WDI, World Bank	-

Primary Indicator	Code	Secondary Indicator	Unit	Data Source	Type
(1)	(2)	(3)	(4)	(5)	(6)
	L25	Methane emission	Kiloton of CO2 equivalent	WDI, World Bank	-
	L26	Nitrous oxide emissions	Thousand metric tons of CO2 equivalent	WDI, World Bank	-

Data pre-processing

Indicator data must first be standardized to eliminate the influence of dimensions, unit differences, and positive or negative directions of data using formulas (1) and (2).

$$X'_{jt} = \frac{X_{jt} - \min_t\{X_{jt}\}}{\max_t\{X_{jt}\} - \min_t\{X_{jt}\}};\ j\text{: Positive Index} \quad (1)$$

$$X'_{jt} = \frac{\max_t\{X_{jt}\} - X_{jt}}{\max_t\{X_{jt}\} - \min_t\{X_{jt}\}};\ j\text{: Negative Index} \quad (2)$$

Where X_{jt} is the value of indicator-j in year-t; $\max_t\{X_{jt}\}$ is maximum value dan $\min_t\{X_{jt}\}$ is minimum value for each index throughout the year. X'_{jt} is an indicator that has been standardized.

Index Entropy Weight Method

The Index Entropy Weight Method (IEW) measures the relative intensity of different criteria to determine the average information weight in decision-making (Deng et al., 2020). Entropy weight gives more objective results because weight determination is not influenced by data evaluation and is based on index variation differences. Based on available information, the resulting weight shows the degree of importance and trend changes (Guan & Guo, 2022). The steps taken to determine the entropy weight follow Tang (2015) as follows:

(a) calculating the ratio of index j in year t (R_{jt})

$$R_{jt} = X'_{jt} / \sum_{t=1}^{m} X'_{jt} \quad (3)$$

(b) calculating information entropy from index j (e_j)

$$e_j = -\frac{1}{\ln m} \sum_{t=1}^{m} R_{jt}\, x \ln R_{jt} \quad \text{; m is total of years} \quad (4)$$

(c) calculating entropy redundancy (d_{jt})

$$d_j = 1 - e_j \quad (5)$$

(d) calculating weight index (w_{jt})

$$W_j = d_j / \sum_{j=1}^{n} d_j \quad (6)$$

(e) calculating index for each system (U)

$$Ut, t = \sum_{p=1}^{r} W_{p,t}.X'_{p,t} \text{ ; for tourism system} \quad (7)$$

$$Ue, t = \sum_{e=1}^{s} W_{e,t}.X'_{e,t} \text{ ; for economic system} \quad (8)$$

$$Ul, t = \sum_{l=1}^{t} W_{l,t}.X'_{l,t} \text{ ; for ecological system} \quad (9)$$

W is a weight obtained by the Information Entrophy Weight (IEW) method and X' is a standardized indicator.

Coupling Coordination Degree Model

CCDM is used for comprehensive assessment of the sensitive relationship between the tourism, economic, and ecological systems (Fei et al., 2021; Pang et al., 2023; Wang & Zhang, 2022). The results show that a method that combines CCDM with IEW can be implemented as a practical approach to evaluating intersystem sensitivity in coupling relationships (Duan et al., 2020; Tang, 2015). The relationship between tourism, economy, and ecology can be seen as a mechanism of feedback effect, which is a combined system consisting of the tourism system, economic system, and ecological system. The general form of the degree of coupling of the three systems is shown in the equation below:

$$C_{it} = 3\ x\ \left[\frac{Up_{it}\ x\ Ue_{it} x\ Ul_{it}}{(Up_{it} + Ue_{it} + Ul_{it})^3}\right]^{1/3} \quad (10)$$

C is the combined level of interaction between tourism, economy, and ecology; C has a value of 0 to 1. If the value of C is close to 1, then there is a stronger interaction among the three systems and vice versa. The degree of coupling only reflects the strength of interaction between systems, whereas the degree of coordination measures the level of alignment between systems to reflect the tendency of the system to move from imbalance to equilibrium. The model of coupling coordination degree is as follows:

$$T_{it} = \alpha . Up_{it} + \beta . Ue_{it} + \gamma . Ul_{it} \quad (11)$$

$$D_{it} = \sqrt{C_{it} x\ T_{it}} \quad (12)$$

D shows the degree of coordination of the coupling, and T is a comprehensive evaluation index for tourism-economy-ecology and reflects the overall system benefits. Coefficient value $\alpha = \beta = \gamma = \frac{1}{3}$ assuming the three systems have the same important role.

After calculating the degree of coupling coordination for the tourism, economic, and ecological systems, the degrees of coupling coordination are traditionally and subjectively divided into several levels. However, here, and referring to previous research, the level of coupling coordination is divided to more objectively reflect the coordinated level of development of the tourist-economic-ecology system.

RESULTS AND DISCUSSIONS

Tourism System

The tourism system in analysis is composed of various indicators (secondary index) and formed into two primary indices with weighing values, which show the magnitude of the role of indicators in the system (Table 1). Based on the primary index, the tourism instrument has a total role of 55.48%, which is more determining the formation of the tourism system compared to the tourism scale, which has a role of 44.52%. The secondary indices that have the most impact on the tourism system as a whole are private domestic investment of accommodation and food service activities category (16.68%), average international tourist spending per visit (13.38%), number of non-star accommodation (12.86%), and government expenditure on tourism function (11.02%). The fourth role of this indicator is 53.93% of the total indicator in the system, making it a potential top priority for enhancing the tourist system's performance.

Table 2. Indicators, Weight and Descriptive Statistics in Subsystems

Primary Indicator	Code	Secondary Indicator	Weight	Mean	Standard Deviation	Max	Min
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TOURISM SUBSYSTEM							
Tourism Scale (0,4452)	P11	Number of foreign tourist visits	0.0537	10,244,973	3,801,677	16,106,954	4,052,923
	P12	Average tourist expenditure per visit	0.1338	1,236	315	2,165	996
	P13	Number of foreign guests at the star hotel	0.0534	9,185	4,133	16,700	2,248
	P14	Number of foreign guests at non-star hotels	0.0396	2,279,926	909,505	3,418,559	366,442
	P15	Number of domestic tourists at the star hotel	0.0544	43,168	24,634	74,067	2,248
	P16	Number of domestic tourists at non-star hotels	0.0506	41,765,758	15,310,802	59,592,567	14,547,831
	P17	GDP of Accommodation and food service activities category (I)	0.0597	329,661	79,556	440,208	200,282

Primary Indicator	Code	Secondary Indicator	Weight	Mean	Standard Deviation	Max	Min
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tourism Instrument (0,5548)	P21	Number of accommodations available at star hotel	0.0860	2,325	824	3,644	1,306
	P22	Number of accommodations available at non-star hotel	0.1286	18,227	5,158	27,179	13,281
	P23	Government expenditure on tourism function	0.1102	3,896	2,580	10,700	1,409
	P24	FDI of Accommodation and food service activities category (I)	0.0633	626,920	257,333	1,089,606	242,242
	P25	Private domestic investment of Accommodation and food service activities category (I)	0.1668	4,611,750	5,115,708	16,163,067	390,341
ECONOMY SUBSYSTEM							
Economic scale (0,3367)	E11	GDP per capita	0.0709	45	11	59	29
	E12	GDP primary sector	0.0559	2,524,812	487,262	3,162,656	1,674,248
	E13	GDP secondary sector	0.0745	3,687,762	985,649	5,017,186	2,218,064
	E14	GDP tertiary sector	0.0781	4,959,255	1,493,018	7,001,319	2,791,368
	E15	Export plus import/GDP (*degree of openness*)	0.0572	0.40	0.05	0.46	0.32
Economic benefit (0,2471)	E21	Unemployment level	0.0508	7,399,101	597,204	8,592,490	6,898,796
	E22	Labor force participation level	0.0503	67	1	68	66
	E23	Household consumption per capita	0.0734	25	6	34	16
	E24	Labor compensation	0.0727	15	1	17	14
Economic instrument (0,4162)	E31	Individuals using the internet	0.1304	26	15	54	11
	E32	Gross fixed capital formation	0.0699	3,717,238	1,025,091	5,121,371	2,127,841
	E33	Electricity distributed to customers	0.0679	196,496	39,437	247,653	134,193
	E34	Foreign direct investment	0.0428	26,732,968	4,786,534	32,239,752	16,214,772
	E35	Private domestic investment	0.1053	209,071,265	124,135,772	413,535,524	60,626,308
ECOLOGY SUBSYSTEM							
Ecological support (0,4663)	L11	Government expenditure on environmental function	0.0940	10,300	2,879	16,094	6,550
	L12	Arable land	0.2085	13.14	0.74	14.01	12.45
	L13	Forest area	0.0926	955,908	24,775	996,592	921,332
	L14	Access to clean fuel and technology for cooking	0.0713	65	15	84	41
Ecological pressure (0,5337)	L21	Fertilizer Consumption	0.1247	236	25	263	183
	L22	Agricultural land	0.1215	32	2	34	29
	L23	The amount of clean water channeled by the pure water company	0.0809	3,193,747	746,926	4,350,726	2,269,318
	L24	CO_2 emission	0.0610	502,827	55,839	605,291	415,537

Primary Indicator	Code	Secondary Indicator	Weight	Mean	Standard Deviation	Max	Min
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	L25	Methane emission	0.0657	323,936	8,758	339,613	312,450
	L26	Nitrous oxide emissions	0.0800	65,823	6,124	75,596	57,756

Economic System

The economic system consists of primary indices of economic scale, economic benefits, and economic instruments assembled from various indicators in a secondary index. The economic instrument index has a significant role in the economic system, with a total impact of 41.62%. The most important indicator composer of this index is the proportion of individuals using the internet, with a role of 13.04%. Private domestic investment also has a considerable role in economic systems, with an impact of 10.53%. The GDP tertiary sector supports the most significant role in the economic scale index with an effect of 7.81%. In comparison, on the economic benefit index, the major role is household consumption, which is 7.34%, and employee compensation, which is 7.27%.

Ecological System

The quality of the ecology is determined by the stresses experienced and the supportive factors that help the ecological environment to recover. In this study, ecological pressure factors have a more significant influence on the system than ecological support capacity, with a portion of 53.37%. The most critical indicator to support the ecological system is arable land. Arable land can absorb environmental pollutants better without burdening land, unlike agricultural land (Lee & Syah, 2018). The most influential indicators on the ecological pressure index are fertilizer consumption and agricultural land, which represent ecological pressures on the soil. The portions are consecutive, at 12.47% and 12.15%. Meanwhile, ecological pressure from the side of air quality, represented by CO2, NO, and methane gases, has an impact of 20.67% on the ecological system. The role of the government in increasing ecological support is also noted to be quite significant, with a share of 9.40%.

Result of coupling coordination degrees

The growth of the tourism sector has driven rapid economic growth. Meanwhile, the ecological system is also under increasing pressure. To achieve sustainable development, it is essential to explore the relationship and evolutionary characteristics between the three systems: tourism, economics, and ecology (Pang et al., 2023). Comprehensive development for each tourism, economy, and ecological system is presented in Figure 1. The tourism and economic system have similar growth patterns between 2010 and 2020, despite fluctuations at the end of the period due to the pandemic. Meanwhile, the ecological system has seen a decreasing fluctuation during the same period. In the early period between 2010 and 2014, the Indonesian ecological environment system recorded superiority over the economic system with a declining pattern until 2015, when the economic system began to outperform the ecological systems. Meanwhile, the tourism system overcame the ecological system in 2017. The development of the economy and tourism industry has put pressure on the ecological system (Lee & Syah, 2018).

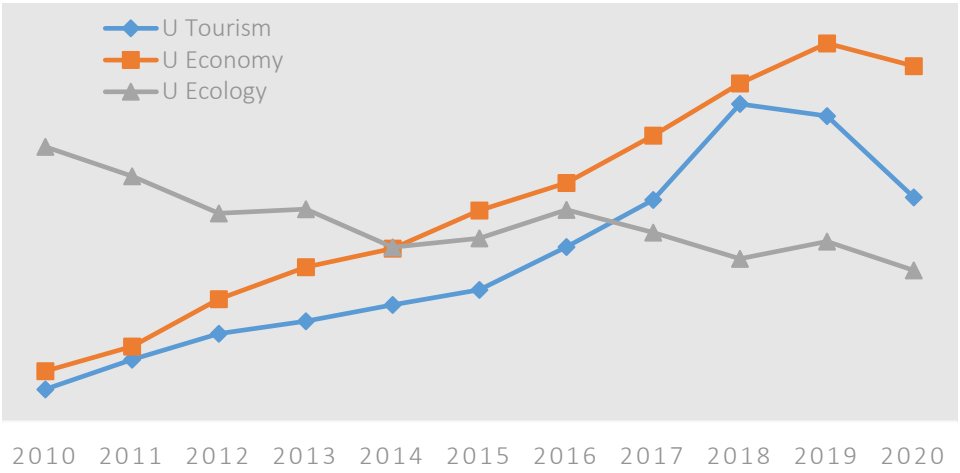


Figure 1. Comprehensive Development of Tourism-Economy-Ecology Systems

The degree of coupling indicates the strength of interaction between the systems analyzed. Figure 2 shows the degree of combined interaction between two systems and three tourism, economic, and ecological systems at once. The interaction between the economy and tourism has been solid from the beginning to the end, with grade values approaching one or at the high phase level. These two systems in Indonesia are mutually supportive, as mentioned in the research of tourism lead growth hypothesis proved by Mardhani et al. (2021), Primayesa et al. (2019), and Economic-Driven Tourism Growth confirmed by Sokhanvar et al. (2018).

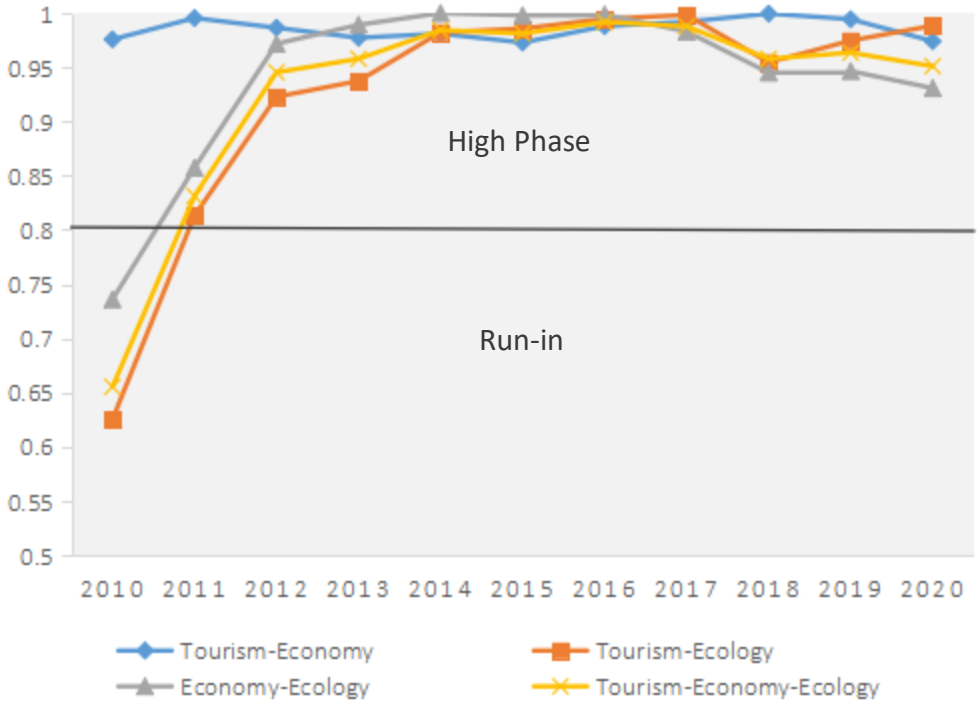


Figure 2. Coupling Degree of Combination Tourism-Economy-Ecology System

On the other hand, the interactions between tourism-ecology systems and economy-ecology have the same patterns of increasing. However, there are slight differences at the end of the study period. Between 2018 and 2020, the tourism-ecology system has increased, especially during the pandemic when environmental-based tourism is more prominent. On the contrary, the economic-ecology system tends to decrease due to the decline in economic performance during the epidemic. This increase depicts a solid interactive relationship from year to year. 2010 both systems were already

in the run-in phase and increased to a high phase in 2012 until 2020. Indonesian ecological environment policies are growing, driven by global demands for sustainable development.

The strength of the inter-system interaction does not reflect the level of coordination between the three. This requires an analysis of the degree of coordination using the CCDM method. The degree of coordination between the tourism-economy-ecology system in Indonesia has been increasing and divided into several periods between 2010 and 2020. The coordination among tourism, economy, and ecology is still at the approaching disorder stage or is on the threshold of imbalance between 2010 and 2011. Tourism in this period is still not a priority sector; the economic infrastructure that supports tourism, such as transport and accommodation, is only available in specific destinations, and the quality of the environment is not yet much burdened. Between 2012 and 2013, the coordination of the three systems increased from bare coordination to primary coordination between 2014 and 2015. Tourism has begun to be a highlight in increasing Indonesian economic growth, with abundant natural and cultural potential demonstrated by the promotion of tourism as one of the national priority programs for improving the well-being of the people in the RPJMN 2015–2019 (*Rencana Pembangunan Jangka Menengah Nasional* or National Medium-Term Development Plan).

The development of system coordination is improving in 2016, and it will be at the level of intermediate coordination by 2018. Tourism is believed to be a stimulus that drives the regional economy. Many regions have started improving the quality of their respective tourism from the ecological side and community engagement (Musaddad et al., 2019). The highest level of coordination during the study period is in 2019, achieving well coordination. Tourism performance is rising with increasing awareness of sustainable tourism, and new tourist destinations are starting to emerge with the themes of eco-tourism and nature conservation. Significant research on eco-tourism in Indonesia has also been conducted from 2015 to 2019 (Sisriany & Furuya, 2020). However, this level of coordination declined again in 2020 due to a pandemic that has caused the system's performance to decline, especially in the tourism and economic systems. The comprehensive development of the ecological system has also been reduced due to the increased use of agricultural land and fertilizer in the farm sector during the pandemic.

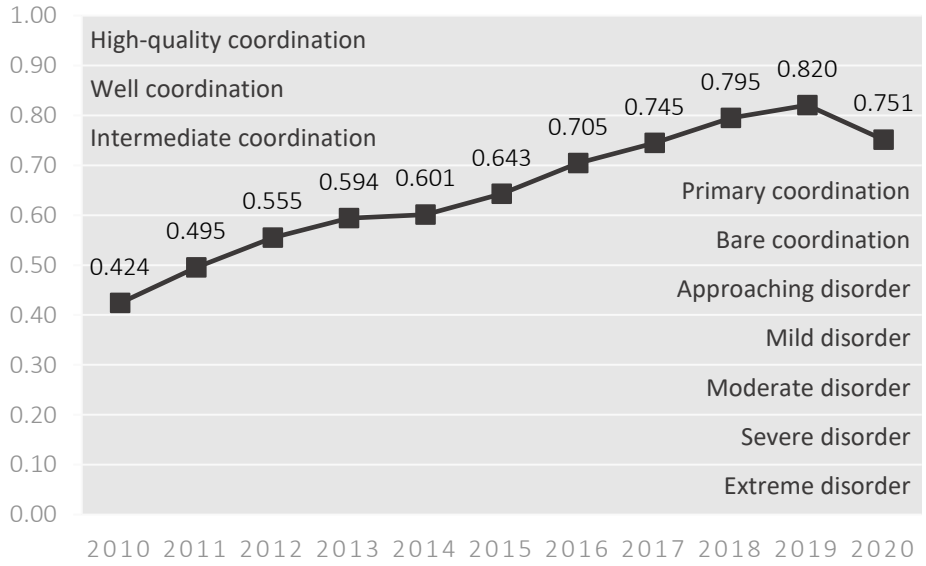


Figure 3. Coupling Coordination Degree of Tourism-Economy-Ecology System

Discussion

Based on the impact of each indicator in the subsystem, it shows that significant policy priorities for the development of the tourism sector are infrastructure, investment and government regulations. Instruments such as infrastructures have become an important part of attracting tourist visitation, making easy access to accommodation and availability to attractions. Lim et al. (2018) proved that tourism infrastructure strategies by building facilities can boost tourism demand. It was supported by

Nguyen (2021), who stated that investments in three components of tourism infrastructure, namely transport and communications infrastructures, hotel and restaurant industries, and recreational facilities, have a solid and positive impact on the attractiveness of international visitors.

The role of domestic investment in supporting the tourism supply side, such as investment in the hospitality and restaurant industries, as well as recreational facilities, can mobilize resources for the whole of society, especially the private sector, as this sector is highly commercial and profitable (Nguyen, 2021). On the demand side, foreign tourist spending plays a considerable role in the tourism system. The spending of foreign tourists in Indonesia can potentially reduce poverty for entire households, both urban and rural (Hartono, 2020).

The impact of the government on the regulatory side also plays a considerable role. Government policies have correlations with tourism resources and simultaneously affect the competitiveness of tourism enterprises (Susanto, 2019). The government is also committed to establishing collaboration and active participation among actors involved in tourism development (Sentanu & Mahadiansar, 2020). Zahra (2010) concluded that the government's role is important in delivering tourism policy. This is proven by the failure of the public and private tourism sectors to educate policymakers at the regional level on related policy issues, being the cause of poor implementation of tourism policy at the local level.

In the other hand, economic subsystem supported by availability of facilities and infrastructure and domestic power such as domestic investment and domestic consumption. Infrastructure is an essential part of creating superior economic performance in the form of amenities and access. The use of the Internet as an embodiment of ICT (Information and Communication Technology) progress is an integral part of accessing opportunities in the economy. The use of the Internet has been shown to facilitate the economic interaction of supply and demand to accelerate economic growth and improve the quality of life in ASEAN countries, including Indonesia (Wahab et al., 2020). Tourism also relies heavily on ICT infrastructure to provide information, promotions, and transactions (Hadood et al., 2021). Meanwhile, domestic investments have a more significant role than the FDI (Foreign direct investment). It demonstrates the existence of economic independence and the deprivation of foreign capital (Feriyanto, 2020; Ridzuan et al., 2018).

The tertiary sector is directly linked to the regional income (Sunarsih & Sapta, 2015). The services sector is consumed directly by domestic demand, so it grows better even during times of crisis at the global level (Noland et al., 2012). The tertiary sector also supports employment and economic growth, especially in urban areas (Suryadarma et al., 2010). Furthermore, the economic benefits received by households through wages and salaries are reflected in household consumption. Household consumption expenditure indicators indicate a significant influence on economic growth in Indonesia (Afiftah et al., 2017; Varlina & B Amar, 2019).

Ecological subsystems are proven to be still constrained in terms of pressure on soil and air quality. Using chemicals for Indonesian agriculture has proved inefficient and burdens the environment (Mariyono et al., 2018). Emissions that burden the ecological environment are increasing along with increased economic performance and energy consumption (Ahmad et al., 2019). The role of government regulations to protect the environment must be emphasized. Moslehpour et al. (2023) stated that government support and policy intervention can encourage a reduction in the exploitation of natural resources. Government spending has also been shown to boost Indonesia's ecological environment quality index (Oktavilia et al., 2021).

The degree of coupling shows a strong interaction relationship between the tourism-economic-environmental system. It can be interpreted that a stimulus in one subsystem will significantly impact other subsystems. This can guide policymaking and see the impact when a subsystem experiences a decline due to special conditions. The increasing degree of coupling coordination indicates that the three systems can run side by side and support each other. The improved performance of one system will drive the performance of the other system.

However, there is a need to be concerned because increased coordination is precisely opposed to the declining performance of the ecological system (Figure 1). In some Indonesian areas, tourism may be expanding too quickly without considering sustainability issues that affect both the local community and the ecological environment (Ollivaud & Haxton, 2019). Environmental quality is one of

the critical parts of sustainable development. Tourism development is heavily dependent on the natural environment. An ecologically friendly environment is an essential basis for sustainable tourism development and can also be a unique attraction for tourists (Butler, 1991). A good quality of the environment can also improve the promotion and competitiveness of a country's tourism (Moslehpour et al., 2023), raising concerns about the future of tourism development in Indonesia.

CONCLUSIONS

The Indonesian tourism potential makes this sector an important part of national development planning with improved economic performance developments over the past decade. However, the progress of the tourism sector raises many ecological issues, such as garbage deposits, air emissions, and environmental degradation. Tourism has a complex relationship with the economy and the quality of the environment, which is known as the tourism-economy-ecology system. The study of the three links of this system is essential to encourage the development of sustainable tourism industries that provide economic benefits without sacrificing the quality of the ecological environment. An integrated study of these three systems can be done using the coupling coordination degree method (CCDM). This method provides an overview of the rate of interactions and the level of coordination or cooperation of the three systems over time. CCDM is a method widely used to analyze coordination interactions between tourism-economy-ecology simultaneously.

The results of the analysis showed that the most critical indicator in the tourism system is domestic investment in the accommodation and food service activities category (I), with an impact of 16.68%; the economic system is supported by individuals using the internet to an effects 13.04%; whereas the most influential index on the ecological system is the consumption of fertilizer with a portion of 12.47%. The degree of coupling between the tourist-economy-ecology system has increased from the run-in phase to the high phase, indicating the strong relationship between the three systems. Meanwhile, the degree of coupling coordination from 2010 to 2020 has managed to increase from approaching disorder to well coordination. It shows the three systems are increasingly supportive of each other in the coordination process. However, this increased level of coordination is accompanied by the decline in the ecological environment system, which is an important part of sustainable tourism development. Governments need to formulate policies that focus on improving the quality of the environment so that coordination between the three systems can be enhanced in a harmonious and balanced manner, as well as benefiting the public's well-being. Making tourism more sustainable not just by creating eco-tourism destinations but by improving integrated support systems such as transition from fossil-fueled energy and transportation, better waste management, and a more efficient use of resources.

CCDM may serve as an alternative method for determining priority indicators that are the most influential for government policy targets in each system. Such as investment in waste processing, which is still an obstacle in the tourism area, increasing domestic tourists as a domestic market force that can withstand foreign crises, focusing on tourist income rather than the number of tourists to maintain the carrying capacity of tourist destinations and involving local residents in increasing awareness and enforcing regulations related to the environment to maintain the quality of the tourism environment in their area.

Coupling coordination method also provides an overview of the extent to which tourism, economy, and ecological environment are integrated as one related system within a sustainable tourism framework. The simplicity of this method makes it easy to apply for central or local government planning and evaluation. The research still has limitations regarding indicator selection and the extent of data accessibility. Using indicators more reflective of each system can be carried out through further research. This method is not limited to the three systems but can also be applied to other systems. Apart from that, the scope of the study can be more detailed at the regional, local, or specific tourism destination level.

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