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Is Tourism Coordinated with the Economy and the Environment in Natural World Heritage Cities in China?

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Abstract: For tourist cities, coordination between tourism and socio-economic and natural environments is crucial for sustainable urban development. While the positive correlation between a Natural World Heritage (NWH) designation and local urban tourism growth has been validated, the interplay among tourism, the economy, and the environment remains underexplored. We conceptualize NWH cities as complex adaptive systems and establish an evaluation framework to assess the relationships among tourism, economic, and environmental subsystems. Using 34 NWH cities in China as case studies, we apply a coupling coordination degree model to evaluate the sustainability indices of the three subsystems and their interrelationships. Additionally, the obstacle degree model identifies specific obstacles in cities with suboptimal coordination, leading to targeted management recommendations. Our findings reveal that while tourism and economic sustainability indices have shown consistent upward trends, environmental sustainability has experienced a decline. The coupling coordination degrees among the three subsystems have generally increased, albeit with fluctuations in some cities. Environmental-related indicators are the main obstacle factors to imbalanced development in some cities from 2015 to 2020. Therefore, the primary challenge for sustainable management lies in the environmental subsystem. This study provides a relational perspective for evaluating the sustainability of NWH cities and offers targeted recommendations for enhancing their sustainable development, contributing to the broader discourse on heritage management and sustainable urban practices.

Keywords: natural world heritage; heritage cities; coupling coordination; obstacle factors; sustainable tourism

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1. Introduction

World Heritage sites (WHSs) can serve as triggers for regional sustainable development [1]. The relationship between WHSs and regional sustainable development has long been discussed [2]. At the 20th session of the General Assembly of States Parties to the World Heritage Convention, the Policy for the Integration of a Sustainable Development Perspective into the Processes of the World Heritage Convention was officially adopted. The policy objective indicates that WHSs should leverage their potential to advance sustainable development and shape a more inclusive and sustainable socio-economic model during the process of heritage protection.

As an essential component of the United Nations' Sustainable Development Goals (SDGs) for 2030, WHSs ought to contribute, and are capable of contributing, to the attainment of SDG 11, namely "making cities and human settlements inclusive, safe, resilient, and sustainable" [3]. Conversely, local sustainable development also exerts an influence on the long-term conservation and management of heritage resources. For instance, research

conducted by Alshawabkeh et al. (2023) indicates that the urbanization process affects WHSs through an increase in population growth and infrastructure construction activities [4]. Up to now, it remains a formidable challenge to reconcile the two management goals of heritage protection and local urban development.

Bertacchini et al. (2024) assert that heritage designation is a policy intervention commonly acknowledged to have considerable consequences for the economies of cities and regions where heritage sites are located and for the welfare of local communities [5]. Among them, tourism is the most researched and most concerning among these influences. The research of Hosseini et al. (2021) indicates that the WH brand has a positive influence on tourism demand in developing countries [6]. An empirical study by Zhang et al. (2022) on 287 prefecture-level cities in China reveals that WHSs significantly enhance regional tourism [7]. A study by Su and Lin (2014) in China also demonstrates that there is a positive correlation between heritage and the number of tourists, and the relationship with natural heritage is stronger than the relationship with cultural heritage [8]. This raises an important question: is tourism prosperity brought about by the inscription of a Natural World Heritage (NWH) designation in harmony with social and economic development in local cities?

On the other hand, a recent review of threats and challenges to WHSs conducted by the International Union for Conservation of Nature (IUCN) in its World Heritage Outlook 3 revealed that, globally since 2017, more NWHSs have deteriorated than improved. Sustainable finance has emerged as the most frequently cited issue, and rated as a serious concern in IUCN's World Heritage Outlook 2 and 3 [9]. In developing countries, tourism serves as a vital driver of economic growth for heritage cities [10]; consequently, it is a crucial factor in garnering the support of local governments and the public. However, the impact of heritage tourism is multifaceted and not limited to the heritage area, but has a substitute effect or negative impact on surrounding areas, such as prefecture-level cities [11]. Obviously, heritage tourism does not necessarily contribute to the sustainable development of local cities, but heritage protection cannot be separated from the support of local cities. Therefore, in developing countries, strengthening the coordination between tourism and local economic development is crucial for securing municipal support for NWH protection and enhancing the economic sustainability of such initiatives.

NWH sites are recognized for their exceptional values in terms of nature conservation and are esteemed as the most significant protected areas on earth [9]. However, research on NWH sites has been relatively underdeveloped and lags behind that of cultural WHSs [12]. Under the influence of global climate change, the relationship between WHSs and regional sustainable development has grown increasingly tighter. The conservation of NWH sites not only directly enriches the living environment for present and future generations but also serves as a significant asset for economic development by attracting investment and ensuring the provision of green, local, and stable employment opportunities [13]. Existing studies have indicated that there is a positive correlation between heritage and the number of tourists, and the impact of NWH sites on the number of tourists is greater than that of cultural WHSs [8]. Furthermore, NWH sites have significantly enhanced tourism demand in developing countries [14]. The reputation of WH has driven the rapid growth of the local tourism industry [3] and exerted negative impacts on the environment of these sites [6]. Is the vigorous development of tourism brought about by NWH sites in harmony with the environmental sustainability of local cities in developing countries?

The relationship between tourism growth, economic development, and environmental protection in Natural World Heritage cities (NWHCs) is crucial for the sustainability of both heritage conservation and local urban development. But the nature of their relationship remains unclear. Addressing this gap, this study investigates three key questions: (1) What is the relationship between tourism, the economy, and the environment in NWHCs? (2) What

factors impede their coordinated development? (3) How can the level of coordination be enhanced? This research focuses on 34 Chinese NWHCs, employing a coupled coordination degree model to assess the coordinated level among tourism, the economy, and the environment. Additionally, an obstacle degree model is utilized to identify specific hindering factors. Based on these findings, the study proposes targeted management strategies. The findings are expected to advance the sustainable development of NWHCs, bolster ongoing societal support for heritage conservation, and aid in achieving SDG 11.

2. Materials and Methods

2.1. Assessment Framework

Cities are typical complex adaptive social–ecological systems [15,16]. Their sustainable development aims to achieve a harmonious balance between socio-economic activities and the natural environment [17]. NWH inscription is an intervention policy which can make a city a tourist destination. NWHCs are influenced by human and natural factors, both within and beyond their boundaries, as well as cross-scale interactions, making them more vulnerable to climate change, policy shifts, epidemics, and other challenges. Studies have indicated that tourism often finds itself at the intersection of socio-economic and ecological tensions in urban sustainable development [18].

To evaluate the sustainability of NWHCs from the perspective of coordinating relationships between tourism, the economy, and the environment, this paper views NWHCs as complex adaptive systems consisting of three subsystems (economic subsystem, environmental subsystem, and tourism subsystem), namely the tourism–economy–environment system. Being listed as a WHS is an external intervention at the macro level that will have varying degrees of impact on the three subsystems. For instance, it leads to increased investment in infrastructure construction in NWHCs, augmented investment in natural environment restoration, enhanced tourism popularity, and so forth. Within the tourism–economy–environment system, there is also frequent interaction among the three subsystems. For example, the improvement of road facilities enhances tourism accessibility, the restoration of the ecological environment boosts tourism attractiveness, and tourism development increases local economic income but exerts pressure on the natural ecological environment, and so on. This paper primarily assesses whether the interactive relationships among the three subsystems are close (i.e., the degree of coupling) and whether the relationships of the subsystems are coordinated (i.e., the degree of coupling coordination). The specific evaluation content is shown in Figure 1.

2.2. Study Area

China officially joined the World Heritage Convention on 12 December 1985, and subsequently became one of the countries with the fastest-growing number of WHs globally. After the 46th World Heritage Conference in 2024, there are a total of 231 NWH sites worldwide. Among them, China possesses 15 NWH sites, being the country with the largest number of such heritage sites globally, accounting for 6.5% of the total of similar heritage sites worldwide. These 15 NWH sites involve a total of 40 cities. Due to the following reasons, the relevant cities were not included in this assessment: (1) Given that the "Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai Gulf of China (Phase II)" and "Badain Jaran Desert—Towers of Sand and Lakes" were newly inscribed on the WH List in July 2024, their impact effects have not yet emerged. (2) Data for some indicators in Tongren, the city where Fanjing Mountain is located, were not available. Consequently, associated cities are excluded from this assessment. This study evaluates a total of 34 cities (Table 1 for details). The spatial distribution of NWH sites and the 34 cities is shown in Figure 2.

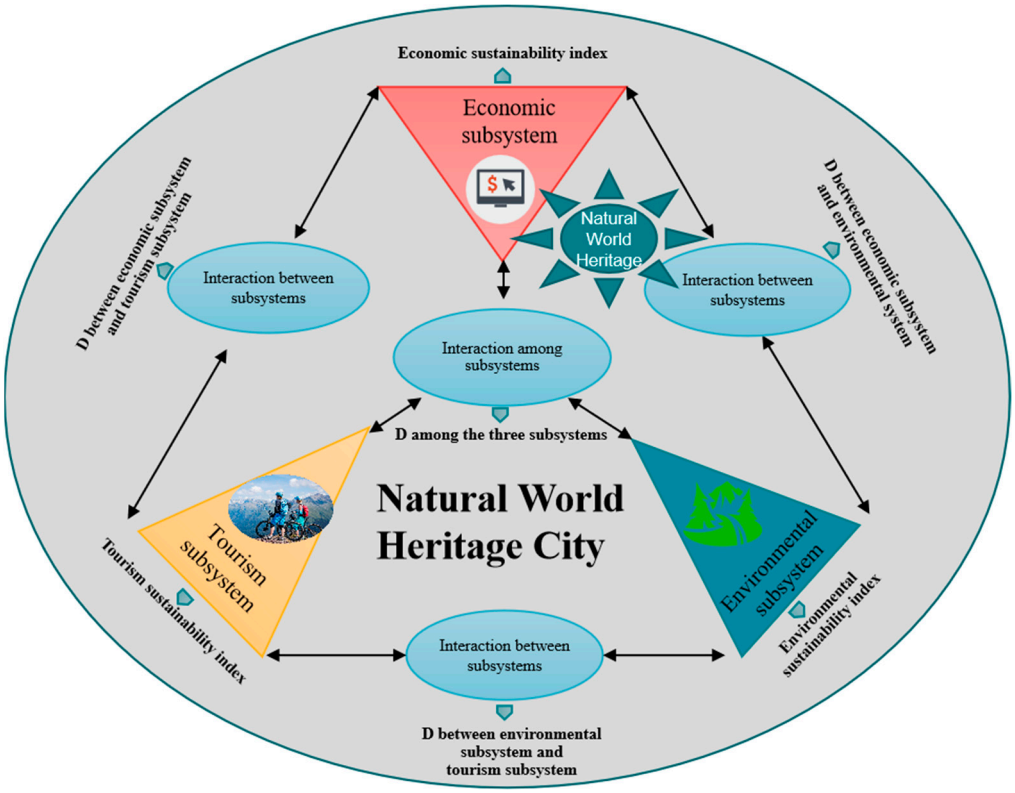

Figure 1. Assessment framework for evaluating the coupling coordination degree (D) among tourism, economic, and environmental subsystems in NWHCs.

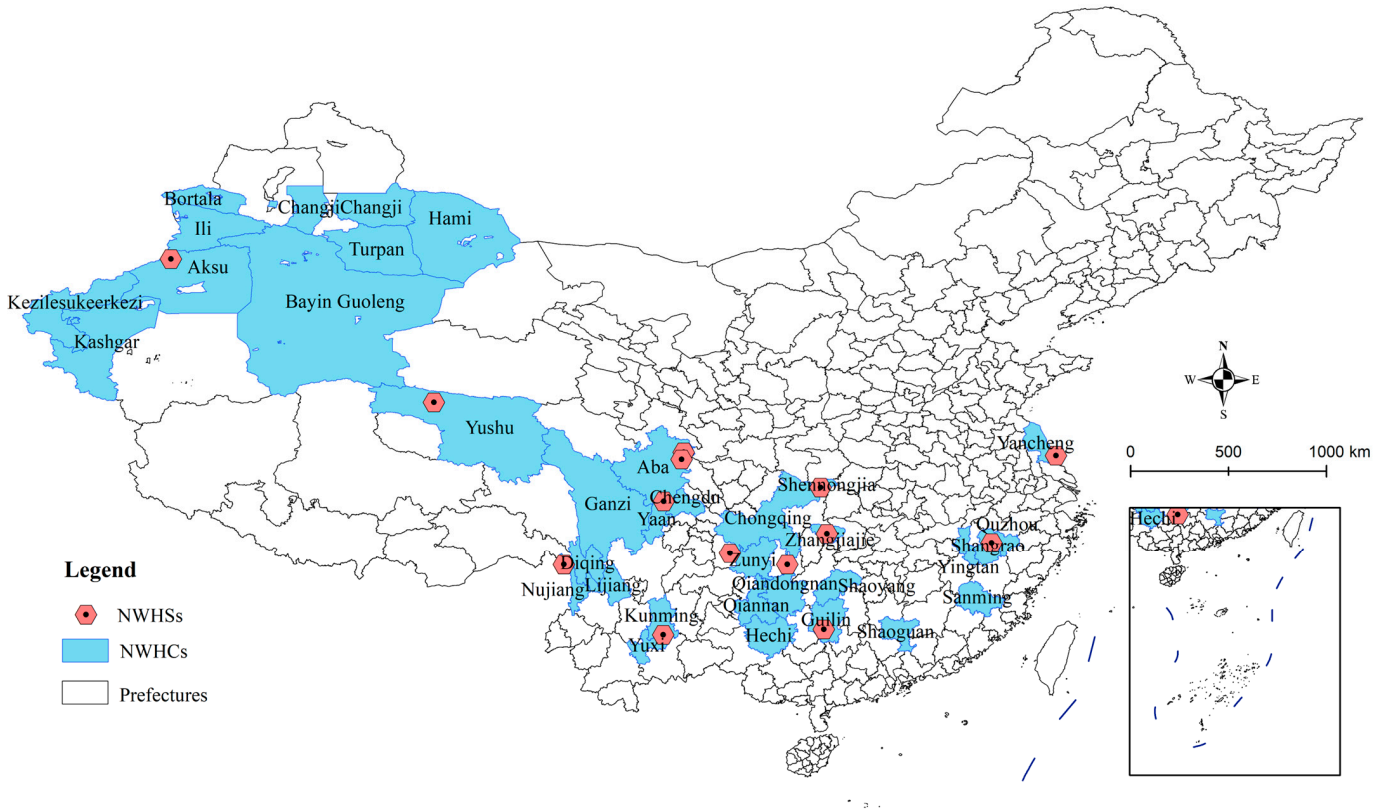

Figure 2. Spatial distribution map of China's NWHCs. Notes: NWHSs stands for Natural World Heritage sites; NWHCs stands for Natural World Heritage cities.

Table 1. NWH sites and associated cities in China.

No.	Property Name	Date of Inscription	Provinces Involved	Prefectures Involved	Criteria			
					VII	VIII	IX	X
1	Huanglong Scenic and Historic Interest Area	December 1992	Sichuan	Aba Tibetan and Qiang Autonomous Prefecture	√			
2	Jiuzhaigou Valley Scenic and Historic Interest Area	December 1992	Sichuan	Aba Tibetan and Qiang Autonomous Prefecture	√			
3	Wulingyuan Scenic and Historic Interest Area	December 1992	Hunan	Zhangjiajie	√			
4	Three Parallel Rivers of Yunnan Protected Areas	July 2003	Yunnan	Lijiang, Diqing Tibetan Autonomous Prefecture, Nujiang Lisu Autonomous Prefecture	√	√	√	√
5	Sichuan Giant Panda Sanctuaries	July 2006	Sichuan	Chengdu, Yaan, Aba Tibetan and Qiang Autonomous Prefecture, Ganzi Tibetan Autonomous Prefecture				√
6	South China Karst (phase I)	June 2007	Yunnan, Guizhou, Chongqing	Kunming, Qiannan Buyi and Miao Autonomous Prefecture, Chongqing	√	√		
7	Mount Sanqingshan	July 2008	Jiangxi	Shangrao	√			
8	China Danxia	August 2010	Guizhou, Fujian, Hunan, Guangdong, Jiangxi, Zhejiang	Zunyi, Sanming, Shaoyang, Shaoguan, Yingtan, Quzhou	√	√		
9	Chengjiang Fossil Site	July 2012	Yunnan	Yuxi		√		
10	Xinjiang Tianshan	June 2013	Xinjiang	Kashgar, Kezilesukeerkezi Autonomous Prefecture, Aksu Area, Bayin Guoleng Mongolian Autonomous Prefecture, Turpan, Hami, Ili Kazakh Autonomous Prefecture, Bortala Mongolian Autonomous Prefecture, Shihezi, Changji Hui Autonomous Prefecture	√		√	
11	South China Karst (phase II)	June 2014	Guangxi, Chongqing	Guilin, Hechi, Qiandongnan Miao and Dong Autonomous Prefecture	√	√		
12	Hubei Shennongjia	July 2016	Hubei	Shennongjia Forest Area			√	√
13	Qinghai Hoh Xil	July 2017	Qinghai	Yushu Tibetan Autonomous Prefecture	√			√
14	Yancheng Yellow Sea Wetlands (phase I)	July 2019	Jiangsu	Yancheng				√

It can be observed from Table 1 that NWH sites present a certain temporal sequence in terms of highlighting their universal values. Before 2003, they were mainly focused on natural scenic beauty, and then gradually transitioned to geological landforms, geological evolution processes, ecosystems and biodiversity protection, and habitat protection. They now cover all four categories of natural heritage standards (as listed in Table 1), namely

outstanding natural beauty (natural phenomena or aesthetic importance) (vii); distinctive geological features (geology) (viii); prominent ecosystems (ix); and biodiversity (x). There is no doubt that the areas they protect have outstanding universal value in terms of nature conservation.

Tourism is an important industry for these cities. In 2023, the 34 cities received 4.3 billion tourists and generated revenue of CNY 2434 billion. China's NWHSs are all established based on one or more protected areas, such as nature reserves, forest parks, or geoparks [19]. NWH sites, as the most attractive part of protected areas, have consistently ranked among China's foremost natural tourist destinations. In 2021, China's protected areas received over two billion visitors, accounting for more than half of the total domestic tourist population (https://content-static.cctvnews.cctv.com/snow-book/index.html?item_id=12110211581994945438&track_id=1e785e7d-8b98-490f-a741-91a20db37559 (accessed on 24 December 2024)). The high demand for natural tourism has resulted in a significantly larger number of visitors to China's NWH sites compared to other countries, leading to greater tourism pressure [20].

According to the "Regulations on the Application and Protection of World Natural Heritage, Mixed Natural and Cultural Heritage (for Trial Implementation)" issued by the Ministry of Housing and Urban-Rural Development (MOHURD), strict restrictions are placed on all kinds of construction activities unrelated to heritage protection in the surrounding areas of WH sites [21]. Consequently, industrial development in the surrounding areas of heritage sites has been subject to numerous limitations. In 2023, the average GDP of the 34 natural heritage cities stood at CNY 319 billion, lower than the national average of CNY 379 billion for the same year. Simultaneously, NWH sites fall within prohibited development areas as defined by National Major Function Oriented Zoning and ecological red lines currently being established, which may pose greater challenges for coordinating future economic development and ecological protection.

2.3. Methodology and Data

2.3.1. Index System and Data

Referring to existing literature, this study selected 24 indicators from the tourism, economic, and environmental subsystems. The weights of the indicators were determined using the entropy method, as detailed in Zhang et al. (2023) [11]. The connotation, reference literature, and data sources of the indicators are detailed in Table 2.

Table 2. Index and data sources.

Subsystem	Indicators (Code)	Sign	Definition	References	Source
Tourism (A)	Tourist arrivals (A_1)	+	Persons	[22]	Annual Statistical Bulletin on National Economy and Social Development of Each City; City Statistical Yearbook; China Urban Construction Statistical Yearbook
	Tourism income (A_2)	+	RMB		
	Tourist density (A_3)	+	Average number of tourists per day/number of permanent residents		
	Density of tourism economy (A_4)	+	Tourism income/Area of the city		

Table 2. *Cont.*

Subsystem	Indicators (Code)	Sign	Definition	References	Source
Tourism (A)	Degree of tourism dependence (A_5)	+	Tourism revenue/GDP	[23]	Annual Statistical Bulletin on National Economy and Social Development of Each City; City Statistical Yearbook; China Urban Construction Statistical Yearbook
	Growth rate of tourism revenue (A_6)	+	Percent		
	Growth rate of tourist arrivals (A_7)	+	Percent		
	Per capita tourism spending (A_8)	+	RMB	[24]	
Economy (B)	Consumer price index (CPI, B_1)	+	Index		
	Contribution ratio of tertiary industry (B_2)	+	Percent	[25]	
	Urban–rural gap (B_3)	–	RMB		
	Medical facilities (B_4)	+	Number of hospital beds per 10,000 people		
	Gross Domestic Product (GDP, B_5)	+	RMB	[10]	
	Per capita GDP (B_6)	+	RMB	[22]	
	Total fiscal revenue (B_7)	+	RMB	[25]	
	Per capita deposit balance (B_8)	+	RMB		
Ecology (C)	Human footprint index (C_1)	–	(Index)	[26]	https://www.x-mol.com/groups/li_xuecao/news/48145 (accessed on 1 December 2024)
	Population density (C_2)	–	Quantity of permanent residents/city area	[3]	Annual Statistical Bulletin on National Economy and Social Development of Each City
	Nighttime light value (C_3)	–	Index		[27]
	Normalized Difference Vegetation Index (NDVI, C_4)	+	Index		https://search.earthdata.nasa.gov/search (accessed on 1 December 2024)
	Area of afforestation by human effort (C_5)	–	Area		Municipal National Economy and Social Development Statistical Bulletin
	Per capita possession of agricultural products (C_6)	+	Kg		City or Provincial Statistical Yearbook
	PM2.5 (C_7)	–	$\mu g/m^3$		[28]
	Emission of greenhouse gases (C_8)	–	Total annual CO_2 emissions	[25]	[29]

2.3.2. Coupling Coordination Degree Model

Let $x_1', x_2', x_3' \cdots x_n'$ denote the indicators of the economic subsystem and represent the standardized value of x'. The economic sustainability index is then defined as $f_1(x) = \sum_{i=1}^{n} w_i x_i$, where w_i indicates the weight of indicator i within the economic subsystem. Analogously, the tourism and environmental sustainability indices are expressed as $f_2(x)$ and $f_3(x)$, respectively.

The coupling coordination degree among these subsystems is determined using the following Equations (1)–(3).

$$C = \sqrt[n]{f_1(x) \times f_2(x) \cdots f_n(x) / (f_1(x) + f_2(x) \cdots f_n(x))^n} \quad (1)$$

$$T = \gamma_1 f_1(x) + \gamma_2 f_2(x) \cdots \gamma_n f_n(x) \quad (2)$$

$$D = \sqrt{C \times T} \quad (3)$$

Here, C denotes the coupling degree, D represents the coupling coordination degree, γ is the weight coefficient of the respective subsystem, and n indicates the number of subsystems. For n = 3, T signifies the comprehensive sustainability index of the tourism–economy–environment system. Drawing on established research [30–33], this study adopts the classification criteria for coupling degree and coupling coordination degree, as outlined in Table 3.

Table 3. Criteria for classification of the coupling degree and the coupling coordination degree.

Criteria for Classification of the Coupling Degree		Criteria for Classification of the Coupling Coordination Degree	
C	**Coupling Level**	**D**	**Coupling Coordination Level**
[0.0~0.3)	Seriously low coupling development	[0.0~0.2)	Seriously unbalanced development
		[0.2~0.4)	Slightly unbalanced development
[0.3~0.5)	Low coupling development	[0.4~0.6)	Balanced development
[0.5~0.8)	High coupling development	[0.6~0.8)	Good balanced development
[0.8~1.0]	Superiorly high coupling development	[0.8~1.0]	Superiorly balanced development

2.3.3. Obstacle Degree Model

To identify factors impeding the sustainable development of the tourism–economy–environment system in NWHCs, we utilized the obstacle degree model, as outlined in the following equations [34]:

$$I_{ij} = 1 - x'_{ij} \quad (4)$$

$$O_j = F_j I_{ij} / \sum_{j=1}^{n} F_j I_{ij} \quad (5)$$

$$Q_j = \sum O_j \quad (6)$$

Here, x'_{ij} denotes the standardized value of indicator j in year i, I_{ij} reflects the deviation degree of indicator j, F_j represents the contribution degree of indicator j (expressed by its weight), O_j indicates the obstacle degree of indicator j, and Q_j signifies the obstacle degree of a subsystem.

3. Results and Discussion

3.1. Sustainability Index

As illustrated in Figures 3 and 4, the tourism sustainability index of NWHCs exhibited a consistent upward trend from 2000 to 2018, but it started to decline in 2019. Spatially, prior to 2015, the tourism sustainability index in western natural heritage cities lagged behind that of their central and eastern counterparts. By 2020, however, the disparity between the eastern and western regions had diminished significantly. Nonetheless, the average tourism sustainability index across the 34 cities declined sharply from 0.92 in 2019 to 0.59 in 2020, primarily due to the impact of COVID-19 (Figure 4). This highlights the vulnerability of the tourism subsystem in NWHCs to external shocks and emergencies.

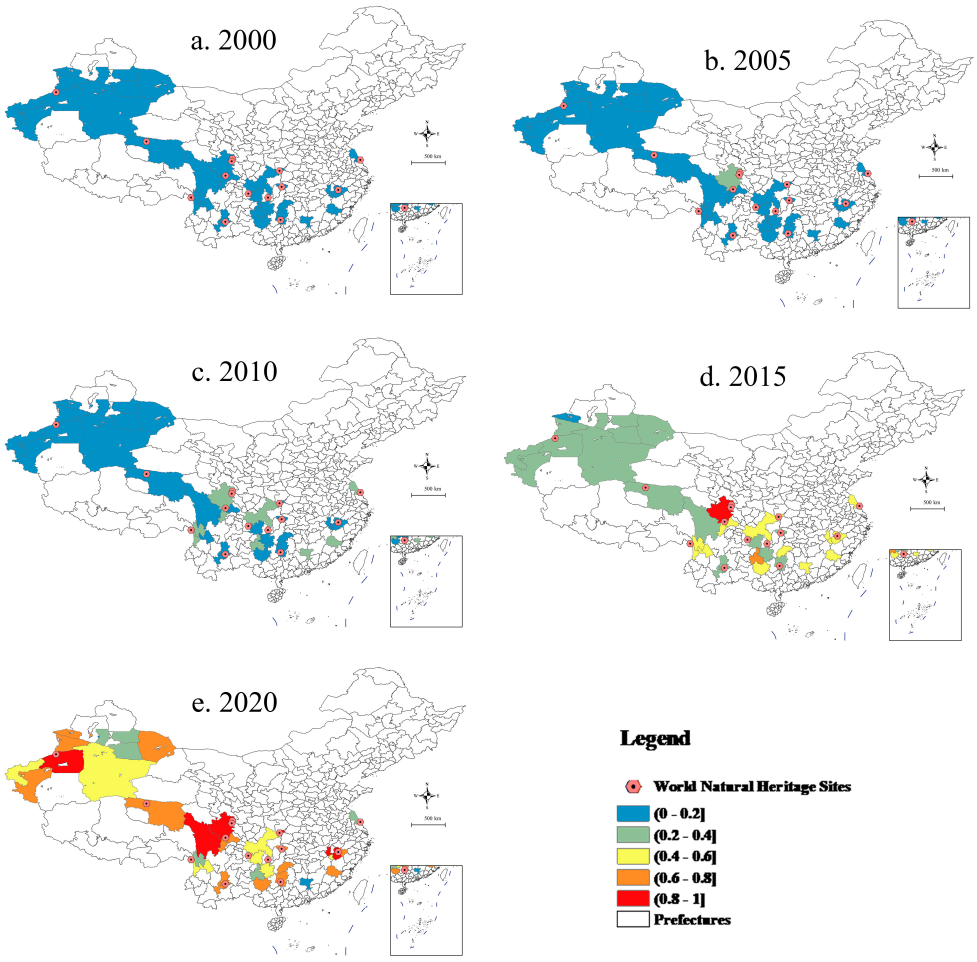

Figure 3. Tourism sustainability index of China's NWHCs from 2000 to 2020.

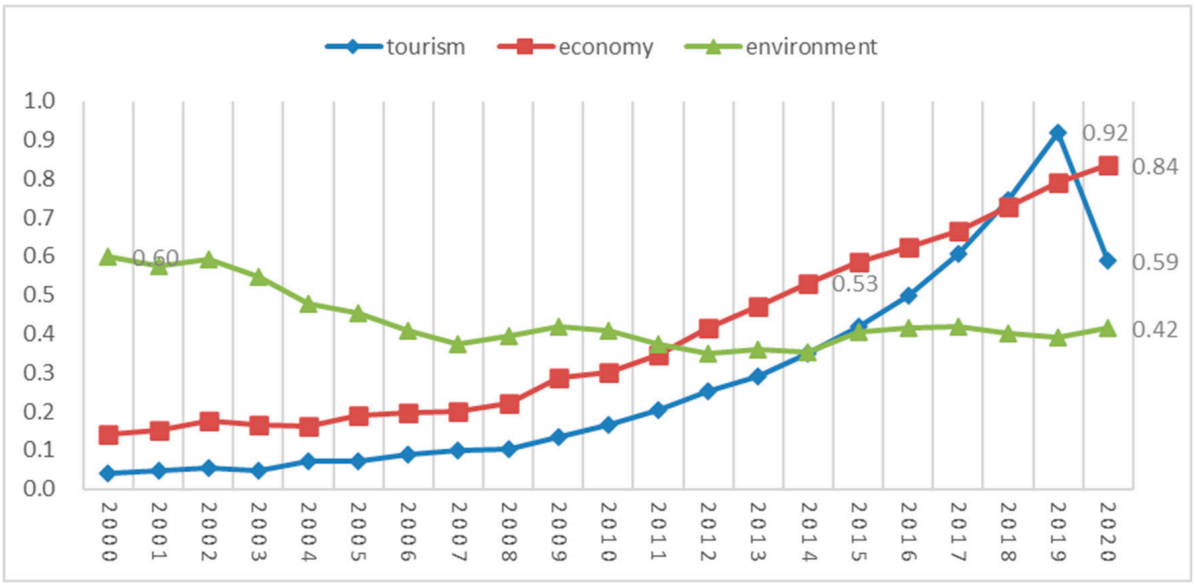

Figure 4. Average sustainability index of China's NWHCs from 2000 to 2020.

As shown in Figure 5, similar to the tourism subsystem, the economic sustainability index of China's NWHCs demonstrated a consistent upward trend from 2000 to 2020. Spatially, there were no significant disparities among the eastern, central, and western regions. However, the average economic sustainability index across all cities exceeded

0.5 by 2014 and rose to 0.84 by 2020, significantly higher than the average tourism sustainability index during the same period (Figure 4). Prior to 2018, the economic sustainability of NWHCs surpassed their tourism sustainability, although the upward trend suggests a potential reversal in the future. These findings indicate that, despite stringent restrictions on industrial development and construction in and around NWH sites, the economic subsystems of these cities have not been significantly adversely affected to date.

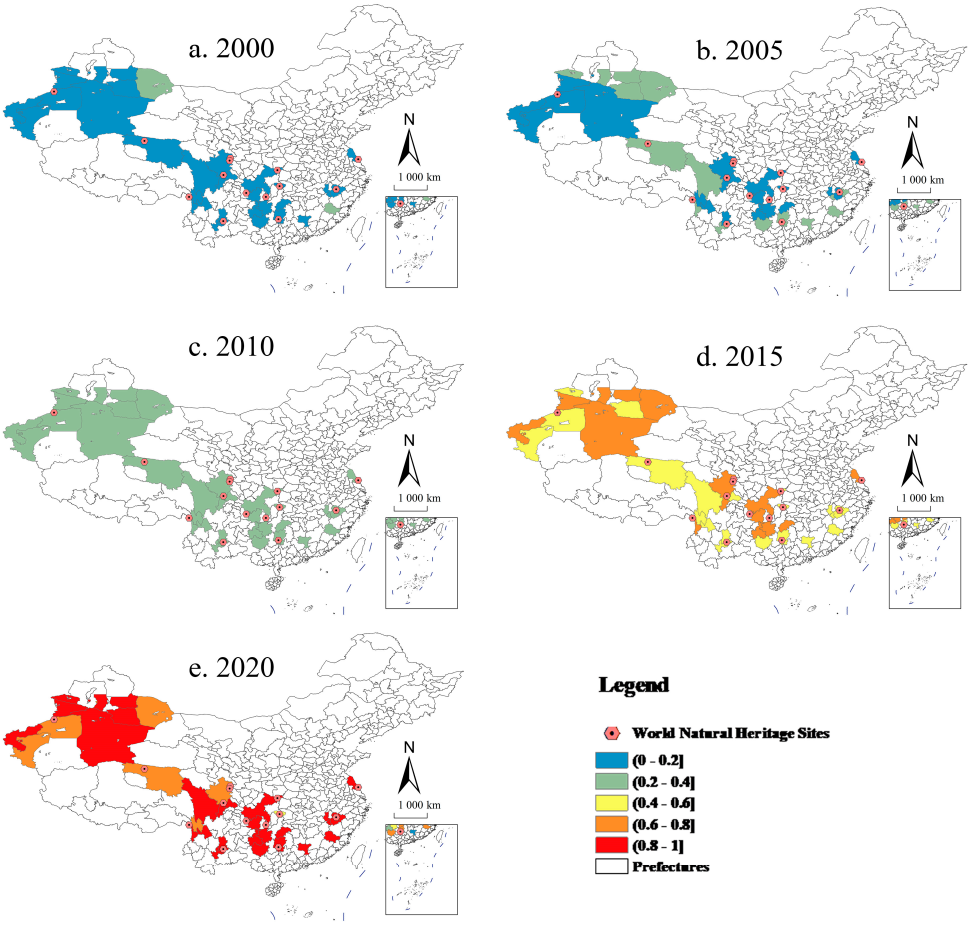

Figure 5. Economic sustainability index of China's NWHCs from 2000 to 2020.

As illustrated in Figure 6, the environmental sustainability index of the 34 NWHCs exhibited a general downward trend from 2000 to 2015, followed by a gradual recovery thereafter. This indicates that, unlike the steady improvement observed in tourism and economic development, the natural environment in these cities underwent a phase of deterioration before beginning to recover. This shift aligns closely with the Chinese government's introduction of the ecological civilization strategy in 2012 and the subsequent release of the Opinions on Accelerating the Construction of Ecological Civilization by the Central Committee of the Communist Party of China and the State Council in 2015. These findings underscore the high sensitivity of NWHCs to environmental policies. However, it is noteworthy that the declining trend in the environmental sustainability index has not yet reversed in the northwestern cities of Turpan, Aksu, and Bayin Guoleng.

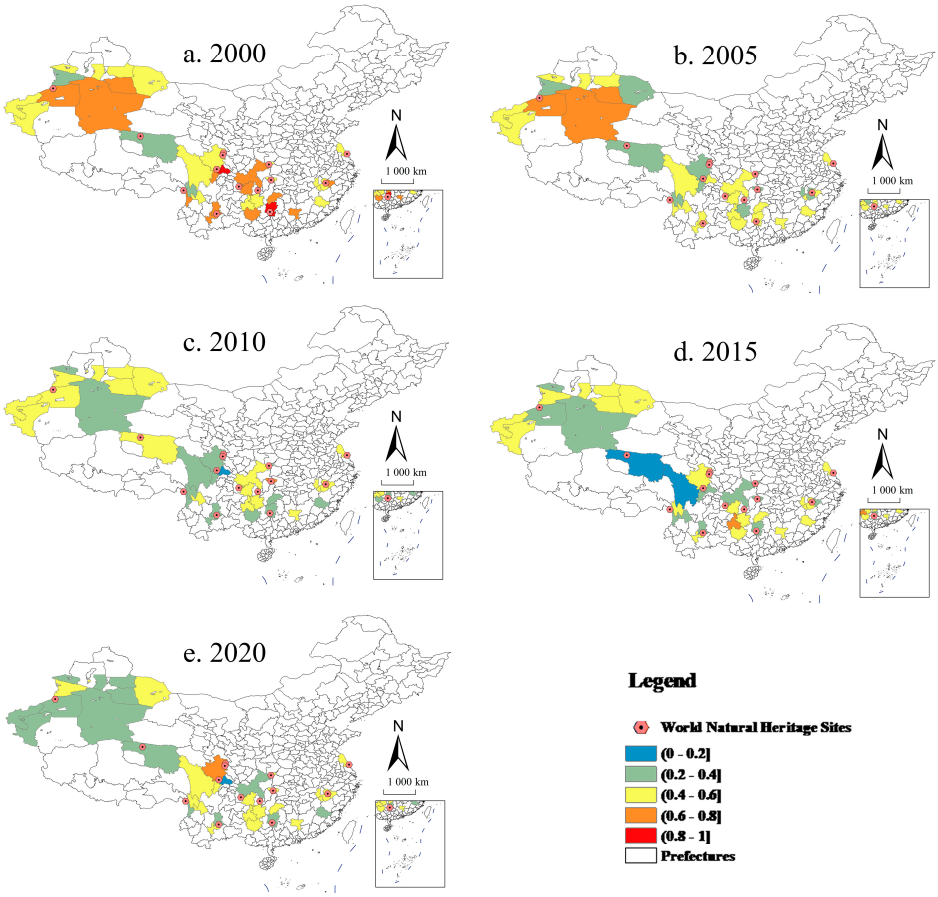

Figure 6. Environmental sustainability index of China's NWHCs from 2000 to 2020.

3.2. Coupling Degree

As shown in Figure 7a, the coupling degree between the tourism and economic subsystems remained consistently high from 2000 to 2020, indicating a strong interactive relationship between tourism development and economic growth. Figure 7b reveals that, except for the years 2000 (0.32) and 2001 (0.43), the coupling degree between the environmental subsystem and the economic subsystem consistently reached or exceeded the "High coupling development" level. This suggests that the interaction between the environmental subsystem and the economic subsystem has also been robust over the past two decades. The coupling degree between the tourism and environmental subsystems reached or surpassed the "High coupling development" level after 2005, while it remained at the "Low coupling development" level prior to 2005, even dropping to the "Seriously low coupling development" level in 2000 (Figure 7c). This implies that the interaction between tourism and the environment was limited before 2005 but became closely linked thereafter. This shift is likely attributable to the relatively low tourist numbers and small-scale tourism development in the early years, which had minimal environmental impacts. The comprehensive coupling degree among the three subsystems was at the "Seriously low coupling development" level from 2000 to 2001, improved to the "Low coupling development" level from 2002 to 2012, and reached the "High coupling development" level after 2013 (Figure 7d). This indicates that the interactive relationship among the three subsystems has only become tightly interconnected in the past decade.

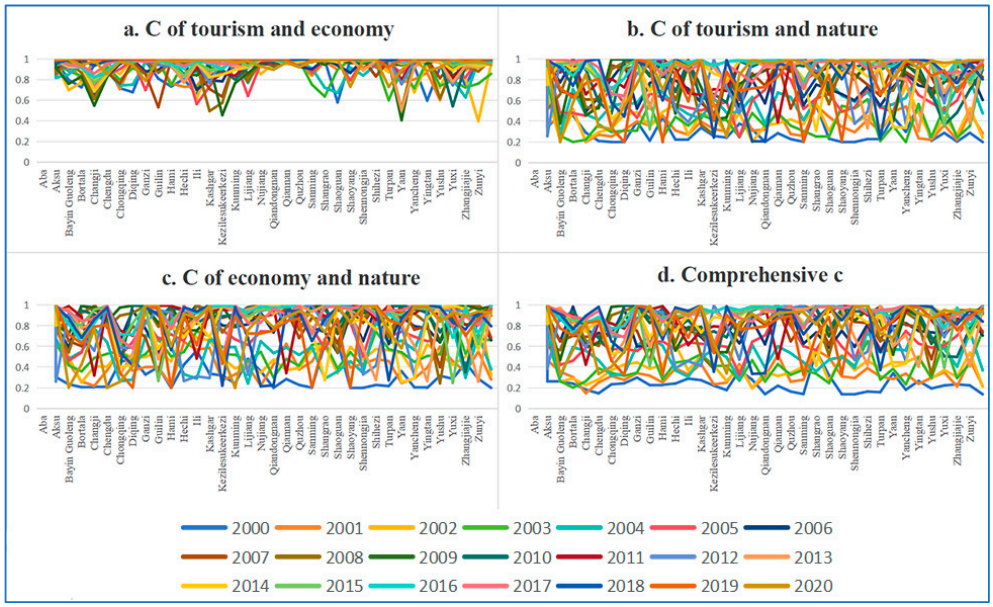

Figure 7. Coupling degree of China's NWHCs from 2000 to 2020. Note: C stands for coupling degree.

3.3. Coupling Coordination Degree

From 2000 to 2020, the coupling coordination degree between the tourism subsystem and the economic subsystem exhibited a consistent upward trend (Figures 8 and 9). By 2010, over 77% of the NWHCs had reached the "Balanced development" level, and by 2020, this figure had risen to 86%, achieving the "Superiorly balanced development" level. This demonstrates that the relationship between tourism and economic development in NWHCs was mutually reinforcing and beneficial during the 2010–2020 period. This is consistent with Wang's (2021) argument that WH promotes the development of local industries by boosting tourism [10]. However, prior to 2005, despite their strong interconnection, the relationship between the two subsystems was not well-coordinated.

From 2000 to 2010, the coupling coordination degree between the tourism subsystem and the environmental subsystem showed little change, with most cities fluctuating around the "Slightly unbalanced development" level (Figure 10). However, from 2015 to 2020, the coupling coordination degree in most cities exhibited an upward trend. This aligns with the earlier rise in the environmental sustainability index, indicating that the implementation of the ecological civilization strategy has also significantly promoted the coordinated development of the tourism and environmental subsystems. Nevertheless, attention should be paid to cities with fluctuating trends. For instance, in the northwest, cities such as Changji, Kezilesukeerkezi, Kashgar, Bortala, and Ili improved from "Slightly unbalanced development" to "Good balanced development" between 2005 and 2015, but Changji, Kezilesukeerkezi, and Aksu subsequently declined to their previous levels (Figure 10). A similar trend was observed in Chongqing in the central region. Additionally, cities like Chengdu and Yuxi exhibited fluctuating patterns. In contrast, most eastern cities, such as Sanming and Yancheng, demonstrated a consistent upward trend.

From 2000 to 2020, the coupling coordination degree between the environmental and economic subsystems generally exhibited an upward trend, although fluctuations were observed in certain regions, such as Chongqing, Ganzi, Kezilesukeerkezi, Aksu, Kashgar, and Shangrao (Figure 11). After 2005, most NWHCs achieved a coupling coordination degree at or above the "Balanced development" level. However, it is noteworthy that while Changji, Kezilesukeerkezi, Aksu, and Chengdu reached a level above "Good balanced development" in 2015, their coupling coordination degree declined to "Slightly unbal-

anced development" by 2020. This decline is likely associated with the decrease in the environmental sustainability index of these four cities.

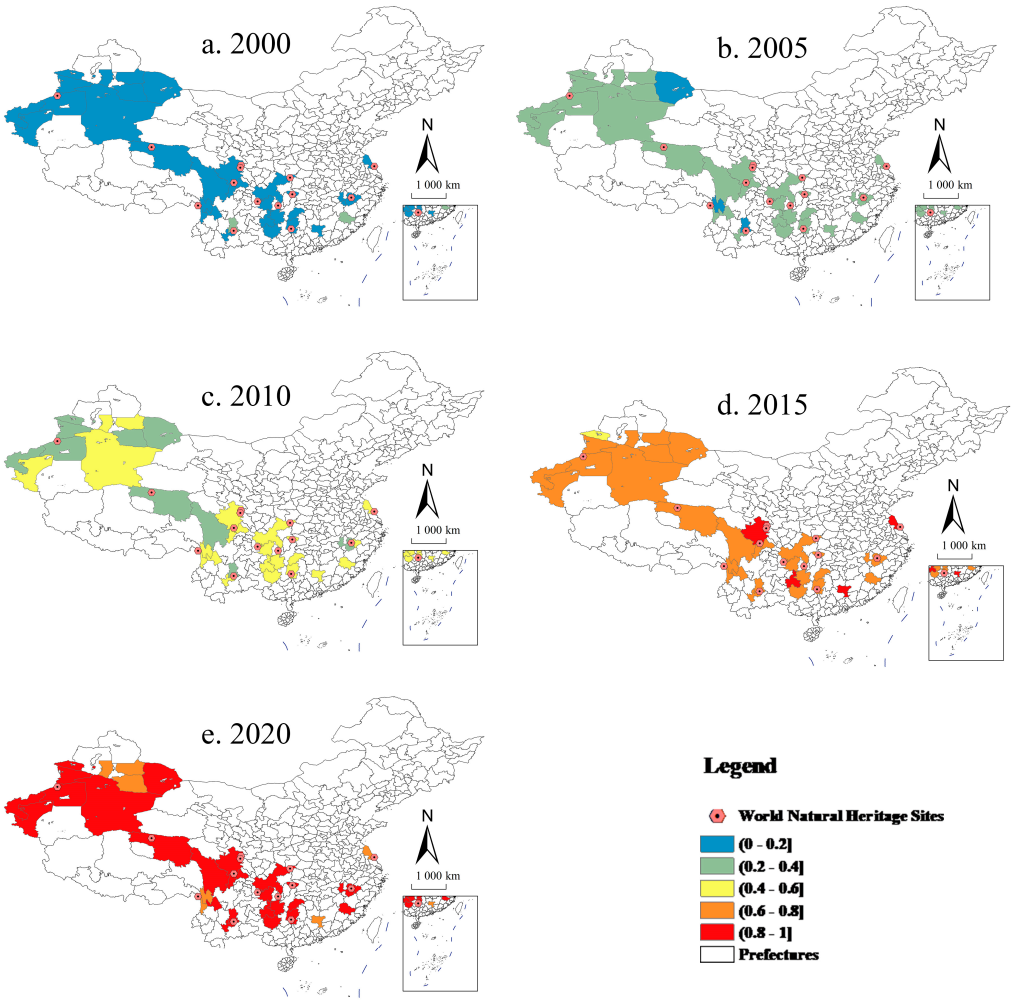

Figure 8. Coupling coordination degree of the tourism subsystem and economic subsystem.

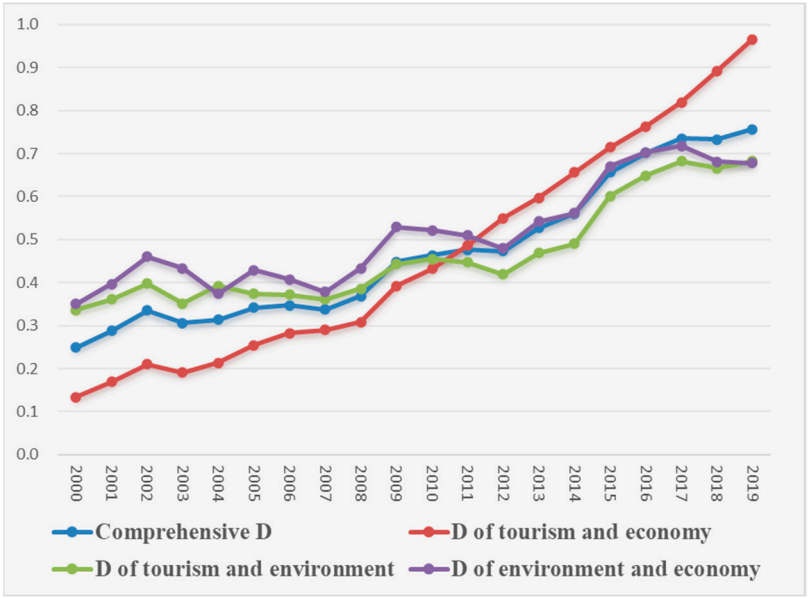

Figure 9. Average coupling coordination degree of China's NWHCs from 2000 to 2020.

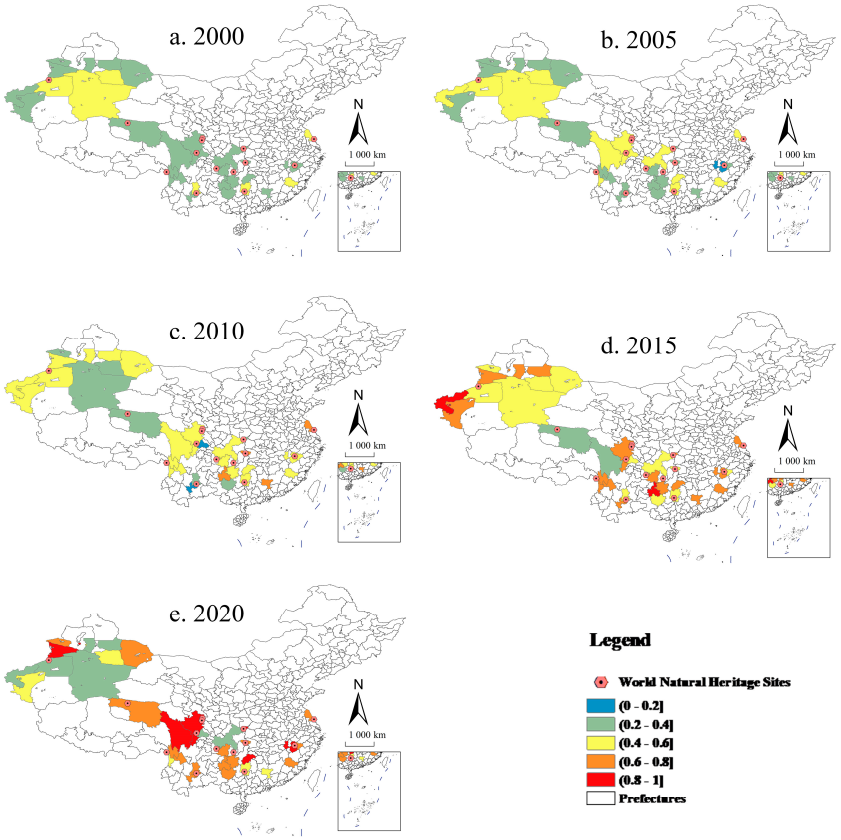

Figure 10. Coupling coordination degree between the tourism subsystem and the environmental subsystem.

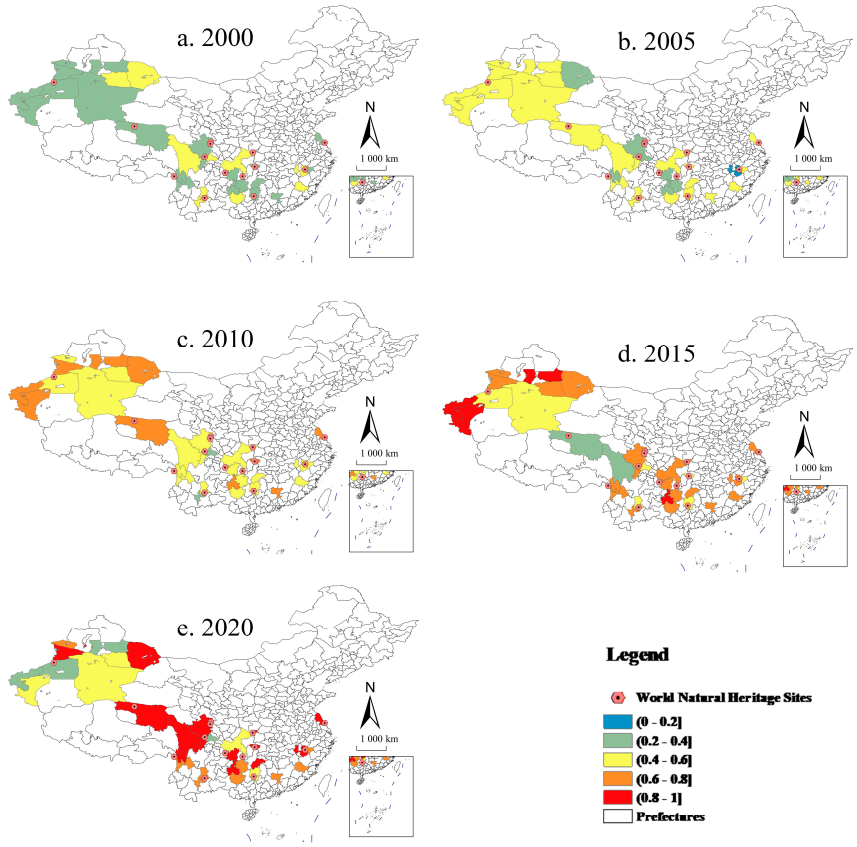

Figure 11. Coupling coordination degree between the environmental subsystem and the economic subsystem.

As illustrated in Figure 12, although the comprehensive coupling coordination level among the three subsystems exhibited an overall upward trend during the study period, it was not until after 2010 that most cities achieved coordinated development or higher levels. As indicated by the preceding analysis, frequent interactions and coordinated relationships among the three subsystems in the 34 heritage cities only reached relatively optimal levels within the past decade. Furthermore, fluctuating patterns in coupling coordination levels were observed in several cities. For example, Turpan rose to the "Balanced development" level in 2005 but dropped back to its original level by 2010 before subsequently rebounding. A similar fluctuation pattern was observed in Ganzi.

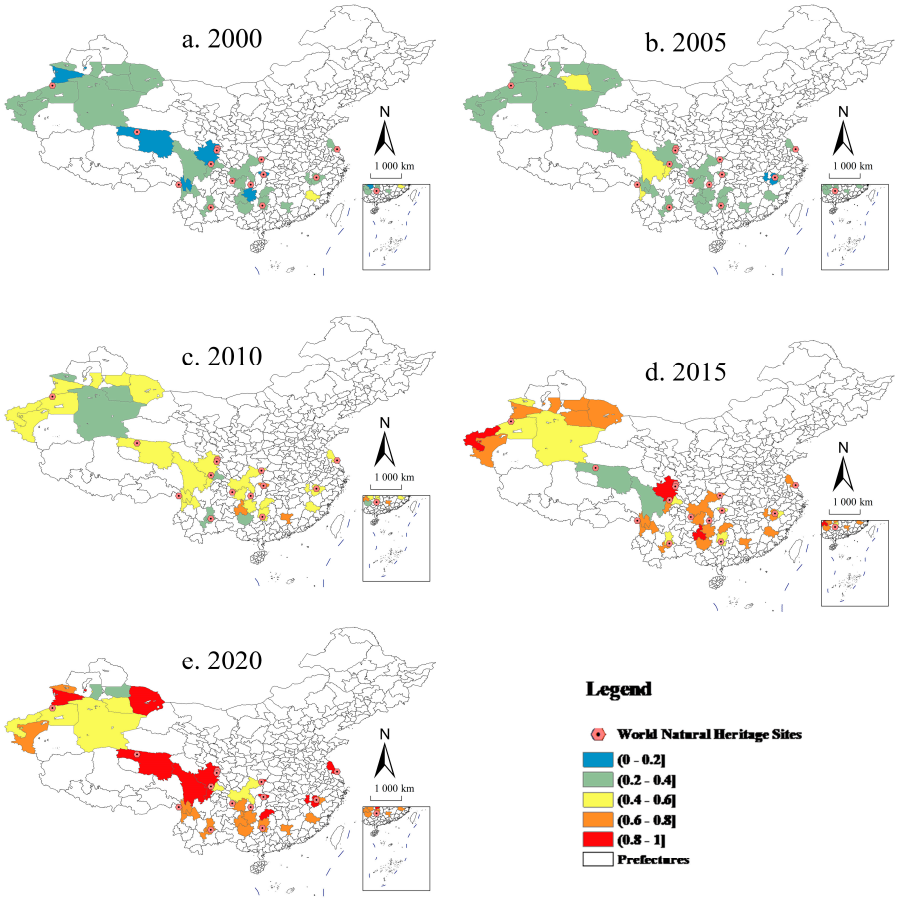

Figure 12. Comprehensive coupling coordination degree of tourism, economic, and environmental subsystems.

3.4. Obstacle Degree

To more precisely promote the coordinated development of NWHCs, we conducted an obstacle analysis of six cities whose 2020 coupling coordination degree still fell below "Balanced development". The top three obstacle indicators and their corresponding degree in the past five years are shown in Table 4. It is evident that Aksu, Bayin Guoleng, and Changji are mainly affected by both environmental and tourism factors, while Kezilesukeerkezi, Chengdu, and Chongqing are significantly impacted by environmental elements.

As previously analyzed, the tourism sustainability index for Changji and Bayin Guoleng significantly decreased from 2019 to 2020 due to the COVID-19 pandemic and a substantial drop in tourism revenue. This highlights the vulnerability of tourism development in these two cities, underscoring the need to enhance the resilience of their tourism systems. Specific measures can include increasing the diversity of tourism projects and adjusting the structure of tourism projects to enhance their appeal to local tourists.

Table 4. Top three indicators with respect to obstacle degree.

City	2016		2017		2018		2019		2020	
	Obstacle Indictors	**Obstacle Degree**	**Obstacle Indictors**	**Obstacle Degree**	**Obstacle Indictors**	**Obstacle Degree**	**Obstacle Indictors**	**Obstacle Degree**	**Obstacle Indictors**	**Obstacle Degree**
Aksu	C_2	0.1480	C_2	0.1559	C_2	0.1815	C_2	0.2700	C_2	0.2502
	A_4	0.0946	A_4	0.0969	C_8	0.1110	C_8	0.1555	C_8	0.1479
	A_2	0.0945	A_2	0.0967	A_2	0.0781	B_3	0.1136	C_5	0.1097
Bayin Guoleng	C_2	0.2383	C_2	0.2639	C_8	0.0553	C_2	0.4796	C_2	0.3005
	A_4	0.0913	A_4	0.0965	C_2	0.3137	C_5	0.1426	C_5	0.0905
	A_2	0.0844	A_2	0.0904	C_5	0.0968	C_8	0.0840	A_4	0.0862
Changji	A_4	0.1178	A_4	0.1145	C_2	0.0932	C_2	0.1952	A_4	0.1161
	A_2	0.1161	A_2	0.1136	A_4	0.0798	C_1	0.1201	A_2	0.1145
	C_2	0.1035	A_5	0.0904	A_2	0.0797	C_6	0.1187	C_2	0.0979
Chengdu	C_8	0.1612	C_4	0.0013	C_8	0.2211	C_8	0.2470	C_8	0.1876
	C_6	0.1264	A_6	0.0025	C_6	0.1746	C_6	0.2019	C_5	0.1565
	C_5	0.1104	B_4	0.0073	C_5	0.1632	C_5	0.1978	C_6	0.1505
Chongqing	C_2	0.1597	C_2	0.1834	C_2	0.2122	C_2	0.2566	C_2	0.1788
	C_8	0.1239	C_8	0.1411	C_8	0.1693	C_8	0.2089	C_8	0.1415
	A_4	0.0798	C_3	0.0726	C_3	0.0875	C_3	0.1130	A_1	0.0868
Kezilesukeerkezi	C_1	0.1386	C_8	0.1250	C_8	0.1308	C_3	0.1479	C_8	0.1306
	C_8	0.0999	A_3	0.1211	C_5	0.1284	C_8	0.13664	C_2	0.1157
	A_4	0.0892	C_2	0.0931	C_2	0.1140	C_2	0.1322	A_3	0.0993

The environmental sustainability index for Changji, Bayin Guoleng, Aksu, and Kezilesukeerkezi has shown a continuous decline since 2018, primarily driven by changes in indicators such as C_8, C_2, C_5, and C_3. For the future development of these four cities, it is essential to adopt low-carbon and green development models to mitigate negative environmental impacts. Additionally, as these cities are home to the Xinjiang Tianshan NWH site, promoting heritage ecotourism, expanding environmental education initiatives, and enhancing low-carbon tourism infrastructure will help reduce the environmental footprint of tourism activities. These measures will support the sustainable development of the environmental subsystem and improve its coordination with other subsystems.

Chengdu and Chongqing have seen a continuous decline in their environmental sustainability index over the past three years, mainly due to increased environmental impacts from human activities (e.g., C_2, C_8, C_3). Research by Alshawabkeh et al. (2023) indicates that urbanization processes affect natural heritage through population growth and infrastructure development [4]. Chengdu and Chongqing are both well-known metropolises in China. Urbanization not only brings challenges to environmental sustainability but also affects the protection of NWH sites. Therefore, in the future, big cities should pay more attention to coordination between heritage resource protection, socio-economic development, and environmental protection.

3.5. Implications

3.5.1. Theoretical Implications

NWH sites face dual pressures from both climate change impacts and anthropogenic activities, including tourism, agriculture, and livestock farming [3,35]. In light of these global challenges, state parties and relevant organizations have intensified conservation research efforts to better reconcile heritage preservation with regional development. However, significant research gaps remain in terms of understanding the relationship between NWH sites and sustainable urban development, particularly when compared to the extensive studies conducted on cultural WH sites [36]. Current management practices for NWH sites frequently fail to adequately integrate heritage conservation with urban planning and socio-economic development strategies [37,38].

It is crucial to recognize that the local environment serves not merely as a passive backdrop for heritage sites, but rather as an integral component of heritage itself, contributing substantially to biodiversity conservation through various mechanisms [39]. However, the reliance on protected areas alone has proven insufficient for comprehensive biodiversity conservation. Consequently, the concept of heritage sustainability must evolve beyond the narrow focus on site preservation to encompass its broader role in fostering sustainable development within local communities [13]. This expanded perspective necessitates a more holistic approach that considers the complex interplay between ecological preservation, urban development, and heritage conservation.

The sustainable development of protected areas and regions depends not only on the sustainable levels of their subsystems but also on the balance between them [11,33]. The impact of the COVID-19 pandemic has further highlighted the complex interactions among the three core sustainability principles: ecological integrity, social relevance, and financial viability [40]. While the NWH title promotes tourism prosperity in local cities, it does not necessarily contribute to their sustainable development. In this study, the sustainability of the tourism and economic subsystems has continuously increased, and their development is coordinated. However, the sustainability of the environmental subsystem has shown a declining trend, with some cities experiencing uncoordinated development between the environment and either the tourism or economic subsystems. If left unaddressed, more cities may face developmental imbalances or worsen existing ones, thereby affecting the sustainable development of NWHCs. This undermines one of the key objectives of WH conservation and management: leveraging their potential to drive regional sustainable development. Therefore, future research on the sustainable development of NWHCs should continue to focus on the interrelationships among tourism, the economy, and the environment rather than concentrating on any single aspect alone.

Financial constraints are a prevalent issue facing many NWH sites globally [19,41]. Compounding this challenge, evidence suggests a trend of declining governmental support for protected areas in various regions [42]. In some developing countries, the perception that WH status impedes economic growth has resulted in inadequate conservation efforts [10]. Addressing this challenge requires a balanced approach that integrates heritage conservation with socio-economic development and environmental protection. Such an approach is essential, as conservation initiatives are more likely to gain local support when they contribute to community well-being, foster socio-economic progress, and promote environmental sustainability. This ensures that NWH sites become resources for regional economic growth rather than liabilities [2].

Tourism development serves as a critical link between NWH sites and local urban areas, acting as a catalyst for economic growth and cultural ecosystem services [9]. In China, the tourism boom generated by heritage designation has been instrumental in garnering widespread governmental and public support for NWH conservation. For many nations, particularly developing and underdeveloped countries, tourism revenue is a vital funding source for NWH preservation [19,41]. This highlights the need for comprehensive research into the interrelationship between tourism development, local economies, and environmental impacts. Such research should aim to establish sustainable tourism models that support the long-term development of both heritage sites and their adjacent urban areas, making NWH integral to resilient and sustainable urban communities [36].

The environmental sustainability challenges observed in cities such as Changji, Bayin Guoleng, Aksu, and Kezilesukeerkezi highlight a critical need for enhanced environmental monitoring in remote NWH sites and their adjacent areas. Unlike cultural WH sites, NWH sites are frequently situated in remote or expansive regions, which complicates the effective monitoring of tourism and other economic activities [26]. Although environmental

monitoring within the heritage sites themselves is generally robust, the surrounding areas often suffer from insufficient oversight. This neglect can lead to delayed detection of habitat loss and biodiversity decline, potentially resulting in severe ecological consequences. The experiences of cities like Chengdu and Chongqing illustrate the detrimental effects of urbanization on the environmental baseline—encompassing air, water, soil, and light quality—essential for NWH conservation.

3.5.2. Practical Implications

From 2000 to 2020, the tourism and economic sustainability indices exhibited a consistent upward trajectory, while the environmental sustainability index experienced a decline, contributing to imbalanced development in certain cities. Notably, the environmental sustainability index has shown signs of recovery following the implementation of China's ecological civilization construction strategy. However, four NWHCs—Changji, Kezilesukeerkezi, Aksu, and Chengdu—continue to face declining environmental sustainability, resulting in a slight imbalance in the coupling coordination between their environmental subsystems and the economic and tourism subsystems. To achieve better coordinated development in China's NWHCs, environmental sustainability must remain a central focus of management efforts. Addressing environmental challenges is critical to ensuring the long-term balance and synergy among the economic, tourism, and environmental subsystems. Strengthening environmental protection measures, enhancing monitoring systems, and promoting sustainable practices will be essential to mitigate the adverse impacts of economic and tourism growth on the ecological integrity of these heritage cities. By prioritizing environmental sustainability, policymakers and stakeholders can foster a more harmonious and sustainable development model for NWHCs, aligning with the broader goals of ecological civilization and regional sustainability.

As noted earlier, China implements stringent regulations on industrial development within and around NWH sites. However, the vast spatial scale of these heritage areas often results in insufficient enforcement of management practices, particularly in regulating tourism-related activities such as accommodation, dining, and entertainment. This challenge is prevalent in NWH sites due to their remote locations and expansive territories [43]. In heritage cities, especially within NWH sites, the preservation of outstanding universal value requires restrictions on intensive development in and around these areas [44]. Consequently, environmentally detrimental urban functions, such as waste management and industrial activities, are frequently displaced to other parts of the city. This displacement, combined with pressures from climate change and human activities (e.g., tourism, local livelihood activities), underscores the urgent need for enhanced environmental monitoring in remote and peripheral areas. Furthermore, city managers must prioritize the selection of industries that minimize the environmental impact of economic development [45].

Research demonstrates that effective ecological and environmental protection can drive local economic growth [10]. Looking ahead, greater emphasis should be placed on improving the efficiency of ecological and environmental protection, extending efforts beyond the heritage sites and their immediate surroundings. This includes prohibiting the planning of projects that fail to meet environmental impact assessment standards and halting the development of non-compliant initiatives. Such measures are essential to ensure sustainable development and mitigate the adverse effects of urban expansion and tourism on both heritage sites and broader urban ecosystems.

Heritage conservation cannot rely solely on top-down interventions by governments and global heritage organizations or the expertise of heritage professionals. Instead, it must actively involve local communities and other stakeholders [2]. Studies have demonstrated that the conservation of natural heritage is most effective when achieved through

a combination of proactive measures taken by governments, businesses, and indigenous peoples [12]. However, indigenous communities often receive insufficient attention as key contributors to the conservation and sustainable development of natural heritage [45]. In China, the public property rights attribute of natural heritage necessitates government-led protection. Moreover, the presence of numerous community residents within and around heritage sites highlights their close relationship with these areas. Positive interactions between heritage sites and local communities can significantly enhance natural heritage protection. It is therefore crucial to respect, understand, and integrate communities into heritage planning and management, establish mechanisms for compensating local communities, and optimize the relationship between communities and heritage sites to promote both heritage protection and regional sustainable development.

On the other hand, tourism's heavy reliance on a healthy ecological environment necessitates vigilance regarding its potential negative impacts on the broader urban ecosystem. According to the IUCN World Heritage Outlook 3, tourism is among the top current threats assessed as high or very high in 2020 for both Asia and Europe, while its impact is relatively less significant in regions such as Africa, the Americas, and Oceania [35]. This regional disparity highlights the varying degrees of pressure tourism exerts on NWH sites across different continents, underscoring the need for context-specific management strategies. The Second Cycle Report of the World Heritage Asia-Pacific Region further emphasizes that the primary factors affecting the sustainable development of NWH sites in China are tourism (90%), transportation (70%), and service facility construction (40%). While UNESCO's initial goal was to identify and protect sites of outstanding universal value, its designation is often leveraged as a marketing tool to attract tourists [46]. Given that tourism remains a primary means of fostering human–nature relationships and securing economic support for many NWH sites, particularly in Asia and Europe, pursuing low-impact tourism methods and advancing innovative management techniques remain critical directions for future efforts.

Furthermore, a threat to an NWH site rarely occurs in isolation [47]. Research by Falk and Hagsten (2024), based on the UNESCO State of Conservation database, reveals that threats related to transport infrastructure and tourism are often interconnected and bundled together [26]. Moreover, the pressure from tourism and visitation has persisted over time, even during the COVID-19 pandemic period (2020–2023), while most other threats experienced a noticeable decline during the same period. This underscores the enduring and complex nature of tourism-related challenges, which require sustained attention and innovative management strategies to ensure the long-term conservation of NWH sites. Addressing these challenges will involve not only regulating tourism activities but also integrating sustainable transportation solutions and community-based conservation initiatives to create a more balanced and resilient approach to heritage management.

To address these challenges, it is essential to promote sustainable tourism practices, such as ecotourism initiatives, low-carbon transportation systems, and green infrastructure. Simultaneously, enhancing environmental awareness among visitors, managers, and local residents is critical to mitigating the adverse environmental effects of tourism development. These measures will help ensure that tourism contributes positively to both heritage conservation and the sustainable development of urban areas.

4. Conclusions

The findings of this study reveal a consistent annual improvement in the sustainability of tourism and economic subsystems within China's NWHCs, accompanied by a steady upward trend in their coupling coordination degree. Currently, 80% of these NWHCs have achieved "Superiorly balanced development" in the coordination between tourism and the economy, while the remaining cities are classified at a "Good balanced development" level.

This indicates that the stringent restrictions on industrial development and construction within and around NWH sites have not significantly hindered the economic subsystems of these cities. Notably, the strong alignment between tourism and economic subsystems underscores the positive synergy between the tourism boom driven by NWH designation and the economic development of these cities.

However, the sustainability of the environmental subsystem has exhibited a declining trend, with only partial recovery observed following the implementation of China's ecological civilization construction strategy. This demonstrates the responsiveness of NWHCs to environmentally focused macro-policies. Despite this progress, the environmental sustainability of certain cities—such as Changji, Kezilesukeerkezi, Aksu, and Chengdu—continues to decline, resulting in a lack of coordination between environmental and economic development, as well as among the three subsystems. Consequently, environmental protection remains the most pressing challenge for the sustainable development of NWHCs.

In light of these findings, city managers are strongly justified in actively supporting the nomination, protection, and utilization of NWH sites. However, it is imperative to integrate these efforts with robust local environmental protection initiatives to mitigate the adverse impacts of tourism and economic growth. This integrated approach is essential to ensure the long-term sustainability of both heritage conservation and urban development. Future research should further explore the mechanisms underlying the coordination among these subsystems and evaluate the effectiveness of policy interventions aimed at enhancing environmental sustainability in NWHCs.

Currently, both international and domestic development agendas, such as the 2030 Agenda for Sustainable Development and China's 13th and 14th Five-Year Plans, increasingly highlight the role of heritage activation in fostering socio-economic sustainable development. The findings of this study demonstrate that, overall, the tourism boom driven by NWH sites positively interacts with local economic development and environmental protection. Actively promoting the utilization of heritage resources can significantly contribute to the creation of sustainable cities. However, achieving a balance between natural conservation and socio-economic development remains a critical challenge in the management of NWHCs. Addressing this challenge requires integrated strategies that align heritage conservation with broader sustainable development goals, ensuring that economic and environmental priorities are harmonized for long-term resilience.

This study has several limitations that warrant acknowledgment. First, while it examines the overall coordination among tourism, the economy, and the environment in NWHCs, it does not sufficiently account for the unique characteristics of individual cities or heritage sites, such as the size of the heritage area, spatial location, and transportation conditions. These factors are likely to play a significant role in shaping the dynamics of sustainable development but were not explored in detail. Future research should address this gap by conducting in-depth case studies on specific heritage sites or cities. Such an approach would yield a more nuanced understanding of the interplay between heritage tourism, regional economic development, and environmental protection, thereby providing tailored insights for policymakers and heritage managers to design more effective and context-specific strategies.

Additionally, the study's reliance on aggregated data may obscure localized variations and challenges, which could be critical for understanding the diverse realities of NWHCs. By incorporating qualitative methods and site-specific analyses, future research could further enrich the findings and enhance their practical applicability. Addressing these limitations would not only advance academic understanding but also contribute to more targeted and impactful conservation and development policies.

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