sustainability

MDPI

Article

Exploring the Relationships between Tradeoffs and Synergies among Island Ecosystem Service Bundles: A Study on Zhoushan Archipelago Located on the Southeast Coast of China

Yang Xiao [1,2,3], Huan Zhang [4,5,*], Ke Ma [4], Hadinnapola Appuhamilage Chintha Crishanthi Perera [6], Muhammad Zahir Ramli [7] and Yuncheng Deng [8,9,*]

1 Island and Coastal Zone Institute, Urban and Rural Innovation Design Research Center, Zhejiang University, Hangzhou 310058, China; yangxiao84@hotmail.com
2 Academician Workstation of Zhai Mingguo, University of Sanya, Sanya 572022, China
3 Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu 610041, China
4 College of Civil Engineering and Architecture, Zhejiang University, Hangzhou 310058, China; 22312111@zju.edu.cn
5 Center for Balance Architecture, Zhejiang University, Hangzhou 310058, China
6 Department of Zoology and Environmental Management, Faculty of Science, University of Kelaniya, Kelaniya 11600, Sri Lanka; chinthap@kln.ac.lk
7 Institute of Oceanography and Maritime Studies, Kuliyyah of Science, International Islamic University Malaysia, Kuantan 25200, Malaysia; mzbr@iium.edu.my
8 Island Research Center, Ministry of Natural Resources, Pingtan 350400, China
9 Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai), Zhuhai 519082, China
* Correspondence: 0014979@zju.edu.cn (H.Z.); dengyuncheng2006@163.com (Y.D.)

Abstract: Due to the rapid rise of China's coastal economic zone, the urbanization of the surrounding islands has accelerated. Intensive disturbance caused by human activities and frequent changes in land types have resulted in the continuous erosion of ecological sources and the degradation of ecosystem services on the islands year by year. It is particularly important to explore sustainable development strategies for the islands to achieve a balance between conservation and development, which is particularly important for the islands in the process of urbanization. Taking Zhoushan Archipelago as an example, this paper uses multi-source spatial data and employs InVEST models and USLE to quantify island ecosystem services. Furthermore, using principal component analysis and cluster analysis, the study aims to identify clusters of island ecosystem services and investigate their tradeoffs, synergistic mechanisms, and regional heterogeneity using spatial analysis. In addition to providing island urban planners with effective zoning governance recommendations and assistance in spatial planning to promote coordinated and sustainable development, the findings of this study can assist in the development of appropriate management plans for each ecological functional service cluster on islands.

Keywords: islands; urbanization; ecosystem services bundles; tradeoffs; synergies

Citation: Xiao, Y.; Zhang, H.; Ma, K.; Perera, H.A.C.C.; Ramli, M.Z.; Deng, Y. Exploring the Relationships between Tradeoffs and Synergies among Island Ecosystem Service Bundles: A Study on Zhoushan Archipelago Located on the Southeast Coast of China. *Sustainability* **2024**, *16*, 394. https://doi.org/10.3390/su16010394

Academic Editor: Irene Petrosillo

Received: 17 October 2023
Revised: 21 November 2023
Accepted: 11 December 2023
Published: 2 January 2024

1. Introduction

Ecosystem services refer to the direct or indirect benefits that ecosystems provide to human wellbeing [1–5]. With growing recognition and evidence that the concept of ecology and environment is a valuable tool for guiding landscape planning and decision making, governments and NGOs around the world are now using ecological approaches to address sustainability challenges [6,7]. Due to the significance of ecosystem services in promoting sustainable development, there has been rapid growth in the research on ecosystem service provision in recent years. Studies have indicated that at least two-thirds of ecosystem services globally are presently diminishing, and this trend is expected to intensify in the upcoming decades [6]. The increase in certain ecosystem services may lead to a decrease in other services that are equally important to human interests, in particular the provision of services and the regulation of services. Studies conducted at the local level have demonstrated that many ecosystem services, including water regulation, carbon storage, and soil erosion control, are experiencing a decline both temporally and spatially [8–10]. As a result, there is a growing need for accessible and user-friendly information that can aid in comprehending the mechanisms driving changes in ecosystem services, and support informed and sustainable decision making.

Land use and cover are crucial factors for providing ecosystem services [11–16], as their capacity is directly related to the types and spatial arrangement of ecosystems. For this reason, the Law of the People's Republic of China on the Protection of Offshore Islands, one of China's basic laws, clearly stipulates the strengthening of the protection of ecosystems [8,17]. Land-use changes affecting biophysical and biochemical processes significantly affect a wide range of ecosystem services on a global scale. Changes in ecosystem services are often driven by alterations in land use, making land-use change a significant factor to consider. Developing a better understanding of how land-use changes impact the delivery of ecosystem services is essential for promoting sustainable ecosystem management [18–21]. However, the root cause of changes in land use must be examined. Many studies have explored the impact of land-use change on ecosystem services, linking observed changes to factors like heightened human activity, urban expansion, agricultural and mining practices, and climate change [22–30]. But few studies have analyzed the real drivers of land-use change, especially in most cases where the drivers are location-specific. As a result, identifying these drivers becomes more complex, but it is important for decision making and management optimization.

Ecological 'tradeoffs' occur when the increased use of one ecosystem service leads to a reduction in the supply of another, while 'synergy' describes situations where the simultaneous enhancement or reduction in two or more ecosystem services occurs [31,32]. The interaction between various types of ecosystem services has different interest needs at different space and time scales, and almost all decisions on ecosystem services involve tradeoffs of interests; the tradeoff synergy is common among ecosystem services on a global scale, while showing obvious geographical differences and dynamic changes [31,33,34]. In recent times, the research of ecosystem services and their interrelationships has emerged as a multidisciplinary frontier, spanning geography, ecology, and ecological economics. At present, the relevant theories of geography and ecology are mainly used to conduct qualitative analysis of the tradeoffs and synergies of ecosystem services. There have been few studies quantifying the benefits of ecosystem services [35]. Studies at a single point in time cannot reflect the dynamics of relationships between ecosystem services, so more and more studies are beginning to focus on how relationships between ecosystem services change over time. Researching the tradeoffs and synergies of ecosystem services, along with their underlying drivers, can enhance our understanding of the distinctive features of different ecosystem services and contribute to a more comprehensive understanding of them.

Zhoushan Archipelago is the gateway to East China and is located in Zhejiang Province, facing the Pacific Ocean, bordered by Shanghai, Hangzhou, and Ningbo [36]. In the context of rapid urbanization, it is bound to affect the ecosystem health of Zhoushan Archipelago in the face of a sharp increase in construction land, an accelerated non-agricultural transformation of cultivated land, a rapid decrease in tidal flats and wetlands, and an increasingly deteriorating environment [4,37]. Islands present special challenges in terms of sustainable development, and this has been addressed through a range of qualitative and quantitative approaches [38–41].

While the traditional planning strategy of the Zhoushan Archipelago is oriented toward industrial development, it does not adequately consider the ecological perspective or does not take the ecological factors into account in a comprehensive manner. As an adjunct to the existing planning system, land-use analysis from the perspective of ecosystem services can be used to analyze land uses among islands. Zhoushan Archipelago is a typical example of an archipelago on the southeast coast of China [42], with scarce land resources, a diverse land-use pattern, and significant conflicts between industrial development and ecosystems. We analyzed the tradeoffs and synergies among various ecosystem service bundles in the Zhoushan Archipelago and suggested targeted suggestions and strategies for land-use planning for these bundles. In addition to the fact that archipelagos are collections of islands with distinct characteristics, their management is even more challenging, involving the negotiation of often-divergent needs and potentials across marine and terrestrial environments. This paper proposes a corresponding management plan for each ecological function service cluster of the islands, which can provide effective zoning governance suggestions for island city planners, as well as assisting in spatial planning, promoting the coordinated sustainable development of each zone, and minimizing tradeoffs between them. The specific objectives of the study include the following: (1) quantify island ecosystem services; (2) conduct ecological function zoning; (3) clarify the mechanisms of action and regional differences in tradeoffs and synergies.

2. Materials and Methods

2.1. Study Area

Zhoushan Archipelago, located in the southeast coast of China, is in the northern part of Zhejiang Province in the East China Sea. It is situated north of the outer edge of the Yangtze River estuary, west of Hangzhou Bay, connected to the Lishan Islands, which open up the Yangtze River Delta and the Yangtze River basin open to the outside world, the sea gateway [43]. Zhoushan Archipelago is the largest archipelago in China, covering a total area of 22,200 km^2, which includes 1400 km^2 land area and 20,800 km^2 sea area. Its natural geomorphology mainly consists of mountains, plains, and coastal mudflats and wetlands, and the islands show a distribution trend of 'large islands near shore and small islands discrete' [5]. There are many islands in Zhoushan Archipelago; among them, the larger ones are Zhoushan Island, Daishan Island, and Jintang Island. Zhoushan City (prefecture level), which is established as an Archipelago, consists of four administrative districts, namely Daishan County, Putuo District, Dinghai District, and Shengsi County (Figure 1).

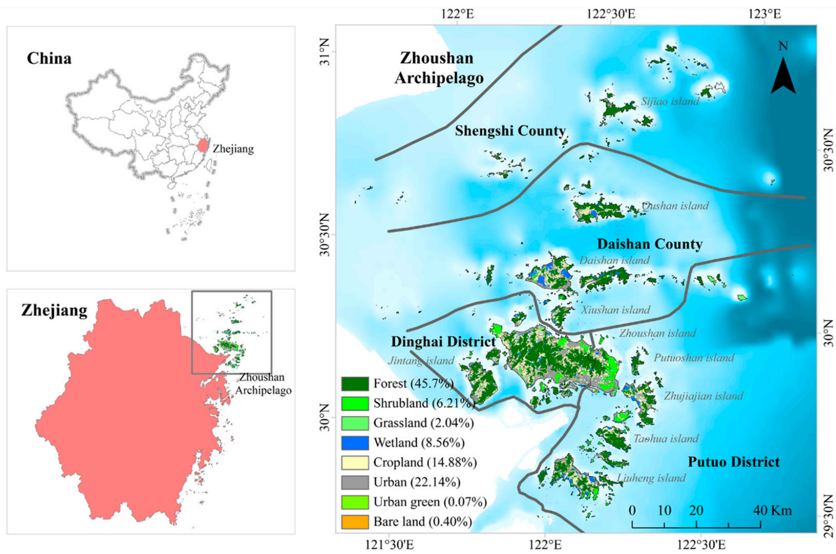


Figure 1. Distribution of landscape types in Zhoushan Archipelago.

Zhoushan Archipelago has a subtropical marine monsoon climate, with a warm and humid climate. The archipelago experiences an annual temperature between 15.8 °C and 16.7 °C on average, with an average of 2025 to 2262 h of sunshine per year. The islands receive an average annual precipitation of 1356.3 mm and have a frost-free period lasting from 254 to 293 days each year. The region's favorable climate creates an environment that is favorable for the growth and development of a diverse range of biological communities.

The region is dominated by hilly terrain, with the topography sloping from southwest to northeast, with many large islands in the southwest and small islands in the northeast. The vegetation types of the island mainly include coniferous forest, mixed coniferous and broad coniferous forest, broad-leaved forest, bamboo forest, scrub, and sandy and saline plant communities [44]. Soil types mainly include red soil, coarse bone soil, stony soil, and sandy soil, among which coarse bone soil accounts for more than half of the area of hilly mountains; followed by red soil, accounting for 35.1%, which is mostly distributed in the foothills and is the main soil for the distribution of forest vegetation [4].

Over the last few decades, the Zhoushan Archipelago has undergone rapid urbanization, establishing itself as a key center for politics, economics, and culture. This growth, driven by an expanding population and economy, is largely attributed to the development of port services, tourism, and the marine product industry. However, this accelerated progress has resulted in considerable changes in land use and cover, placing significant pressure on the area's fragile ecosystems and limited land resources [45,46].

2.2. Ecosystem Services Indicators

The study aimed to investigate the features of the primary ecosystem services in Zhoushan Archipelago in 2020 by evaluating 6 ecosystem services in total, comprising 1 provisioning service, 2 cultural services, and 3 regulating services. The ecosystem services examined in this research were selected by their significance to the area, the requirement to encompass all three categories of ecosystem services (provisioning, regulating, and cultural), and the accessibility of pertinent data (as depicted in Table 1).

Table 1. List of selected ecosystem services with their potential indicators and data source.

Services	Indicators	Indicator Description	Data Name	Resolution	Source
Provisioning	Crop production	Yield of essential crops can be calculated by weighting the total output of grain crops and vegetables to cropland according to the NDVI, t/hm^2 [47]	Land use	30 m	RESDC [a]
			Field measurements	Points	Ground surveys
			Statistical data	/	BZS [b]
			NDVI	30 m	RESDC [a]
Cultural	Tourism Scenery	Landscape (fruits, vegetables, ocean, etc.) scores that take into account the visibility, accessibility, and tourists' evaluation of attractions, 0–100	DEM	30 m	SRTM [c]
			Survey data	Points	Questionnaire
			Road	Lines	OSM [d]
			Points of interest	Points	Amap [e]
	Tourism Culture	Buddhist culture that takes into account the web ratings, 0–100	Survey data	Points	Questionnaire
			Web ratings	Points	Baidu [f]
Regulating	Water retention	Annual water yield, m^3/hm^2	Land use	30 m	RESDC [a]
			Precipitation	Points	CMA [g]
			Surface runoff	Points	Ground surveys
			Evapotranspiration	Points	CMA [g]
	Carbon sequestration	Net Ecosystem Productivity (NEP), gC/m^2	Land use	30 m	RESDC [a]
			NPP		GRSENP [h]
			Soil data	1000 m	LAIRG [i]
	Soil erosion control	Soil erosion reduction, t/hm^2	Land use	30 m	RESDC [a]
			Precipitation	Points	CMA [g]
			DEM	30 m	SRTM [c]
			Soil data	1000 m	LAIRG [i]
			NDVI	30 m	RESDC [a]

Note: [a] Resource and Environmental Science and Data Center (RESDC, https://www.resdc.cn/, accessed on 17 November 2023), [b] Bureau of Zhoushan Statistics (BZS, http://xxgk.zhoushan.gov.cn/, accessed on 17 November 2023); [c] The NASA Shuttle Radar Topographic Mission (SRTM, http://dwtkns.com/srtm30m/, accessed on 17 November 2023); [d] Open Street Map (OSM, https://www.openstreetmap.org/, accessed on 18 November 2023); [e] Amap (https://lbs.amap.com, accessed on 18 November 2023); [f] Baidu map (https://map.baidu.com/, accessed on 18 November 2023); [g] China Meteorological Administration (CMA, http://data.cma.cn, accessed on 18 November 2023); [h] Geographic Remote Sensing Ecological Network Platform (GRSENP, www.gisrs.cn, accessed on 18 November 2023); [i] Land–Atmosphere Interaction Research Group (LAIRG, http://globalchange.bnu.edu.cn, accessed on 18 November 2023).

2.3. Ecosystem Service Quantification

While ecosystem services are abundant, not all of them are amenable to mapping and modeling. Therefore, the study focused on 6 ecosystem services that are commonly mapped and modeled due to the availability of reliable spatial data and established methods: crop production, cultural tourism, scenic tourism, carbon sequestration, water retention, and soil erosion control [7]. Out of these ecosystem services, carbon sequestration is related to the fundamental capacity of the landscape for production; crop production and soil erosion control are crucial for agriculture industry; water yield, tourism scenery, and culture have direct implications for resident's livelihoods. Various models and algorithms were utilized to estimate the ecosystem services, including the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model, the Carnegie–Ames–Stanford Approach (CASA) model [48], the Revised Universal Soil Loss Equation (RUSLE) model, and others. A summary of the estimation methods is presented in Table 2, while the detailed formulas can be found in reports from related research [22,49–56].

Table 2. Estimation methods for quantifying ecosystem services.

Indicators	Formula	Formula Description
Crop production	$GP_x = \frac{NDVI_x}{NDVI_{sum,i}} \times GP_{sum,i}$	Crop production has a significant linear relationship with the Normalized Difference Vegetation Index (*NDVI*) [56]. GP_x is the grain yield of cell x (t/yr); $GP_{sum,i}$ is the total grain yield of county I; $NDVI_x$ is the NDVI of cell x, $NDVI_{sum,i}$ is the sum of NDVI of arable land in county i.
Tourism Scenery	$TR_s = L_a \times L_v$	TR_s is the score of tourism scenery. L_a represents accessibility to scenic spots and was determined through distance analysis using a road map in a GIS layer. L_v represents the visibility from attraction and was calculated using viewshed analysis, a method employed involves the identification of raster surface locations that are perceptible to a collection of observer features, specifically designated as scenic spots. To obtain this value, the viewshed tool of ArcGIS was employed with a Digital Elevation Model [54].
Tourism Culture	$TR_c(s_0) = \sum_{i=1}^{n} \lambda_i \times Z(s_i)$	The tourism culture score (TR_c) was obtained through tourist evaluations and interpolated using kriging interpolation. $Z(s_i)$ denotes the observed data at a specific location i. λ represents the unknown weight assigned to the observed value at the ith position. Additionally, n signifies the total count of observed data instances [54,57].
Water storage	$WR = (P - ET - R_a) \times A_i \times 10^{-3}$ $R_a = P_h \times \alpha$	In the formula for estimating water storage (m^3/yr), P represents precipitation for each pixel in millimeters per year (mm/yr) and ET symbolizes the actual evapotranspiration occurring at each individual pixel (mm/yr). Similarly, R_a represents the surface runoff taking place at each pixel (mm/yr), and A_i is utilized to represent the spatial extent of the ecosystem in square meters (m^2). P_h is rainfall that generates runoff, and α is the runoff coefficient [33].
Carbon sequestration	$NEP = NPP - 0.592 \times Rs^{0.714}$ $R_s = 1.55e^{0.031T} \times \frac{P \times 0.001}{P+0.68} \times \frac{SOC}{SOC+2.23}$	In the formula for estimating carbon sequestration value NEP (gC/(m^2·yr)), NPP characterizes the net uptake and fixation of carbon dioxide (CO_2) by the ecosystem (gC/(m^2·yr)). The computation of NPP can be achieved through the utilization of the Carnegie–Ames–Stanford Approach (CASA), employing the principle of light use efficiency (LUE) as established by Potter et al. (1993). R_s denotes soil respiration, which quantifies the release of carbon dioxide (CO_2) from the soil (gC/(m^2·yr)). The estimation of R_s can be accomplished through the application of Chen's methods [55]. T represents the average annual air temperature in degrees Celsius (°C), P represents annual precipitation in millimeters (mm), and SOC denotes topsoil soil organic carbon (kg C/m^2), The estimation of SOC can be achieved through the application of Chen's methods [55].
Soil erosion control	$SC = R \times K \times LS \times (1 - C \times P)$	In the formula for estimating soil conservation capacity SC (t/yr), R represents annual rainfall erosivity in MJ mm/(ha·h·yr), which is determined using Fu's methods [22]. K denotes soil erodibility (t·ha·h/(ha·MJ·mm)). The quantification of soil erodibility is accomplished by employing the Erosion/Productivity Impact Calculator (EPIC) model [53]. The topographic factor, LS, is a parameter that captures the influence of slope length and steepness on soil erosion. The calculation of LS is performed using an Arc Macro Language (AML) script within the ArcGIS 10.3 software, as outlined by Hickey (2000). C is the dimensionless vegetation cover factor, estimated using the Normalized Difference Vegetation Index (NDVI) method, while P is the dimensionless conservation practice, estimated using the Wener method [22,52].

2.4. Tradeoffs and Synergies Analysis

To evaluate the associations between different ecosystem services, Pearson parametric correlation tests were conducted using R v3.5 statistical software [32]. It is calculated as follows:

$$\rho_{x,y} = \frac{N\sum_{i=1}^{N} x_i y_i - \sum_{i=1}^{N} x_i \sum_{i=1}^{N} y_i}{\sqrt{N\sum_{i=1}^{N} {x_i}^2 - \left(\sum_{i=1}^{N} x_i\right)^2}\sqrt{N\sum_{i=1}^{N} {y_i}^2 - \left(\sum_{i=1}^{N} y_i\right)^2}}$$

In the formula, X and Y denote the variables (representing ecosystem services), and N represents the number of sample cells. When $\rho_{x,y}$ equals 0, X and Y are not linearly correlated. If $\rho_{x,y}$ is greater than 0, X and Y exhibit a synergistic relationship. Conversely, if $\rho_{x,y}$ is less than 0, X and Y demonstrate a tradeoff relationship. When $\rho_{x,y}$ is closer to 1, the correlation is higher.

N is the sample size.

2.5. Ecosystem Service Bundles

The study employed K-means clustering through the fact extra package in R 4.2.0 to identify clusters of municipalities with similar combinations of ecosystem services. These clusters were referred to as ecosystem service bundle types and were determined based on the principle of similarity, where tradeoffs and synergies between ecosystem services were consistent within each cluster [58]. To determine the optimal number of clusters, the study utilized the elbow method, which evaluates variability through within-group homogeneity or heterogeneity. The resulting ecosystem service bundles were visualized using ArcGIS software to display their spatial distribution, and rose plots were generated for each cluster to visually illustrate the mean values of ecosystem services and the characteristics of each cluster (source: https://www.guru99.com/r-k-means-clustering.html, accessed on 1 August 2023).

3. Results

3.1. Spatial Pattern of Island Ecosystem Services

The spatial distribution characteristics of ecosystem services of islands were calculated based on the hexagon as statistical unit (Figure 2). There is a great variation in the ecosystem services supplement across the landscape. The central plains of the islands are the primary areas with high food production, while the central mountainous regions of the islands are mainly characterized by low food production. Regions that exhibit high levels of food production are primarily situated in the lowlands surrounding the islands, characterized by predominantly red soil, flat terrain, and ample rainfall, which is the main food growing area in Zhoushan Archipelago.

Tourism scenery and cultural services are highest in the central mountainous region of the Archipelago, where the vegetation type is primarily forest and shrub. The elevation is high, the natural scenery is well preserved, and a large number of famous temples, ruins, and other humanistic cultural distributions can be found, resulting in high cultural service output. In addition, the water storage, carbon sequestration, and soil conservation are higher in the central mountainous region than in other areas around the Archipelago. In the central hilly region of the Archipelago, the main vegetation types are forest and shrub, which have higher vegetation cover and depression, making them show stronger water retention, soil conservation, and carbon sequestration ability.

The global Moran's I indices of ecosystem services were calculated based on hexagonal statistical units (Table 3). It is clear from the table that the global Moran's I indices of all six ecosystem services in Zhoushan Archipelago are greater than 0 ($p < 0.01$), indicating that there is significant spatial aggregation (positive spatial autocorrelation) for all six ecosystem services in the islands. Furthermore, findings from other studies suggest that there are notable tradeoffs and synergies among various ecosystem services in Zhoushan Archipelago [59]. Due to the above characteristics, it can be inferred that certain clusters of ecosystem services exist in the islands.

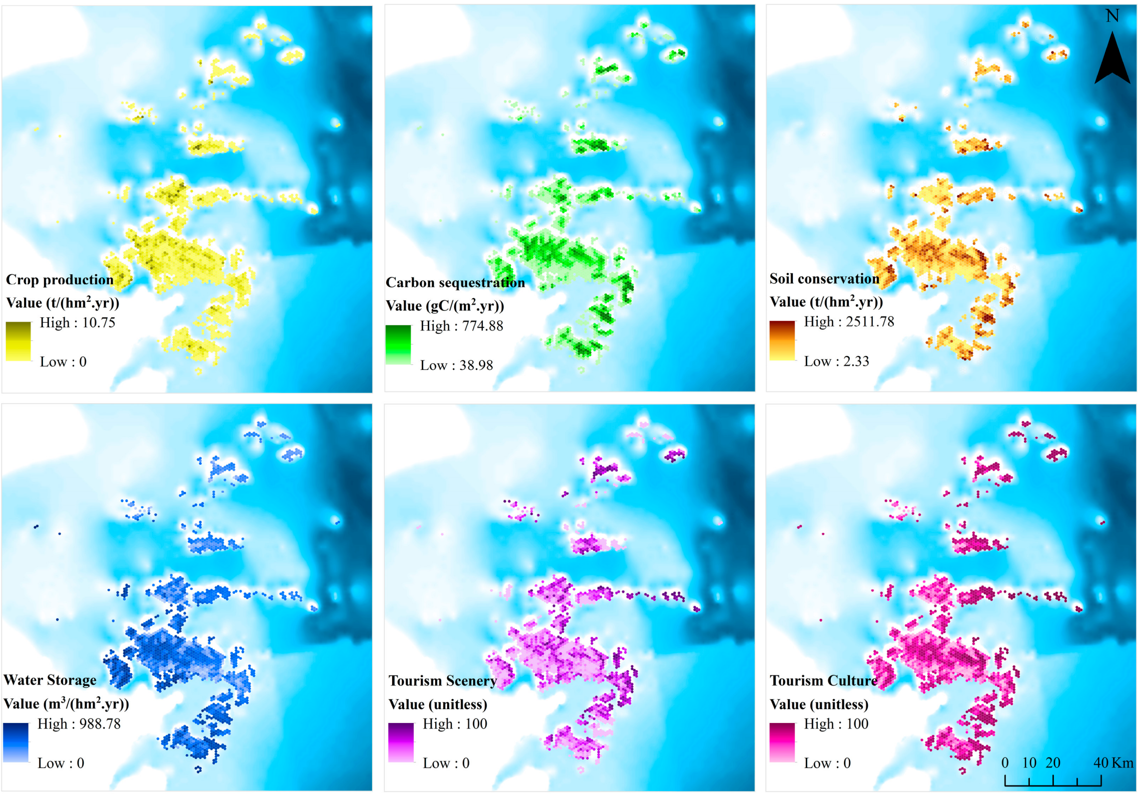


Figure 2. Spatial distribution of ecosystem services in Zhoushan Archipelago.

Table 3. The Moran's value for various ecosystem services in Zhoushan Archipelago.

	Crop Production	Tourism Scenery	Tourism Culture	Water Storage	Carbon Sequestration	Soil Erosion Control
Moran's I	0.11	0.12	0.15	0.16	0.10	0.08
Z Score	56.24	59.96	75.00	82.08	50.02	40.40
p	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

3.2. Spatial Distributions of Island Ecosystem Services Bundles

K-means cluster analysis can accurately classify ecosystem service bundles. In this study, six ecosystem services from 1791 statistical units in Zhoushan Archipelago were subjected to K-means cluster analysis. The study ultimately identified three distinct types of ecosystem service bundles, as depicted in Figure 3. The three types of ecosystem service bundles are: Ecosystem Service Bundle 1, which is based on agricultural production; Ecosystem Service Bundle 2, which is based on forest regulation and tourism; and Ecosystem Service Bundle 3, which is based on mixed land balance. Based on the three service bundles, Zhoushan Archipelago was divided into three ecological function zones: the central island food production zone; the central mountainous forest ecological regulation–tourism zone; and the southern development–protection balance zone. The ecosystem services of each ecological function zone were counted, and food production services were highest in the central island ring food production zone; water connotation, carbon sequestration services, and soil conservation were highest in the central mountainous forest ecological regulation–tourism zone; and tourism services were highest in the southern development–protection balance zone.

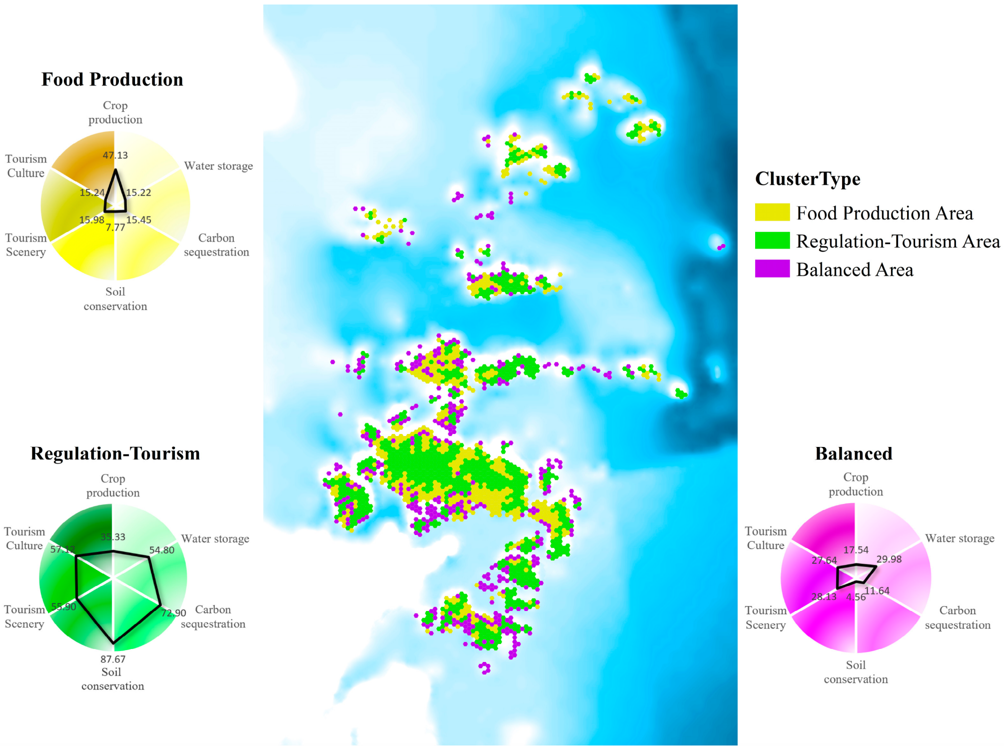


Figure 3. Spatial distribution of the three bundles and occurrence of different ecosystem services in each bundle (radar graphs). Graphs were built by comparing the total supply value of a given ecosystem service within the bundle and the total supply of the same ecosystem service across the whole Archipelago (The proportion of total given ecosystem service occupied by given ecosystem service within the bundle, value range 0–100%).

3.3. Tradeoffs and Synergies among Bundled Island Ecosystem Services

Central Round Island Food Production Zone (Bundle 1): The area of this zone is about 29.59%. This zone is concentrated in the Round Island Plain, with fertile soil, mainly red soil, and arable land as the main land-use type and the climate type is subtropical marine monsoon climate, with flat terrain and abundant precipitation. At the same time, the zone has strong human interference, frequent agricultural activities, and prominent food production services, but the soil conservation, water connotation, and carbon sequestration services are relatively weak. Tourism and cultural services are on the rise as the frequency of human activities increases, and there is a certain synergy between food production and cultural services in this zone (Figure 4).

Central Mountainous Forest Ecological Regulation–Tourism Zone (Bundle 2): The area of this zone is about 46.85%, the zone is mainly distributed in the central mountain range of the main island. The main types of vegetation are middle subtropical evergreen broad-leaved forest, the central forest area is the largest natural forest area in Zhoushan, influenced by the subtropical maritime monsoon climate, high temperature, and rain in summer, suitable for forest growth and development. This zone has the highest vegetation cover, good growth dynamics, balanced functions of soil conservation, water connotation, and carbon sequestration. The quality of ecological environment has been greatly improved, which belongs to the ecological surplus zone. The ecosystem supply services in this zone are significantly lower than the regulating services, showing a clear tradeoff, but a good synergy between regulating services and tourism and cultural services is presented (Figure 4).

Southern Development–Protection Balance Zone (Bundle 3): This zone covers about 23.56% and is concentrated in the discrete areas along the coast of Zhoushan Archipelago. Each ecosystem service is fairly balanced in terms of its composition structure. The food production and regulating services in this zone have a tradeoff relationship (Figure 4).

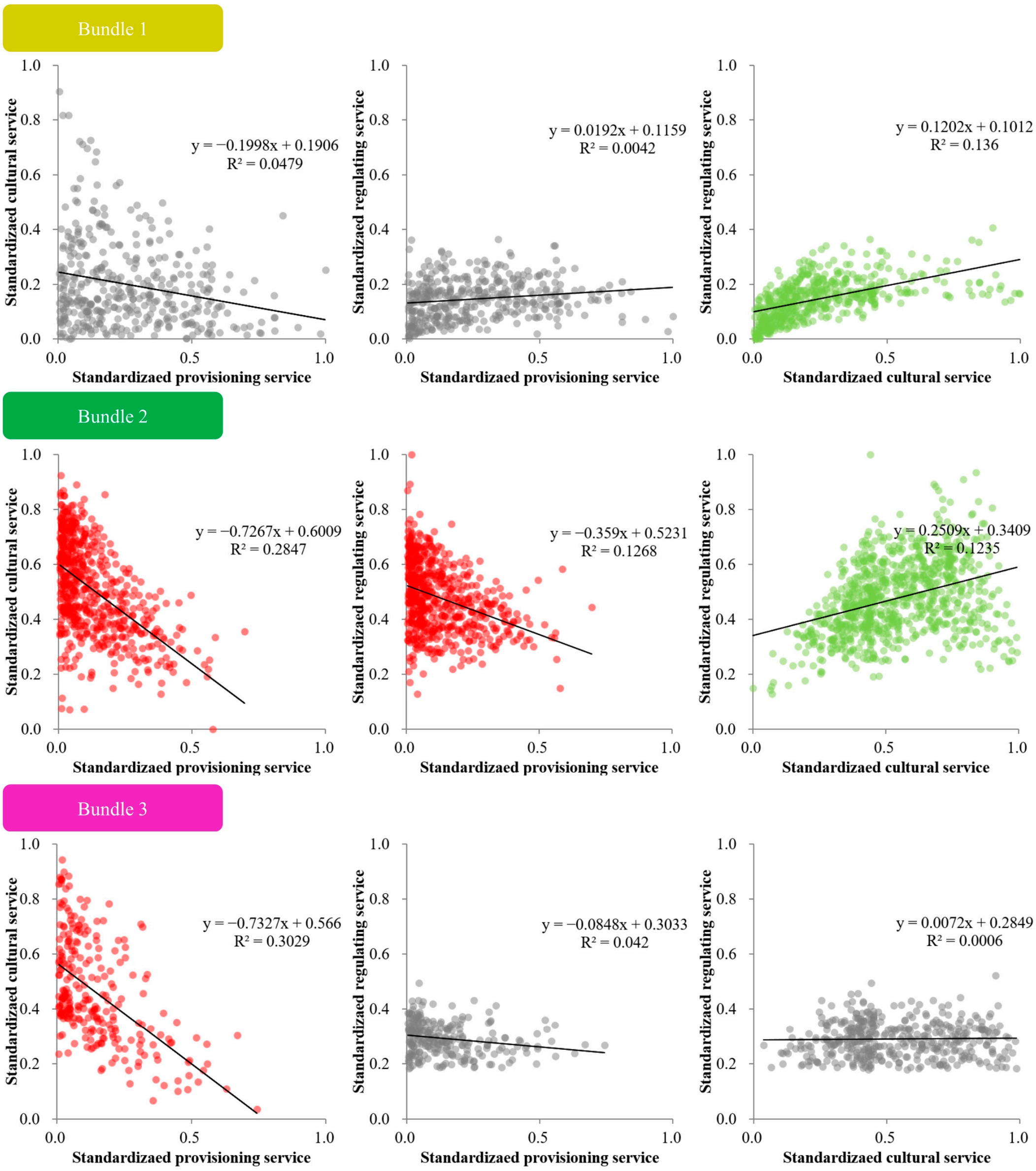


Figure 4. Synergies and tradeoffs among bundled island ecosystem services (red indicates the presence of significant tradeoffs; green indicates the presence of significant synergetic effects).

4. Discussion

Different land-use types lead to different changes in landscape patterns and different spatial impacts on ecosystem services, i.e., spatial heterogeneity of landscape patterns. Analyzing the landscape pattern enables the quantitative determination of the spatial distribution characteristics of ecosystem service components, offering fundamental details for studying the dynamic changes in landscape patterns. The conclusion of this paper is that the similar ecosystem service has obvious aggregation characteristics in geospatial, and the various ecosystem services in each ecosystem service cluster show spatial tradeoffs and synergies. According to the results, the Zhoushan Archipelago has rich and irregular landscape diversity. As there are several types of plaques, the supply capacity of various ecosystem services in the ecosystem service cluster varies greatly across the landscape as a whole.

Ecosystem service clusters are a combination of multiple ecosystem services. In addition to characterizing the spatial agglomeration characteristics and regionally dominant service functions of various ecosystem services, the effective identification of ecosystem service clusters can reveal the combination of different ecosystem services by clarifying their internal spatial structure characteristics [60]. Studies on service clusters typically focus on understanding the overall pattern of an area. These types of research are frequently conducted in densely populated urban regions along the southeastern coast where land use is constrained and ecological landscape management is challenging. The tension between economic development and ecological conservation is apparent, and research on the relationship between economic development and ecological protection is primarily conducted from a novel perspective focusing on ecosystem service clusters. In this paper, the islands of Zhoushan City are divided based on the zoning of ecosystem functions. Zhoushan City has identified three ecological function zones that are aligned with its land-use planning, and the zoning management based on the relationship between ecosystem services is of practical significance for the integration of regional resources in the future.

The changes in ecosystem pattern processes-functions and services will lead to the fact that tradeoffs or synergies between different ecosystem services. Although the current research results on ecosystem service tradeoffs and synergies are abundant, problems and limitations still exist. There is still a lack of dynamic trend change analysis of ecological-service-related relationships; meanwhile, tradeoffs and collaborative studies are mostly based on quantitative analysis of statistical relationships, and the expression of differences in regional space still needs to be supplemented [17]. Principal component analysis and cluster analysis can be used to accurately divide ecosystem service clusters, which is conducive to clarifying the mechanism of action and regional differences in tradeoffs and synergies. To preserve the integrity of the ecosystem service cluster in Zhoushan City, it is crucial to consider the tradeoffs and synergies between various ecological services while also striving to enhance the benefits associated with these services over time. There are several recommendations in the following content that can be used to optimize different ecosystem service bundles.

4.1. Optimization Strategies for Bundle 1

Those areas with a suitable climate naturally attract people to live and produce, thereby forming settlements. The agricultural production process is arranged around settlements in order to satisfy the ecosystem provisioning needs of the community. Its long history and humanity create a cultural tourism landscape. In specific policy planning, we can combine the current policy orientation of rural revitalization and common prosperity in China, and promote the transformation of traditional agricultural production based on the primary industry to one that combines agriculture and tourism with the combination of primary and tertiary industries in a production mode. Furthermore, it can enhance the value of cultural services in the zone by utilizing the rich historical and cultural heritage of the zone. With the current state of soil protection, water content, and carbon sequestration, the popularization of new agricultural production methods can be strengthened under the presumption of ensuring sufficient ecosystem supply functions (Table 4).

4.2. Optimization Strategies for Bundle 2

Within the central mountainous zone, there are relatively few human settlements and more natural environments, which provide a favorable natural ecological climate and underlying surface environment. Due to the high landscape value, people are naturally attracted to the area, resulting in the synergy of ecosystem cultural services and ecosystem regulation services. The specific policy planning may involve, on the one hand, strengthening the ecosystem regulation service in the relevant areas, primarily in the central mountain zone, under the premise of protection and moderate development, and establishing a natural ecological reserve. In contrast, in some areas with high coastal landscape values, appropriate tourism culture development can be carried out with respect to the original natural style, digging historical deposits and enhancing the value of ecosystem cultural service. Due to the current lack of ecosystem provisioning services, it is possible to consider the ecosystem supply function on the basis of maximizing the protection of natural landscape by carrying out environmentally friendly agricultural production and tourism activities (Table 5).

Table 4. Ecosystem service bundle 1's advantages and disadvantages summary and optimization strategies.

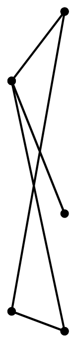
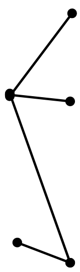
Ecosystem Service Bundle	Advantages and Disadvantages			Optimization Strategies
Central Round Island Food Production Zone (Bundle 1)	Advantage	Superior natural conditions and good climate environment; human activities are frequent, and crop production service is strong.		(1) Promote integration of agriculture and tourism in primary and tertiary industries through the transformation of traditional agricultural production. (2) To enhance the value of tourism and cultural services, it is necessary to investigate the historical context. (3) Maintain supply functions and develop environmentally friendly production and lifestyles.
	Disadvantage	Weak soil protection, water content, and carbon sequestration services.		

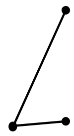
Table 5. Ecosystem service bundle 2′s advantages and disadvantages summary and optimization strategies.

Ecosystem Service Bundle	Advantages and Disadvantages			Optimization Strategies
Central Mountainous Forest Ecological Regulation–Tourism Zone (Bundle 2)	Advantage	Climate tends to be natural, suitable for forest growth and development; strong soil protection, water content, and carbon sequestration services.		(1) Strengthen environmental regulation services in the central mountain area so that nature reserves can be established. (2) In areas with high coastal landscape values, appropriate tourism culture development should be carried out. (3) Produce services through low-impact agricultural production.
	Disadvantage	Ecosystem provision services are weak.		

4.3. Optimization Strategies for Bundle 3

The coastal discrete area is the boundary between the land and the sea [61]. This zone is often used by Zhoushan as an industrial carrier for the production, processing, and culture of fish. In spite of this, the fishery and its downstream industries have a relatively large impact on the environment, and traditional fishery production is capable of causing more pollution. It follows that there is a tradeoff between the service of food production and the service of environmental regulation in this zone. As a supplement to the overall regional planning strategy, the service balance of any specific policy can be used. However, in light of the historical characteristics of its rich fishery production, the fish industry should conduct industrial iteration and upgrading while retaining the industrial forms that have considerable value in the first, second, and third industrial chains. In view of the relationship between food production service and environmental regulation service, agricultural land indicators of this ecosystem service bundle and other ecosystem service bundles can be exchanged, thereby increasing the land indicators available for the further development of this zone within this ecosystem service bundle on the basis of maintaining a balance of ecosystem services (Table 6).

Table 6. Ecosystem service bundle 3's advantages and disadvantages summary and optimization strategies.

Ecosystem Service Bundle		**Advantages and Disadvantages**		**Optimization Strategies**
Southern Development–Protection Balance Zone (Bundle 3)	Advantage	The structure of ecosystem services is fairly balanced; the distribution area belongs to the coastal external strong active area.		(1) Complement the overall planning land use by including a functional, flexible area. (2) Maintain the vitality of the fishing industry, retain the appropriate stage of the industrial chain, and develop in an iterative manner. (3) It is also necessary to increase the available index support for the region through the replacement of land use indexes.
	Disadvantage	There are tradeoffs between food production and regulatory services.		

5. Conclusions

In this study, Zhoushan Archipelago was used as the research area, and K-means cluster analysis was used in this region. The region has been zoned for ecological functions, exploring the ecosystem service types, which are provided by the region. Additionally, the tradeoffs and synergies of multiple ecosystem services within each ecosystem service cluster were quantitatively evaluated using correlation analysis.

The dominant service of the Central Round Island Food Production Zone (Bundle 1) is the food production service, which shows a certain synergy with the maintenance of cultural services and has not yet shown a clear tradeoff and synergy with other regulatory services. The Central Mountainous Forest Ecological Regulation–Tourism Zone (Bundle 2) in the central mountainous area belongs to the ecological surplus area, and the ecosystem food supply in this area is considerably lower than that of the regulating service, indicating a clear tradeoff between one or the other. However, the regulation service and the tourism and cultural services in the region share a good synergy. The ecosystem services in the Southern Development–Protection Balance Zone (Bundle 3) are relatively balanced, and there is a tradeoff between food production and regulatory services in this zone.

Overall, the current state of ecosystem services in the coastal archipelago system represented by Zhoushan is complex and multiregional. The quantitative assessment of ecosystem services in the island ecosystem service cluster in this study can assist in clarifying the tradeoffs and synergies between ecosystem services in different service clusters [62], as well as providing theoretical guidance and technical support to formulate effective, sustainable socioeconomic–ecosystem management programs in island areas. By developing economy and society, island space is developed in a more efficient, ecological manner, and traditional primary industry is transformed into secondary and tertiary industries. Considering the future industrial development process and its allocation of land space, more detailed optimization needs to be carried out from the perspective of ecosystem services, in order to maximize the efficiency of space utilization and ecosystem service output in the future.

Author Contributions: Conceptualization, H.Z.; funding acquisition, H.Z. and Y.X.; investigation, K.M. and H.A.C.C.P.; methodology, Y.X.; project administration, Y.D.; resources, H.Z.; supervision, H.Z. and Y.D.; visualization, M.Z.R., Y.X. and K.M.; writing—original draft, Y.X.; writing—review and editing, H.Z., K.M., Y.D., H.A.C.C.P. and M.Z.R. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported jointly by the Hainan Province's Key Research and Development Project (No: ZDYF2022SHFZ062); National Natural Science Foundation of China (No: 52378042); National Natural Science Foundation of China (No: 71904060); Basic Public Welfare Research Plan of Zhejiang Province (No: LGN20E080002); Sichuan Science & Technology Bureau Program (No:

2022YFS0473); Research Project on Representative Islands Platform for Resources, Ecology, and Sustainable Development (No: 102121221620000009001), and the China Oceanic Development Foundation Project (No: Z.220109).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The datasets generated during and analyzed during the current study are not publicly available due needs of new research currently but are available from the corresponding author on reasonable request.

Acknowledgments: We would like to thank the reviewers and editors for their contributions to improving the manuscript.

Conflicts of Interest: The authors have no relevant financial or non-financial conflict of interest to disclose.

References

1. Deng, Y.; Čuka, A.; Fu, Y.; Wu, J. Multiple Paths towards Eco Islands and Blue Development: Conference Report. *Mar. Policy* **2023**, *149*, 105526. [CrossRef]
2. Deng, Y.; Randall, J.; Ye, F. Island Ecological Restoration and Management Practices Based on Nature: Conference Report. *Mar. Policy* **2022**, *143*, 105188. [CrossRef] [PubMed]
3. Fu, B.-J.; Zhang, L. Land Use Change and Ecosystem Services: Concepts, Methods and Progress. *Prog. Geogr.* **2014**, *33*, 441–446. [CrossRef]
4. Zhang, H.; Xiao, Y.; Deng, Y. Island Ecosystem Evaluation and Sustainable Development Strategies: A Case Study of the Zhoushan Archipelago. *Glob. Ecol. Conserv.* **2021**, *28*, e01603. [CrossRef]
5. Wang, Y.; Cheng, H.; Wang, N.; Huang, C.; Zhang, K.; Qiao, B.; Wang, Y.; Wen, P. Trade-Off and Synergy Relationships and Spatial Bundle Analysis of Ecosystem Services in the Qilian Mountains. *Remote Sens.* **2023**, *15*, 2950. [CrossRef]
6. *Ecosystems and Human Well-Being: Synthesis*; Millennium Ecosystem Assessment (Program) (Ed.) Island Press: Washington, DC, USA, 2005; ISBN 978-1-59726-040-4.
7. Daily, G.C.; Polasky, S.; Goldstein, J.; Kareiva, P.M.; Mooney, H.A.; Pejchar, L.; Ricketts, T.H.; Salzman, J.; Shallenberger, R. Ecosystem Services in Decision Making: Time to Deliver. *Front. Ecol. Environ.* **2009**, *7*, 21–28. [CrossRef]
8. Deng, Y.-C.; Jiang, X. Wetland Protection Law of the People's Republic of China: New Efforts in Wetland Conservation. *Int. J. Mar. Coast. Law* **2023**, *38*, 141–160. [CrossRef]
9. Palmer, M.A.; Hondula, K.L.; Koch, B.J. Ecological Restoration of Streams and Rivers: Shifting Strategies and Shifting Goals. *Annu. Rev. Ecol. Evol. Syst.* **2014**, *45*, 247–269. [CrossRef]
10. Suding, K.N. Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead. *Annu. Rev. Ecol. Evol. Syst.* **2011**, *42*, 465–487. [CrossRef]
11. Findell, K.L.; Berg, A.; Gentine, P.; Krasting, J.P.; Lintner, B.R.; Malyshev, S.; Santanello, J.A.; Shevliakova, E. The Impact of Anthropogenic Land Use and Land Cover Change on Regional Climate Extremes. *Nat. Commun.* **2017**, *8*, 989. [CrossRef]
12. Assefa, W.W.; Eneyew, B.G.; Wondie, A. The Impacts of Land-Use and Land-Cover Change on Wetland Ecosystem Service Values in Peri-Urban and Urban Area of Bahir Dar City, Upper Blue Nile Basin, Northwestern Ethiopia. *Ecol. Process.* **2021**, *10*, 39. [CrossRef]
13. Nahuelhual, L.; Carmona, A.; Aguayo, M.; Echeverria, C. Land Use Change and Ecosystem Services Provision: A Case Study of Recreation and Ecotourism Opportunities in Southern Chile. *Landsc. Ecol.* **2014**, *29*, 329–344. [CrossRef]
14. Wu, X.; Wang, S.; Fu, B.; Liu, Y.; Zhu, Y. Land Use Optimization Based on Ecosystem Service Assessment: A Case Study in the Yanhe Watershed. *Land Use Policy* **2018**, *72*, 303–312. [CrossRef]
15. Hu, H.; Liu, W.; Cao, M. Impact of Land Use and Land Cover Changes on Ecosystem Services in Menglun, Xishuangbanna, Southwest China. *Environ. Monit. Assess.* **2008**, *146*, 147–156. [CrossRef] [PubMed]
16. Fu, B.; Zhang, L.; Xu, Z.; Zhao, Y.; Wei, Y.; Skinner, D. Ecosystem Services in Changing Land Use. *J. Soils Sediments* **2015**, *15*, 833–843. [CrossRef]
17. Deng, Y.; Shi, Y. Recent Developments of China's Institutional Reform for Ocean Management: An Appraisal. *Coast. Manag.* **2023**, *51*, 91–114. [CrossRef]
18. Deng, X.; Gibson, J. Sustainable Land Use Management for Improving Land Eco-Efficiency: A Case Study of Hebei, China. *Ann. Oper. Res.* **2020**, *290*, 265–277. [CrossRef]
19. Sonter, L.J.; Johnson, J.A.; Nicholson, C.C.; Richardson, L.L.; Watson, K.B.; Ricketts, T.H. Multi-Site Interactions: Understanding the Offsite Impacts of Land Use Change on the Use and Supply of Ecosystem Services. *Ecosyst. Serv.* **2017**, *23*, 158–164. [CrossRef]
20. Shao, X.; Jing, C.; Qi, J.; Jiang, J.; Liu, Q.; Cai, X. Impacts of Land Use and Planning on Island Ecosystem Service Values: A Case Study of Dinghai District on Zhoushan Archipelago, China. *Ecol. Process.* **2017**, *6*, 27. [CrossRef]

21. Blumstein, M.; Thompson, J.R. Land-use Impacts on the Quantity and Configuration of Ecosystem Service Provisioning in Massachusetts, USA. *J. Appl. Ecol.* **2015**, *52*, 1009–1019. [CrossRef]
22. Fu, B.; Liu, Y.; Lü, Y.; He, C.; Zeng, Y.; Wu, B. Assessing the Soil Erosion Control Service of Ecosystems Change in the Loess Plateau of China. *Ecol. Complex.* **2011**, *8*, 284–293. [CrossRef]
23. Wang, Y.; Li, X.; Zhang, Q.; Li, J.; Zhou, X. Projections of Future Land Use Changes: Multiple Scenarios-Based Impacts Analysis on Ecosystem Services for Wuhan City, China. *Ecol. Indic.* **2018**, *94*, 430–445. [CrossRef]
24. Wang, M.; Sun, X. Potential Impact of Land Use Change on Ecosystem Services in China. *Environ. Monit. Assess.* **2016**, *188*, 248. [CrossRef] [PubMed]
25. Cumming, G.S.; Buerkert, A.; Hoffmann, E.M.; Schlecht, E.; Von Cramon-Taubadel, S.; Tscharntke, T. Implications of Agricultural Transitions and Urbanization for Ecosystem Services. *Nature* **2014**, *515*, 50–57. [CrossRef] [PubMed]
26. Sun, X.; Crittenden, J.C.; Li, F.; Lu, Z.; Dou, X. Urban Expansion Simulation and the Spatio-Temporal Changes of Ecosystem Services, a Case Study in Atlanta Metropolitan Area, USA. *Sci. Total Environ.* **2018**, *622–623*, 974–987. [CrossRef] [PubMed]
27. Wei, Y.D.; Ye, X. Urbanization, Urban Land Expansion and Environmental Change in China. *Stoch. Environ. Res. Risk Assess.* **2014**, *28*, 757–765. [CrossRef]
28. Martinez-Harms, M.J.; Bryan, B.A.; Figueroa, E.; Pliscoff, P.; Runting, R.K.; Wilson, K.A. Scenarios for Land Use and Ecosystem Services under Global Change. *Ecosyst. Serv.* **2017**, *25*, 56–68. [CrossRef]
29. Lee, Y.-C.; Ahern, J.; Yeh, C.-T. Ecosystem Services in Peri-Urban Landscapes: The Effects of Agricultural Landscape Change on Ecosystem Services in Taiwan's Western Coastal Plain. *Landsc. Urban Plan.* **2015**, *139*, 137–148. [CrossRef]
30. Quintas-Soriano, C.; Castro, A.J.; Castro, H.; García-Llorente, M. Impacts of Land Use Change on Ecosystem Services and Implications for Human Well-Being in Spanish Drylands. *Land Use Policy* **2016**, *54*, 534–548. [CrossRef]
31. Dade, M.C.; Mitchell, M.G.E.; McAlpine, C.A.; Rhodes, J.R. Assessing Ecosystem Service Trade-Offs and Synergies: The Need for a More Mechanistic Approach. *Ambio* **2019**, *48*, 1116–1128. [CrossRef]
32. Xiao, Y.; Xiao, Q.; Xiong, Q.; Yang, Z. Effects of Ecological Restoration Measures on Soil Erosion Risk in the Three Gorges Reservoir Area Since the 1980s. *GeoHealth* **2020**, *4*, e2020GH000274. [CrossRef] [PubMed]
33. Xiao, Y.; Xiong, Q.; Liang, P.; Xiao, Q. Potential Risk to Water Resources under Eco-Restoration Policy and Global Change in the Tibetan Plateau. *Environ. Res. Lett.* **2021**, *16*, 094004. [CrossRef]
34. Chi, Y.; Zhang, Z.; Gao, J.; Xie, Z.; Zhao, M.; Wang, E. Evaluating Landscape Ecological Sensitivity of an Estuarine Island Based on Landscape Pattern across Temporal and Spatial Scales. *Ecol. Indic.* **2019**, *101*, 221–237. [CrossRef]
35. Xiao, Y.; Xiao, Q.; Zhang, J. Balancing the International Benefits and Risks Associated with Implementation of Ecological Policy on the Qinghai-Tibet Plateau, China. *Gondwana Res.* **2023**, *115*, 183–190. [CrossRef]
36. Chi, Y.; Liu, D.; Qu, Y.; Zhang, Z.; Liu, Z. Archipelagic Human-Land Spatial Interrelations: An Empirical Study in Shengsi Archipelago, China. *Land Use Policy* **2023**, *130*, 106671. [CrossRef]
37. Gajić, T.; Minasyan, L.A.; Petrović, M.D.; Bakhtin, V.A.; Kaneeva, A.V.; Wiegel, N.L. Travelers' (in) Resilience to Environmental Risks Emphasized in the Media and Their Redirecting to Medical Destinations: Enhancing Sustainability. *Sustainability* **2023**, *15*, 15297. [CrossRef]
38. Bergamini, K.; Moris, R.; Ángel, P.; Zaviezo, D.; Gilabert, H. Demographic Carrying Capacity Model: A Tool for Decision-Making in Rapa Nui. *Isl. Stud. J.* **2021**, *16*, 178–197. [CrossRef]
39. Sabaté-Bel, F.; Armas-Díaz, A. Commodification or the Right to the Island: The Struggle against the Construction of a Hotel in La Tejita (Tenerife). *Isl. Stud. J.* **2022**, *17*, 214–234. [CrossRef]
40. Mohan, P.S. Sustainable Tourism and the Sustainable Development Goals in Sub-National Island Jurisdictions: The Case of Tobago. *Isl. Stud. J.* **2022**, *17*, 168–191. [CrossRef]
41. Chi, Y.; Liu, D.; Xing, W.; Wang, J. Island Ecosystem Health in the Context of Human Activities with Different Types and Intensities. *J. Clean. Prod.* **2021**, *281*, 125334. [CrossRef]
42. Gu, T.; Liu, S.; Liu, X.; Shan, Y.; Hao, E.; Niu, M. Evaluation of the Smart City and Analysis of Its Spatial–Temporal Characteristics in China: A Case Study of 26 Cities in the Yangtze River Delta Urban Agglomeration. *Land* **2023**, *12*, 1862. [CrossRef]
43. Cai, L.; Hu, Q.; Qiu, Z.; Yin, J.; Zhang, Y.; Zhang, X. Study on the Impact of Offshore Wind Farms on Surrounding Water Environment in the Yangtze Estuary Based on Remote Sensing. *Remote Sens.* **2023**, *15*, 5347. [CrossRef]
44. Zhao, X.; Yi, P.; Xia, J.; He, W.; Gao, X. Temporal and Spatial Analysis of the Ecosystem Service Values in the Three Gorges Reservoir Area of China Based on Land Use Change. *Environ. Sci. Pollut. Res.* **2022**, *29*, 26549–26563. [CrossRef] [PubMed]
45. Wu, Y.; Wang, S.; Wang, J.; Wu, S.; You, H.; Wang, Y. Impact of Land Use on Coastline Change of Island Cities: A Case of Zhoushan Island, China. *Isl. Stud. J.* **2020**, *15*, 335–352. [CrossRef]
46. Qiu, S.; Yue, W.; Zhang, H.; Qi, J. Island Ecosystem Services Value, Land-Use Change, and the National New Area Policy in Zhoushan Archipelago, China. *Isl. Stud. J.* **2017**, *12*, 177–198. [CrossRef]
47. Chen, H.; Yan, W.; Li, Z.; Wende, W.; Xiao, S.; Wan, S.; Li, S. Spatial Patterns of Associations among Ecosystem Services across Different Spatial Scales in Metropolitan Areas: A Case Study of Shanghai, China. *Ecol. Indic.* **2022**, *136*, 108682. [CrossRef]
48. Ma, S.; Wang, L.; Wang, H.; Jiang, J.; Zhang, J. Multiple Ecological Effects and Their Drivers of Ecological Restoration Programmes in the Qinghai-Tibet Plateau, China. *Land Degrad. Dev.* **2023**, *34*, 1415–1429. [CrossRef]
49. Xiao, Y.; Xiong, Q.; Pan, K. What Is Left for Our Next Generation? Integrating Ecosystem Services into Regional Policy Planning in the Three Gorges Reservoir Area of China. *Sustainability* **2018**, *11*, 3. [CrossRef]

50. Potter, C.S.; Randerson, J.T.; Field, C.B.; Matson, P.A.; Vitousek, P.M.; Mooney, H.A.; Klooster, S.A. Terrestrial Ecosystem Production: A Process Model Based on Global Satellite and Surface Data. *Glob. Biogeochem. Cycles* **1993**, *7*, 811–841. [CrossRef]
51. Hickey, R. Slope Angle and Slope Length Solutions for GIS. *Cartography* **2000**, *29*, 1–8. [CrossRef]
52. Lufafa, A.; Tenywa, M.M.; Isabirye, M.; Majaliwa, M.J.G.; Woomer, P.L. Prediction of Soil Erosion in a Lake Victoria Basin Catchment Using a GIS-Based Universal Soil Loss Model. *Agric. Syst.* **2003**, *76*, 883–894. [CrossRef]
53. Zhang, K.L.; Shu, A.P.; Xu, X.L.; Yang, Q.K.; Yu, B. Soil Erodibility and Its Estimation for Agricultural Soils in China. *J. Arid Environ.* **2008**, *72*, 1002–1011. [CrossRef]
54. Chen, N.; Li, H.; Wang, L. A GIS-Based Approach for Mapping Direct Use Value of Ecosystem Services at a County Scale: Management Implications. *Ecol. Econ.* **2009**, *68*, 2768–2776. [CrossRef]
55. Chen, S.; Huang, Y.; Zou, J.; Shi, Y.; Lu, Y.; Zhang, W.; Hu, Z. Interannual Variability in Soil Respiration from Terrestrial Ecosystems in China and Its Response to Climate Change. *Sci. China Earth Sci.* **2012**, *55*, 2091–2098. [CrossRef]
56. Xu, S.; Liu, Y.; Wang, X.; Zhang, G. Scale Effect on Spatial Patterns of Ecosystem Services and Associations among Them in Semi-Arid Area: A Case Study in Ningxia Hui Autonomous Region, China. *Sci. Total Environ.* **2017**, *598*, 297–306. [CrossRef]
57. Li, F.; Guo, S.; Li, D.; Li, X.; Li, J.; Xie, S. A Multi-Criteria Spatial Approach for Mapping Urban Ecosystem Services Demand. *Ecol. Indic.* **2020**, *112*, 106119. [CrossRef]
58. Pellowe, K.E.; Meacham, M.; Peterson, G.D.; Lade, S.J. Global Analysis of Reef Ecosystem Services Reveals Synergies, Trade-Offs and Bundles. *Ecosyst. Serv.* **2023**, *63*, 101545. [CrossRef]
59. Ogbodo, U.S.; Liu, S.; Feng, S.; Gao, H.; Pan, Z. Trade-Offs and Synergies among 17 Ecosystem Services in Africa: A Long-Term Multi-National Analysis. *Remote Sens.* **2023**, *15*, 3588. [CrossRef]
60. Raudsepp-Hearne, C.; Peterson, G.D.; Bennett, E.M. Ecosystem Service Bundles for Analyzing Tradeoffs in Diverse Landscapes. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 5242–5247. [CrossRef]
61. Ai, B.; Zhang, R.; Zhang, H.; Ma, C.; Gu, F. Dynamic Process and Artificial Mechanism of Coastline Change in the Pearl River Estuary. *Reg. Stud. Mar. Sci.* **2019**, *30*, 100715. [CrossRef]
62. Kang, T.; Yang, S.; Bu, J.; Chen, J.; Gao, Y. Quantitative Assessment for the Dynamics of the Main Ecosystem Services and Their Interactions in the Northwestern Arid Area, China. *Sustainability* **2020**, *12*, 803. [CrossRef]