sustainability-2790824-peer-review-v1.pdf

sustainability MDPI

Article

Assessment of Ecosystem Service Value and Social Costs of Carbon Emissions in Island Ecosystems: A Case Study of Zhoushan Archipelago

Firstname Lastname [1], Firstname Lastname [2] and Firstname Lastname [2,*]

[1] Affiliation 1; e-mail@e-mail.com
[2] Affiliation 2; e-mail@e-mail.com
* Correspondence: e-mail@e-mail.com; Tel.: (optional; include country code; if there are multiple corresponding authors, add author initials)

Abstract: Mitigating and adapting to climate change, conserving biodiversity and ensuring human well-being are three central challenges facing humanity today, and these issues are often treated separately, when in fact they are deeply intertwined and share many of the same drivers. Finding an integrated approach that can reduce trade-offs and promote synergies between the SDGs is a focus of current and future research. Assessments of the ecosystem service value (ESV) and the social cost of carbon (SCC) inform national and government management decisions in the areas of ensuring human well-being and climate change mitigation and adaptation, respectively. Studying the correlation between the two provides a theoretical basis for low-carbon and high-quality regional development, achieving economic decarbonisation and improving human well-being. In this study, we take Zhoushan Archipelago as a case study, consider the ESV and SCC in Zhoushan Archipelago during the period 2010-2020, analyse their spatial development characteristics, and analyse the correlation between the two in time and space. The results show that the land area of Zhoushan Archipelago increased between 2010 and 2015, and remained basically stable between 2015 and 2020, and the proportion of each land type increased the most in construction land. Zhoushan Archipelago had carbon emissions during the study period. Forest is the main carbon sink land in Zhoushan Archipelago, followed by mudflat and waterbody, and construction land contributes the most to carbon emissions. The SCC in Zhoushan Archipelago increased by 2452%. The ESV in Zhoushan Archipelago generally decreased during the study period, with a small change of only 1.5%. The global spatial correlation analysis of ESV and SCC showed that there was a significant positive correlation between ESV and SCC in Zhoushan Archipelago during the study period. And it passed the P-value test. However, the local spatial correlation analysis of ESV and SCC showed that the global spatial correlation of ESV and SCC in the island area was specific.

Keywords: Ecosystem Service Value, Social cost of carbon, Zhoushan Archipelago, Spatial correlation

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Sustainability* **2022**, *14*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Received: date
Accepted: date
Published: date

1. Introduction

The rapid increase in carbon emissions leading to global warming has become a focus of concern, prompting the international community to prioritise the development of a green and low-carbon economy as a consensus strategy to address and mitigate climate change[1]. Greenhouse gas emissions are primarily caused by human activities, and compared to carbon emissions from industrial production involving the burning of fossil fuels, land use change introduces greater uncertainty into carbon emissions[2]. The IPCC report on climate change and land states that all scenarios that limit climate change to 1.5 degrees Celsius rely heavily on methods to mitigate land-use change and decarbonise the economy[3]. Land-use change not only affects carbon emissions, but also affects the stability of land ecosystems by altering their structure and function[4], which is critical for maintaining ecosystem services[5]. One of the main objectives in the land-use optimisation problem is to maximise environmental benefits, and the value of ecosystem services is one measure of environmental benefits[6]. Economists also emphasise the explicit comparison of economic costs and environmental benefits[7]. The SCC is an estimate of the economic loss caused by emitting one additional tonne of carbon dioxide[8]. It can be used to evaluate various environmental policies and green investment projects. The valuation of ecosystem service values and carbon emissions provide the basis for national and governmental management decisions in the areas of ensuring human well-being and mitigating and adapting to climate change[9]. In the context of China's double carbon policy and simultaneous emphasis on improving the ecological environment, studying the spatial patterns of carbon emissions and ecosystem service values is of great importance in addressing the challenge of balancing economic growth and environmental protection in the process of societal development.

Ecosystem services refer to the range of benefits that humans directly or indirectly derive from the environment[10]. The Millennium Ecosystem Assessment report categorises ecosystem service functions into supporting, regulating, provisioning and cultural services[11]. The valuation of ecosystem services provides a clear calculation of the benefits that humans derive from ecosystem services, thus supporting informed decision-making[12]. Common methods for estimating the value of ecosystem services can be categorised as energy value analysis, ecological space valuation, material quality valuation and value quantity valuation[13]. Among them, the value quantity evaluation method, which is based on the area of each land use type and its equivalent factor value coefficient, has been widely applied due to its ease of data collection and low estimation cost[14]. The ESV estimation model proposed by Costanza et al.[15] in 1997 has gained widespread recognition and use. Xie et al.[16] revised the ecosystem service types based on China's ecological characteristics and improved the ESV equivalent factor for different land use types. Given China's vast geographical diversity and complex ecosystems, the application of ESV assessment needs to take into account the scale, natural environment and socio-economic conditions of the study area, which requires the adjustment of ESV equivalent factors per unit area to establish a tailored ESV assessment system[17].

Land-use carbon emissions refer to the processes, activities and mechanisms by which land, as it is transformed by the human production activities it supports, releases carbon dioxide into the atmosphere. This process involves both direct and indirect carbon emissions[2]. Land-use change directly affects the carbon balance of terrestrial ecosystems, which in turn affects regional carbon emission levels[18], thereby significantly influencing global carbon cycling processes[19]. Methods for accounting carbon emissions include the land inventory method, the mechanism model simulation method and the carbon emission coefficient method, of which the emission coefficient method is simple and has a wide range of application scales[20]. The assessment of land use carbon emissions in the study area not only provides scientific references for mitigating global warming, but also has practical value for adaptive planning and management of land use[21], the optimisation of land use carbon emissions and its optimised regulation [22] and control [23] have crucial practical significance.

The effects of land use change on carbon emissions and ecosystem service values have been extensively studied and validated[24–26], and current studies typically take both into account to provide evidence for sustainable environmental management. For example, Soumik Saha et al [27] quantified carbon stocks, ecosystem service value status and total primary productivity in the Chota Nagpur Plateau (India). For example, Chen et al. [28]studied the spatial and temporal differences in carbon emissions and ecosystem survival value (ESV) caused by land use cover changes in the Chengdu-Chongqing urban agglomeration in China. In addition, some scholars have investigated the quantitative [29] and spatial[30]relationships between carbon emissions based on land use and the value of ecosystem services. For example, du et al [31] calculated and analysed the ecological and environmental impacts of land use change in Hangzhou, including ecosystem service value (ESV) and carbon emissions. yang et al [32]evaluated the carbon emission intensity and ESV intensity of the Guanzhong Plain urban agglomeration in China during 2000-2020, and concluded that the two showed a significant negative spatial correlation[33]. The use of SCC to represent the correlation between carbon emissions and ESV is compelling and comparable because both are methods of quantitative evaluation from the perspective of monetary value[24]. SCC accounting is often used as evidence for future climate policy and for optimising the structure of carbon emissions[34]. For example, Wilfried Rickels et al. [35] estimate a historical time series of the social cost of carbon and assess how much global wealth has been reduced by individual countries from 1950 to 2018 as a result of their CO2 emissions from fossil fuels and industrial processes. Payments for carbon and payments for ecosystem services have been evaluated to compensate for the loss of livestock income due to reduced grazing regime and to provide carbon sequestration and other benefits[36], but there are few studies on the relationship between carbon emissions and the value of ecosystem services in island ecosystems.

The island ecosystem is a special and complex region located at the interface between the ocean and the land. The ecological structure of the island is simple, land resources are limited, species richness is low and the ecology is fragile[37], yet island ecosystems have significant impacts on the global carbon cycle[38]. At present, there are few studies assessing the carbon emissions[39] and ESV[40,41]of island ecosystems.

This study aims to determine the spatial and temporal evolution and distribution of ESV and SCC in island ecosystems induced by land use change, and to support the implementation of integrated policies for land use management and carbon emission control. Taking Zhoushan Islands as an example, we spatially quantify ESV and SCC from 2010 to 2020 and analyse their spatial and temporal distribution characteristics and evolution patterns. We then conduct a spatial correlation analysis of ESV and SCC based on the grid to explore whether there is a spatial correlation relationship between the two, and their spatial interaction characteristics and local clustering patterns. The research results have significant theoretical and practical implications for promoting low-carbon, green and high-quality regional development.

2. Materials and Methods

2.1. Study Area

The Zhoushan Archipelago is located in the southeastern coastal region of China, south of the Yangtze River estuary, in the East China Sea at the outer edge of Hangzhou Bay. Zhoushan is the first prefecture-level city in China to be organised as an archipelago, comprising 2085 islands, of which 141 are inhabited. It consists of Dinghai and Putuo districts, and Daishan and Shengsi counties. With a marine area of 20,800 square kilometres and a total land area of 1458.76 square kilometres[42], the Zhoushan Cross-Sea Bridge was officially opened in late 2009, and the Zhoushan Archipelago New Area in Zhejiang was established in mid-2011, accelerating the process of urbanisation and industrialisation in the Zhoushan Archipelago. Rapid industrial and economic development, coupled with constraints such as limited land resources and natural disasters, underscore the importance of assessing and protecting the fragile ecosystems of these islands.

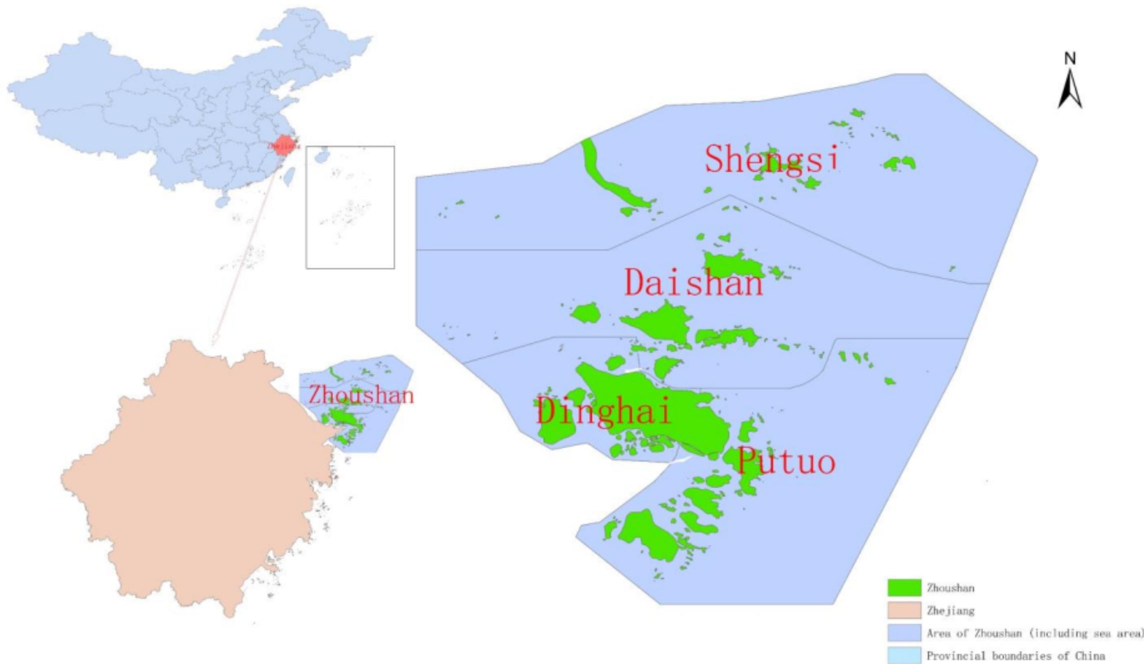

Figure 1. Geographical location map of Zhoushan Archipelago.

2.2. Data Sources and Processing

The data used in this study included land use data, ESV coefficient and carbon emission coefficient data. The land use data and administrative division data for Zhoushan City were obtained from the Chinese Academy of Sciences Resource and Environmental Science and Data Center[43] and the Zhejiang Provincial Geographic Information Public Service Platform[44], respectively. Land classes within the study area were reclassified into eight categories for analysis: farmland, forest, shrubland, grassland, waterbody, construction land, unused land and mudflat. ESV coefficients, carbon emission coefficients, and correction factors were obtained from the Zhoushan Archipelago Bureau of Statistics[42], the National Bureau of Statistics [45]and published relevant literature, as described in Section 2.3.

2.3. Research Methods

2.3.1. Carbon Emission Calculation

Among the eight land-use types in Zhoushan Archipelago, forest, shrubland, grassland, waterbody, unused land, and mudflat serve as carbon sinks, while farmland and construction land act as carbon sources. The carbon emissions for Zhoushan Archipelago were calculated as the sum of the products of the area of each land use type and the corresponding carbon emission coefficient. The calculation formula is as follows:

$$C_i = A_i \times CEC_i \quad (1)$$

In the formulas, i is the land use type, C_i is the carbon emission (t/t) of class i land in Zhoushan Archipelago, $A_i$is the land area (ha), and CEC_i is the carbon emission coefficient (t/ha). The carbon emission coefficients for various land-use types were obtained from relevant published literature, with values as follows: farmland (0.422)[46], forest (-0.581)[47], shrubland (-0.161)[48], grassland (-0.021)[49], waterbody (-0.253)[46], unused land (-0.005)[50], and mudflat (-1.538)[51].

It is noteworthy to consider construction land. The carbon emissions from construction land primarily result from human production and daily life processes, and indirect estimation methods can be employed for calculation. Considering data availability, the carbon emissions for construction land were computed by multiplying the gross output value of the secondary and tertiary industries in Zhoushan Archipelago by their unit Gross Domestic Product（GDP）energy consumption[52]. The calculation formula is as follows:

$$C_S = GDP_{2,3} \times I \times K \quad (2)$$

In the equation, C_S is the carbon emission of building land (t), $GDP_{2,3}$ is the output value of the second and third industries of Zhoushan Archipelago (10,000 yuan). I is the energy consumption of 10,000 yuan of GDP (t standard coal per 10,000 yuan). K is the carbon emission coefficient for coal consumption, set at 0.7476 (t/t)[53].

As of now, the average transaction price in China's eight major carbon market pilot cities was about 29.37 yuan per ton of carbon dioxide[54]. The SCC of the study area can be obtained by calculating the carbon emissions of the study area as in equation (3).

$$SCC = \sum (C_i \times 29.37) \quad (3)$$

2.3.2. Ecosystem Service Value Accounting

(1) ESV Accounting Coefficients

Following the research of Xie et al.[14], this study categorises ecosystem services into four primary types: provisioning services, regulating services, supporting services and cultural services, further subdivided into 11 secondary types. Provisioning services include food production, raw material production and water supply. Regulating services include gas regulation, climate regulation, environmental purification and hydrological regulation. Supporting services include soil conservation, nutrient cycling maintenance and biodiversity maintenance. Cultural services mainly include the providing aesthetic landscape services.

The Zhoushan Archipelago Ecosystem Service Value Equivalence Factor Table is based on the research of Xie et al.[55] Considering the actual land use conditions in the study area and the similarity between landscape types and ecosystem types in the equivalence table, the ecosystem service values for each type are estimated. Accordingly, in the Chinese table of equivalent coefficients for ecosystem service values per unit area, farmland is associated with 'Dry land', forest with 'Mixed forest', shrubland with 'Shrubland', grassland with 'Meadow', waterbody with 'Water', unused land with 'Barren' and mudflat with 'Wetland', and construction land does not provide ecosystem service values. A table of base equivalent coefficients of ecosystem service values per unit area can be obtained and displayed in Table 1.

Table 1. Ecosystem service basis equivalent value per unit area.

Ecosystem classification	Secondary type	Farmland	Forest	Shrubland	Grassland	Waterbody	Construction land	Unused land	Mudflat
Provisioning services	Food production	0.85	0.31	0.19	0.38	0.8	0	0	0.51
	Raw material production	0.4	0.71	0.43	0.56	0.23	0	0	0.5
	Water supply	0.02	0.37	0.22	0.31	8.29	0	0	2.59
Regulating services	Gas regulation	0.67	2.35	1.41	1.97	0.77	0	0.02	1.9
	Climate regulation	0.36	7.03	4.23	5.21	2.29	0	0	3.6
	Environmental purification	0.1	1.99	1.28	1.72	5.55	0	0.1	3.6
	Hydrological regulation	0.27	3.51	3.35	3.82	102.24	0	0.03	24.23
Supporting services	Soil conservation	1.03	2.85	1.72	2.4	0.93	0	0.02	2.31
	Nutrient cycling maintenance	0.12	0.22	0.13	0.18	0.07	0	0	0.18

	Biodiversity maintenance	0.13	2.6	1.57	2.18	2.55	0	0.02	7.87
Cultural services	Providing aesthetic landscape	0.06	1.14	0.69	0.96	1.89	0	0.01	4.73

(2) ESV Coefficient Adjustment

The reference equivalent factor is the ecosystem service value per unit area in China. In order to improve the adaptability, it is necessary to convert the national scale equivalent factor values to the regional scale when applying them to specific events. When applying these coefficients, adjustments are made based on the actual conditions of the study area, taking into account correction factors for crop yield, socio-economic development and resource scarcity.

The equivalent factor values used are defined by the economic value of annual cereal production per hectare in regions with the national average yield. These values serve as key references and form the basis for regional corrections for other types of land use. The correction for cereal yield is based on the ratio of the average cereal yield in the study area to the national average cereal yield. This correction, based on the ratio of cereal yields, reflects regional differences in the total ecological service value compared to the national average[56]:The correction formula is as follows:

$$A = \frac{Q_{ZS}}{Q} \quad (4)$$

Here, A is the Zhoushan Archipelago grain yield correction coefficient, Q_{ZS} and Q represent the per-unit area grain yield in Zhoushan Archipelago and the national average, respectively. According to statistical yearbooks, A is calculated as 0.94 for the years 2005-2020.

The calculation of the socio-economic development coefficient takes into account both willingness and ability to pay. The Engel coefficient represents the share of food expenditure in total personal consumption expenditure. A lower Engel coefficient indicates a lower cost of living, a higher willingness to consume non-food items and a higher willingness to pay. Therefore, the Engel coefficient is used to measure the willingness to pay and GDP per capita represents the ability to pay. The formula for adjusting the ecosystem service value based on the socio-economic development coefficient is as follows:

$$S = \frac{EL_{ZS}}{EL} \times \frac{\overline{GDP}_{ZS}}{\overline{GDP}} \quad (5)$$

Here, S is the socioeconomic development correction coefficient, EL_{ZS} and ELrepresent the Engel coefficients for Zhoushan Archipelago and the national average, respectively, and $\overline{GDP}_{ZS}$ and $\overline{GDP}$ represent the per capita GDP for Zhoushan Archipelago and the national average, respectively. According to statistical yearbooks, S is calculated as 1.89 for the years 2005-2020.

The resource scarcity coefficient reflects the relationship between supply and demand for ecosystem services, with higher scarcity indicating greater demand for services than supply. This coefficient is determined by measuring resource scarcity using population density. The adjustment formula is:

$$R = \frac{\ln P_{ZS}}{\ln P} \quad (6)$$

Here, R is the resource scarcity correction coefficient, $\ln P_{ZS}$ and $\ln P$ represent the population density in Zhoushan Archipelago and the national average, respectively. According to statistical yearbooks, R is calculated as 0.86 for the years 2005-2020.

The calculation formula for the Zhoushan Archipelago standard equivalent factor correction coefficient (EF_{ZS}) is:

$$EF_{ZS} = A \times S \times R \quad (7)$$

The harsh climate and soil conditions on islands limit the development of island vegetation, resulting in differences in vegetation biomass between island and mainland ecosystems. Further adjustments are made to the ecosystem service equivalent of Zhoushan Archipelago's forests.:

$$EF_{forset_{zs}} = \frac{b}{B} \times EF_{forset} \tag{8}$$

Here, $EF_{forset_{zs}}$ is the adjusted per unit area forest ESV equivalent, b is the forest biomass in Zhoushan Archipelago, B is the average biomass of forest ecosystems per unit area in China, and EF_{forset} is the ecosystem service equivalent for Chinese forests.

(3) ESV for Various Land Use Types in Zhoushan Archipelago

Ecosystem service value equivalent (ESVE) refers to the potential capacity of ecosystems to generate the relative contribution of ecosystem services, with a factor of 1 standard unit of ESVE, i.e., the economic value of the annual natural food production of 1 hectare of farmland with a national average yield of 1/7th of the market value of the average local food yield[57]. The formula is:

$$E_V = \frac{1}{7} \times P \times Q \tag{9}$$

Here, E_V is the ESV for one standard equivalent factor, P is the average price of grain (yuan/kg), and Q is the per-unit area grain yield (kg/ha). According to the Zhoushan Archipelago Statistical Yearbook, the average grain yield per unit area during the study period was 4939.81 kg/ha. Additionally, the average price of grain in Zhoushan Archipelago was 2.1 yuan/kg. Through calculations, the ecosystem service value for one standard equivalent factor in Zhoushan Archipelago is determined to be 1481.94 yuan/ha.

The basis ESV equivalent factor was corrected according to Equation (7), and then the forest ESV equivalent factor was further corrected by Equation (8). The ESV per unit area of ecosystem in Zhoushan Archipelago (ESV_{ZS}) was calculated based on the ESV of 1 standard equivalent factor in Zhoushan Archipelago, and the results were displayed in Table 2.

$$ESV_{ZS} = \sum AREA \times E_V \tag{10}$$

Table 2. Ecosystem service value coefficient of Zhoushan Archipelago (unit: yuan /ha).

Ecosystem classification	Secondary type	Farmland	Forest	Shrubland	Grassland	Waterbody	Construction land	Unused land	Mudflat
Provisioning services	Food production	1924.59	540.47	430.2	860.4	1811.38	0	0	1154.75
	Raw material production	905.69	1237.85	973.61	1267.96	520.77	0	0	1132.11
	Water supply	45.28	645.08	498.13	701.91	18770.39	0	0	5864.33
Regulating services	Gas regulation	1517.03	4097.11	3192.55	4460.51	1743.45	0	45.28	4302.02
	Climate regulation	815.12	12256.45	9577.65	11796.59	5185.07	0	0	8151.19
	Environmental purification	226.42	3469.47	2898.2	3894.46	12566.42	0	226.42	8151.19
	Hydrological regulation	611.34	6119.51	7585.14	8649.32	231493.9	0	67.93	54862.06
Supporting services	Soil conservation	2332.15	4968.83	3894.46	5434.13	2105.73	0	45.28	5230.35
	Nutrient cycling maintenance	271.71	383.56	294.35	407.56	158.5	0	0	407.56
	Biodiversity maintenance	294.35	4532.97	3554.83	4936	5773.76	0	45.28	17819.42
Cultural services	Providing aesthetic landscape	135.85	1987.53	1562.31	2173.65	4279.38	0	22.64	10709.76

2.4. Bivariate Spatial Correlation Analysis

To visually analyse the spatio-temporal patterns of ESV and SCC in Zhoushan Archipelago, a fishnet analysis tool was used. The city was divided into a grid of 3 km × 3 km using kilometre grids. By calculating the ESV and SCC for each grid, the spatio-temporal variations of ESV and SCC for Zhoushan Archipelago were obtained. This stage was carried out using ArcGIS 10.4.

Subsequently, the bivariate Moran's index was used to explore the spatial clustering and dispersion between ESV and SCC. The global bivariate Moran's I examined whether there was spatial correlation and the degree of spatial correlation between carbon emission social cost intensity and ESV intensity across the region. Meanwhile, the local bivariate Moran's I showed spatial correlations at specific grid cells[58]. The analysis was carried out using Geoda.

3. Results

3.1. Spatiotemporal Evolution of Land Use Structure in Zhoushan Archipelago

The area of each land-use type was systematically recorded, as detailed in Table 3. The unit is hectare.

Table 3. Temporal changes of land type area in Zhoushan Archipelago, 2010-2020 (unit: hectare).

Land use type	Year 2010	2015	2020
Farmland	25445.86	25694.56	25609.90
Forest	71758.81	70961.86	70919.01
Shrubland	3660.83	3763.73	3763.66
Grassland	1270.99	2302.81	2302.81
Waterbody	6270.76	6342.48	5904.85
Construction land	25728.66	28599.03	29441.51
Unused land	20.50	20.91	20.91
Mudflat	4077.15	4411.54	4133.77
Total land area	138233.57	142096.94	142096.42

Our land use classification results show that the total land area of Zhoushan Archipelago increased between 2010 and 2015, mainly due to human reclamation activities. The area decreased slightly from 2015 to 2020, with relatively small changes. The area of forest and water gradually decreased each year, while the area designated for construction steadily increased. Influenced by human reclamation activities on mudflats, grassland and mudflat areas showed an overall increase. Other types of land use showed relatively stable changes, with small fluctuations in their contribution rates.

3.2. Spatiotemporal Evolution of SCC

Utilizing the area of each land-use type and carbon emission coefficients for Zhoushan Archipelago, the carbon emissions for each land type during 2010–2020 were calculated using formulas (1) and (2). The results are presented in Table 4. According to Equation (3), carbon emissions are used to calculate the SCC, which is divided into five levels from low to high for display, and the results of its spatial and temporal changes are shown in Figure 2.

Table 4. Temporal changes of carbon emissions in Zhoushan Archipelago,2010-2020 (unit: t).

Land use type	Year 2010	2015	2020
Farmland	10738. 15	10843. 11	10807. 38
Forest	−41691. 87	−41228. 84	−41203. 95
Shrubland	−589. 39	−605. 96	−605. 95
Grassland	−26. 69	−48. 36	−48. 36
Waterbody	−1586. 50	−1604. 65	−1493. 93
Construction land	571493. 23	1166625. 60	16078977. 24
Unused land	−0. 10	−0. 10	−0. 10
Mudflat	−6270. 65	−6784. 95	−6357. 74
Total Sink	50165.21	50272.87	49710.03

Source	582231.38	1177468.70	16089784.62
Net carbon emission	532066.17	1127195.83	16040074.59

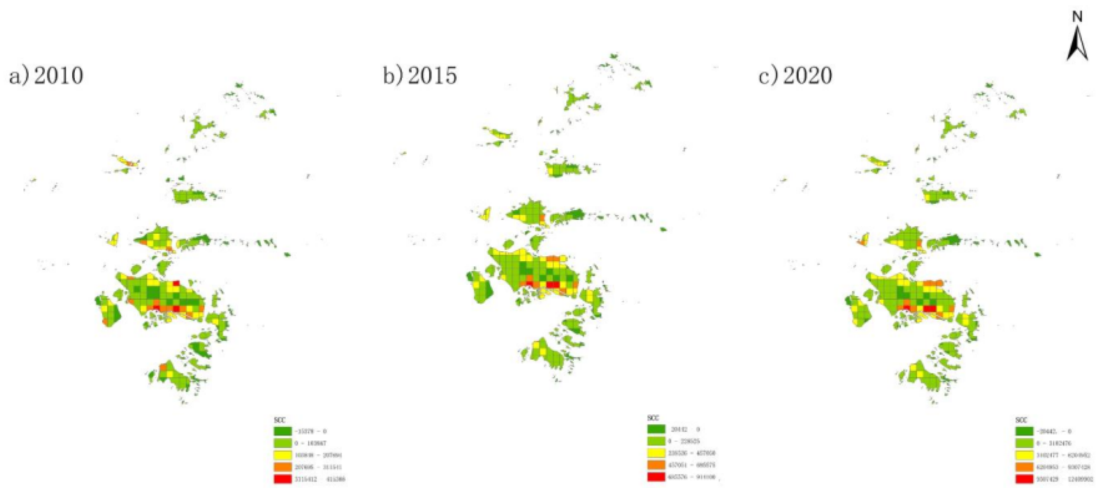

Figure 2. Temporal and spatial changes of SCC in Zhoushan Archipelago.

The carbon emissions results show that the net carbon emissions in Zhoushan Archipelago were consistently positive from 2010 to 2020, reflecting an overall trend in carbon emissions. Between 2010 and 2015, the net carbon emissions showed a significant upward trend, increasing from 53.21 × 10^4 t to 1604.01 × 10^4 t in 2020. The growth trend slowed down between 2015 and 2020. The carbon source showed a similar trend to the net carbon emissions, with a slight decrease in carbon sinks. Looking at the carbon source composition, carbon emissions from construction land increased from 1,057.91 × 10^4 t to 4,125.12 × 10^4 t, making it the main carbon source. This increase was mainly due to the rapid urbanisation and industrialisation of Zhoushan Archipelago after 2010, which led to a significant increase in carbon emissions from construction land. The per capita carbon emissions from construction land, which represents the carbon emission intensity of construction land in each year and the energy consumption structure of the region, has shown a rapid growth trend since 2015, with the per capita carbon emissions from construction land in each year being 22.21, 40.79 and 546.13 t/ha, respectively. Looking at the composition of carbon sinks, forests are the main carbon sink, followed by mudflats. The share of each land category remains relatively constant.

Figure 3 shows significant spatio-temporal variations in the carbon emission intensity of land use in the urban cluster from 2010 to 2015. The lowest level is manifested as a carbon sink, mainly located in the central area of Zhoushan Island, the coastal fringe of larger islands and some fragmented small islands far from land, while all other levels are manifested as carbon sources. Specifically, the areas with higher social cost intensity of carbon emissions are mainly located in Zhoushan Island, Daishan Island, Liuhang Island and Jintang Township, which are the four regions with large areas and the most concentrated population. Yuoshan Island, to the left of Daishan Island, is a typical industrial island, and its carbon emissions have increased steadily over the study period. The scattered islands in the periphery, far from the mainland, are low carbon emission areas, benefiting from their small size, difficult development and sparse human activities.

3.3. Spatiotemporal Evolution of Ecosystem Service Value

Using Formula (9), the spatiotemporal changes in ESV in Zhoushan Archipelago from 2010 to 2020 were calculated based on the area of each land type and its ESV, as shown in Table 5. The ESV temporal changes categorized by land-use type are presented in Table 6. The ESV intensity changes were divided into five levels, and the results are shown in Figure 3.

Table 5. Temporal changes of ESV for functional division,2010-2020 (unit: million yuan).

Secondary ecosystem classification	Year 2010	2015	2020
Food supply	106.49	107.99	106.69
Raw material	124.93	125.99	125.32
Water supply	191.77	195.35	185.48
Gas regulation	378.44	382.04	379.78
Climate regulation	1016.05	1022.74	1017.62
Purifying environment	382.33	387.56	379.63
Hydrology adjustment	2168.77	2208.70	2091.84
Soil conservation	471.60	476.12	473.34
Nutrient cycling	38.69	39.05	38.83
Biodiversity protection	460.92	469.21	461.51
Cultural & amenity services	225.06	229.80	224.86
Total	5565.04	5644.56	5484.88

Table 6. Temporal Changes of ESV by land use type division,2010-2020 (unit: million yuan).

Land use type	Year 2010	2015	2020
Farmland	231.04	233.29	232.53
Forest	2887.49	2855.42	2853.70
Shrubland	126.16	129.70	129.70
Grassland	56.66	102.67	102.67
Waterbody	1783.46	1803.86	1679.39
Construction land	0.00	0.00	0.00
Unused land	0.01	0.01	0.01
Mudflat	480.23	519.61	486.90
Total	5565.04	5644.56	5484.88

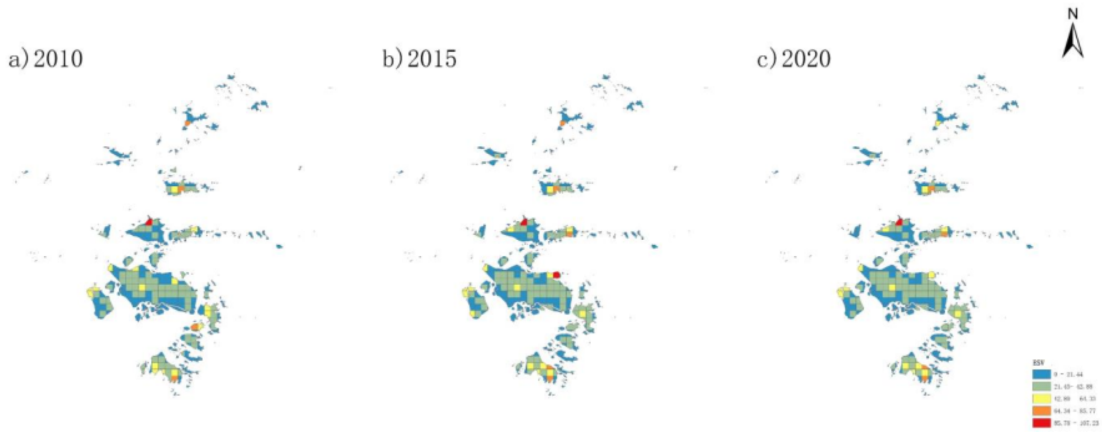

Figure 3. Temporal and spatial variation of ESV in Zhoushan Archipelago.

The results obtained show that the total ESV in Zhoushan Archipelago showed a fluctuating process from 2010 to 2020, characterised by an initial increase followed by a subsequent decrease. Overall, there was a decreasing trend, from 5565.04 million yuan in 2010 to 5484.88 million yuan in 2020, representing a decrease of 1.5%. In terms of individual ESV functionalities, hydrological regulation and climate regulation emerged as major contributors, together accounting for 57% of the total. Climate regulation increased, hydrological regulation decreased and other functions remained stable. Looking at the different land use types, woodland and watershed are the main contributors to ESV, both accounting for 83% of the total, followed closely by mudflat. Grassland increased, watershed decreased and other types fluctuated within a 1% range.

From Figure 4, the spatial and temporal variations of ESV intensity in Zhoushan Archipelago changed slightly over the study period, with an overall decreasing trend.The regions with low ESV values are mainly distributed in coastal areas near large islands, which are also aggregations of built-up areas, while the regions with high ESV values are concentrated in areas with large forest, water and mudflat areas, in line with the distribution of different land use types and their respective ESV contribution rates.

3.4. Spatial Correlation Analysis between ESV and SCC

Using Geoda software, a bivariate global Moran's I index analysis was conducted for the ESV and SCC of carbon emissions in Zhoushan Archipelago from 2020 to 2020. The analysis included 999 randomisations for testing and the results are shown in Table 7. The Moran scatterplot is shown in Figure 4, where each quadrant represents High-High (H-H), Low-High (L-H), Low-Low (L-L) and High-Low (H-L) clustering types. In addition, bivariate local Moran's I analysis was used to examine the spatial clustering relationship within individual grid cells for ESV intensity and social cost intensity of carbon emissions, as shown in Figure 5.

Table 7. Bivariate global Moran 'I index of Zhoushan Archipelago from 2010 to 2020.

Year	Moran 'I	P-value	z-value
2010	0.128	0.001	13.3427
2015	0.141	0.001	14.7151
2020	0.14	0.001	14.3616

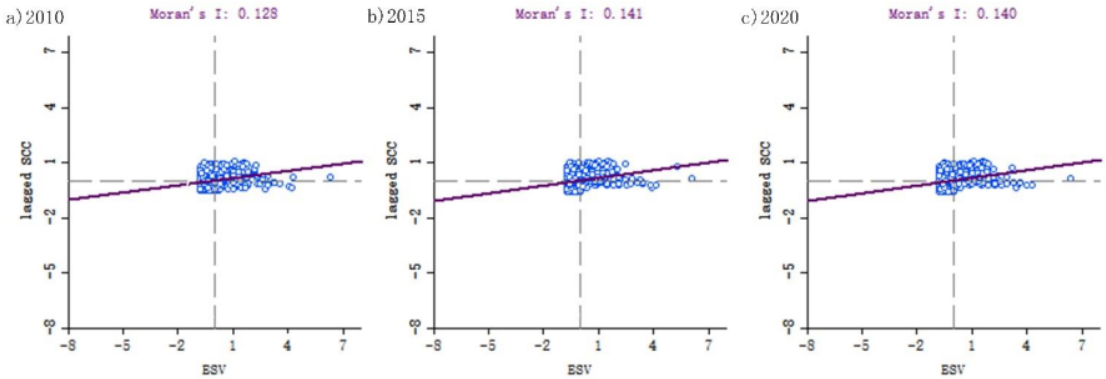

Figure 4. Moran scatter plot 2010-2020.

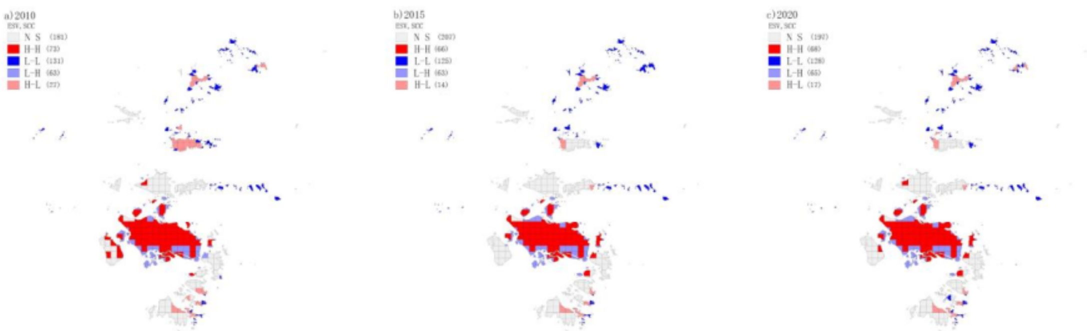

Figure 5. Spatial correlation between ESV and SCC.

The results show that the correlation coefficients between ESV and scc in Zhoushan Archipelago from 2010 to 2020 were 0.142, 0.136 and 0.134, respectively. The Moran's I value was positive, with p-values < 0.01 and z-values > 2.58, indicating a significant positive spatial correlation between ESV and SCC at 99% confidence level. In other words, regions with high ESV tend to have high SCC. This does not seem to fit with our current knowledge. In general, a high ESV corresponds to a low SCC.We have explored the causes of this result through bivariate local analysis. Looking at Figure 5, ESV and SCC are clustered in the first and third quadrants, while they are dispersed in the second and fourth quadrants. This confirms that the H-H and L-L types show clustering, while the L-H and H-L types are spatially dispersed.

Figure 6 shows that the changes in clustering types in Zhoushan Archipelago over time are minimal. During the study period, the number of grids in H-L and L-H increased, while the number of grids in H-H and L-L decreased. H-H and L-L were the regions with positive correlation between ESV and SCC, and L-H and H-L were the regions with negative correlation between ESV and SCC. The proportion of networks with a positive correlation is 24% higher than the proportion of networks with a negative correlation. H-H is mainly concentrated in Zhoushan Island, Putuoshan Island, Daishan Island and other economically active regions with significant carbon emissions. These areas also prioritise environmental protection, resulting in higher ESV. Some islands, such as Shengsi Archipelago and Dongji Archipelago, have L-L characteristics due to their distance from the mainland, limited human activities and lower carbon emissions. At the same time, these areas have single vegetation types and poorer ecological environments, which contribute less to ESV. L-H is distributed in areas where construction land is accumulating on

Zhoushan Island. Urbanisation affects ecological resources in these regions, causing some degree of environmental degradation, resulting in lower ESV and higher carbon emissions. H-L is mainly found on Qushan Island, some islands in Shengsi County and some islands in the eastern part of Putuo District. Local correlations in other regions are not significant (NS).

4. Discussion

The analysis of changes in land use shows that during the study period, changes in total land area were mainly driven by reclamation and development of the Wadden Sea. Overall, the growth of land resources on the islands is limited. Construction land has continued to increase, while other types of land, such as farmland, have decreased proportionately. The inconvenience of transport has been a major factor limiting island development. However, after 2010, the construction of cross-sea bridges in Zhoushan accelerated the development of islands. Rapid economic development and accelerated urbanisation and industrialisation have led to an increase in human activities on built-up areas, resulting in an increase in carbon emissions. From 2010 to 2020, Zhoushan's net carbon emissions increased by 1550.8 × 10^4 t, and the SCC increased by 2452%. The total ESV of Zhoushan Archipelago showed a downward trend during the study period, with a small change of 1.5%. This is attributed to the high ESV of land types such as forests and waterbody, which have strong ecological compensation capabilities. Mudflat, as a characteristic land type of islands, should also not be overlooked. Therefore, future development should pay attention to the protection of forests, waterbody and mudflats in order to increase regional ESV and promote high quality development.

This study was motivated by two main reasons. First, previous studies have mostly treated carbon emissions and ecosystem service values as separate evaluation units to assess environmental benefits, with limited studies on their correlation[28,29,31,59]. Second, scholars have mainly focused their research on the provincial level or above, with less attention to coastal and island areas[60]. Wang's [30] study on the urban agglomeration of the Central Plains found a significant negative spatial correlation between carbon emissions and ESV, which passed the p-value test. In contrast, this study focuses on island cities and examines two separate indicators used to assess environmental benefits, ESV and SCC, and concludes that there is a strong positive spatial correlation at the 99% confidence level between Zhoushan Archipelago's ESV and the SCC. This contradicts previous research. Looking at the reasons for the differences, firstly, the number of grids with a positive correlation between ESV and SCC, i. e. the percentage of regions with a positive correlation, is larger than those with a negative correlation. Second, the scarcity of freshwater resources and the ecological fragility of the islands, the government emphasises the conservation of high ESV areas such as forests, waters and mudflat. Third, the population density of the islands is much lower than that of the inland cities, and the limited land resources of the islands make it impossible to expand the construction land without limitation, and the proportion of construction land is smaller than that of forest and other natural land. Fourthly, the archipelago region is land scattered, low adjacency between grid cells and long distances affects the results, resulting in insignificant correlations in many areas. There are few areas where ESV and SCC show a negative correlation, overlapping with the area where construction land is located.

Our study provides a case analysis of the spatial distribution characteristics of the social costs of land carbon emissions and ecosystem service values associated with land use change during rapid urbanisation. However, there are some potential limitations that require further refinement. First, based on extensive studies that define farmland as a carbon source and refer to carbon emission coefficients, farmland could also act as a carbon sink[61]. Due to the difficulty in obtaining data, the carbon emissions from construction land in Zhoushan Archipelago are based on the output value of secondary and tertiary industries, and the accuracy of carbon accounting may differ from the actual situation. Therefore, in the future, carbon emission coefficients should be determined scientifically and reasonably based on the actual situation of the region.

5. Conclusion

Land use change analysis: From 2010 to 2015, land area increased due to tidal flat reclamation and land reclamation activities, with construction land showing the largest increase among all land types. However, strict policies controlling land reclamation and limited land resources on islands prevent unrestricted expansion of construction land. The total area of islands started to stabilise after 2015.

Spatial and temporal evolution of carbon emissions and their social costs: During the study period, Zhoushan Archipelago showed a trend in carbon emissions. Forests were the main carbon sink land, followed by mudflats and waterbody. Construction land was the largest contributor to carbon emissions. The accelerated industrialisation from 2010 to 2015 led to the rapid development of secondary and tertiary industries, which significantly increased carbon emissions. During the study period, the SCC in Zhoushan Archipelago increased by 2452%.

Spatial and temporal evolution of ESV: The analysis of the temporal and spatial evolution of SCE during the study period showed an overall decrease, which was attributed to the increase in construction land. The change was minimal, with a decrease of only 1.5%. The global spatial correlation analysis of ESV and SCC showed that: The analysis revealed a significant positive spatial correlation between ESV and the social cost of carbon emissions in Zhoushan Archipelago from 2010 to 2020. The Moran's I passed the p-value test. The analysis of the local spatial correlation between ESV and SCC showed that the contribution rate of the area with a positive correlation between the two was 24% higher than the contribution rate of the area with a negative correlation, and that the land with carbon sinks, such as forest, had a high level of retention and accounted for a higher proportion of land use than the land with carbon sources, such as construction land. The global spatial correlation of ESV and SCC in the island region has special features.

Reference

1. Seddon, N.; Chausson, A.; Berry, P.; Girardin, C.A.J.; Smith, A.; Turner, B. Understanding the Value and Limits of Nature-Based Solutions to Climate Change and Other Global Challenges. *Philosophical Transactions of the Royal Society B: Biological Sciences* **2020**, *375*, 20190120, doi:10.1098/rstb.2019.0120.
2. Shi, X.; Zhang, J.; Lu, S.; Wang, T.; Zhang, X. China Carbon Neutralization Research Status and Research Frontier Tracking. *Frontiers in Environmental Science* **2022**, *10*.
3. Liu, M.; Chen, Y.; Chen, K.; Chen, Y. Progress and Hotspots of Research on Land-Use Carbon Emissions: A Global Perspective. *Sustainability* **2023**, *15*, doi:10.3390/su15097245.
4. Special Report on Climate Change and Land — IPCC Site Available online: https://www.ipcc.ch/srccl/ (accessed on 8 December 2023).
5. Canelas, J.V.; Pereira, H.M. Impacts of Land-Use Intensity on Ecosystems Stability. *Ecological Modelling* **2022**, *472*, 110093, doi:10.1016/j.ecolmodel.2022.110093.
6. Hasan, S.S.; Zhen, L.; Miah, Md.G.; Ahamed, T.; Samie, A. Impact of Land Use Change on Ecosystem Services: A Review. *Environmental Development* **2020**, *34*, 100527, doi:10.1016/j.envdev.2020.100527.
7. Rahman, M.M.; Szabó, G. A Novel Composite Index to Measure Environmental Benefits in Urban Land Use Optimization Problems. *ISPRS International Journal of Geo-Information* **2022**, *11*, 220, doi:10.3390/ijgi11040220.
8. Alpino, M.; Citino, L.; Zeni, F. Costs and Benefits of the Green Transitionenvisaged in the Italian NRRP - An Evaluation Using the Social Cost of Carbon. *Energy Policy* **2023**, *182*, 113744, doi:10.1016/j.enpol.2023.113744.
9. Accounting for Ecosystem Service Values in Climate Policy | Nature Climate Change Available online: https://www.nature.com/articles/s41558-022-01362-0 (accessed on 8 December 2023).
10. Jeffers, E.S.; Nogué, S.; Willis, K.J. The Role of Palaeoecological Records in Assessing Ecosystem Services. *Quaternary Science Reviews* **2015**, *112*, 17–32, doi:10.1016/j.quascirev.2014.12.018.
11. Reid, W.; Mooney, H.; Cropper, A.; Capistrano, D.; Carpenter, S.; Chopra, K. *Millennium Ecosystem Assessment. Ecosystems and Human Well-Being: Synthesis*; 2005;
12. Costanza, R. Valuing Natural Capital and Ecosystem Services toward the Goals of Efficiency, Fairness, and Sustainability. *Ecosystem Services* **2020**, *43*, 101096, doi:10.1016/j.ecoser.2020.101096.
13. Li L; Wang XY; Luo L; Ji XY; Zhao Y; Zhao YC; Nabil Bachagha A review of ecosystem service valuation methods. Journal of Ecology 2018, 37, 1233-1245, doi:10.13292/j.1000-4890.201804.031.
14. Xie, Gao Di; Zhang, Caixia; Zhang, Changshun; Xiao, Yu; Lu, Chunxia The value of ecosystem services in China. Resource Science 2015, 37, 1740-1746.
15. The Value of the World's Ecosystem Services and Natural Capita.

16. Xie, Gao Di; Zhen, Lin; Lu, Chunxia; Xiao, Yu; Chen, Cao An expert knowledge-based approach to ecosystem service valorisation. Journal of Natural Resources 2008, 911-919.
17. Liu, L.; Zhang, H.; Zhang, Y.; Li, F.; Chen, X.; Wang, Y.; Wang, Y. *Spatiotemporal Heterogeneity Correction in Land Ecosystem Services and Its Value Assessment: A Case Study of the Loess Plateau of China*; In Review, 2022;
18. Chuai, X.; Huang, X.; Wang, W.; Zhao, R.; Zhang, M.; Wu, C. Land Use, Total Carbon Emissions Change and Low Carbon Land Management in Coastal Jiangsu, China. *Journal of Cleaner Production* **2015**, *103*, 77–86, doi:10.1016/j.jclepro.2014.03.046.
19. Houghton, R.A. Interactions Between Land-Use Change and Climate-Carbon Cycle Feedbacks. *Curr Clim Change Rep* **2018**, *4*, 115–127, doi:10.1007/s40641-018-0099-9.
20. Cai, C.; Fan, M.; Yao, J.; Zhou, L.; Wang, Y.; Liang, X.; Liu, Z.; Chen, S. Spatial-Temporal Characteristics of Carbon Emissions Corrected by Socio-Economic Driving Factors under Land Use Changes in Sichuan Province, Southwestern China. *Ecological Informatics* **2023**, *77*, 102164, doi:10.1016/j.ecoinf.2023.102164.
21. Zhang, F.; Xu, N.; Wang, C.; Wu, F.; Chu, X. Effects of Land Use and Land Cover Change on Carbon Sequestration and Adaptive Management in Shanghai, China. *Physics and Chemistry of the Earth, Parts A/B/C* **2020**, *120*, 102948, doi:10.1016/j.pce.2020.102948.
22. Xia, C.; Zhang, J.; Zhao, J.; Xue, F.; Li, Q.; Fang, K.; Shao, Z.; Zhang, J.; Li, S.; Zhou, J. Exploring Potential of Urban Land-Use Management on Carbon Emissions—— A Case of Hangzhou, China. *Ecological Indicators* **2023**, *146*, 109902, doi:10.1016/j.ecolind.2023.109902.
23. Wu, H.; Qiu, Y.; Yin, L.; Liu, S.; Zhao, D.; Zhang, M. Effects of China's Land-Intensive Use on Carbon Emission Reduction: A New Perspective of Industrial Structure Upgrading. *Frontiers in Environmental Science* **2022**, *10*.
24. Tian, L.; Ye, Q.; Zhen, Z. A New Assessment Model of Social Cost of Carbon and Its Situation Analysis in China. *Journal of Cleaner Production* **2019**, *211*, 1434–1443, doi:10.1016/j.jclepro.2018.11.117.
25. Zhang, G.; Zheng, D.; Xie, L.; Zhang, X.; Wu, H.; Li, S. Mapping Changes in the Value of Ecosystem Services in the Yangtze River Middle Reaches Megalopolis, China. *Ecosystem Services* **2021**, *48*, 101252, doi:10.1016/j.ecoser.2021.101252.
26. Bao, J.; Wang, W.; Zhao, T. Spatiotemporal Changes of Ecosystem Service Values in Response to Land Cover Dynamics in China from 1992 to 2020. *Sustainability* **2023**, *15*, doi:10.3390/su15097210.
27. Saha, S.; Bera, B.; Shit, P.K.; Bhattacharjee, S.; Sengupta, N. Estimation of Carbon Budget through Carbon Emission-Sequestration and Valuation of Ecosystem Services in the Extended Part of Chota Nagpur Plateau (India). *Journal of Cleaner Production* **2022**, *380*, 135054, doi:10.1016/j.jclepro.2022.135054.
28. Effects of Land Use Cover Change on Carbon Emissions and Ecosystem Services in Chengyu Urban Agglomeration, China | Stochastic Environmental Research and Risk Assessment Available online: https://link.springer.com/article/10.1007/s00477-020-01819-8 (accessed on 2 December 2023).
29. Tang, F.; Yin, Y. L.; Zhang, P. T.; Bai, N. Study on the value of ecosystem services and carbon emission risk in Gaoyang County based on land use change. Soil and Water Conservation Research 2019, 26, 265-271, doi:10.13869/j.cnki.rswc.2019.04.040.
30. Wang Boyang, B. Spatial relationship between land use carbon emissions and ecosystem service value. China Water Transport (2nd half) 2021, 21, 77-78.
31. Du, X.; Huang, Z. Ecological and Environmental Effects of Land Use Change in Rapid Urbanization: The Case of Hangzhou, China. *Ecological Indicators* **2017**, *81*, 243–251, doi:10.1016/j.ecolind.2017.05.040.
32. Yang, S.; Zheng, X. Spatio-Temporal Relationship between Carbon Emission and Ecosystem Service Value under Land Use Change: A Case Study of the Guanzhong Plain Urban Agglomeration, China. *Frontiers in Environmental Science* **2023**, *11*.
33. van den Bergh, J.C.J.M.; Botzen, W.J.W. Monetary Valuation of the Social Cost of CO2 Emissions: A Critical Survey. *Ecological Economics* **2015**, *114*, 33–46, doi:10.1016/j.ecolecon.2015.03.015.
34. Comprehensive Evidence Implies a Higher Social Cost of CO2 | Nature Available online: https://www.nature.com/articles/s41586-022-05224-9 (accessed on 8 December 2023).
35. Rickels, W.; Meier, F.; Quaas, M. The Historical Social Cost of Fossil and Industrial CO2 Emissions. *Nat. Clim. Chang.* **2023**, *13*, 742–747, doi:10.1038/s41558-023-01709-1.
36. Muenzel, D.; Martino, S. Assessing the Feasibility of Carbon Payments and Payments for Ecosystem Services to Reduce Livestock Grazing Pressure on Saltmarshes. *Journal of Environmental Management* **2018**, *225*, 46–61, doi:10.1016/j.jenvman.2018.07.060.
37. Li L; Ma YC A review and outlook of ecological vulnerability studies on sea islands. Ocean Development and Management 2018, 35, 60-67, doi:10.20016/j.cnki.hykfygl.2018.10.012.
38. Wang, Xiaoli; Wang Ooi; Shi, Honghua; Zheng, Wei; Zhou, R. A method for estimating carbon sequestration in island terrestrial ecosystems. Journal of Ecology 2014, 34, 88-96.
39. Doorga, J.R.S.; Deenapanray, P.N.K.; Rughooputh, S.D.D.V. Geographic Carbon Accounting: The Roadmap for Achieving Net-Zero Emissions in Mauritius Island. *Journal of Environmental Management* **2023**, *333*, 117434, doi:10.1016/j.jenvman.2023.117434.
40. Zhao, Sheng; Li, Mengna; Wu, Changwen Assessing the energetic value of ecosystem services in Zhoushan Sea. Journal of Ecology 2015, 35, 678-685.
41. Xu, C.; Jiang, W.; Huang, Q.; Wang, Y. Ecosystem Services Response to Rural-Urban Transitions in Coastal and Island Cities: A Comparison between Shenzhen and Hong Kong, China. *Journal of Cleaner Production* **2020**, *260*, 121033, doi:10.1016/j.jclepro.2020.121033.
42. Zhoushan Statistics Bureau Available online: http://zstj.zhoushan.gov.cn/ (accessed on 2 December 2023).
43. Centre for Resource and Environmental Sciences and Data, Chinese Academy of Sciences Available online: https://www.resdc.cn/ (accessed on 2 December 2023).
44. Zhejiang Province Geographic Information Public Service Platform Available online: https://ditu.zjzwfw.gov.cn/ (accessed on 2

December 2023).
45. Data - National Statistical Office Available online: https://www.stats.gov.cn/sj/ (accessed on 2 December 2023).
46. Sun, H.; Liang, H.; Chang, X. L.; Cui, Z.; Tao, Y. Carbon emissions from land use and their spatial correlation in China. Economic Geography 2015, 35, 154-162, doi:10.15957/j.cnki.jjdl.2015.03.023.
47. Chen, L.; Hang, Y.; Li, Q. Spatial-Temporal Characteristics and Influencing Factors of Carbon Emissions from Land Use and Land Cover in Black Soil Region of Northeast China Based on LMDI Simulation. *Sustainability* **2023**, *15*, 9334, doi:10.3390/su15129334.
48. Fang, Jingyun; Guo, Zhaodi; Park, Shilong; Chen, Anping Estimation of carbon sinks in terrestrial vegetation in China from 1981 to 2000. Science China (Series D: Earth Sciences) 2007, 804-812.
49. Xu, Ying; Guo, Nan; Ru, Kaili; Fan, Shenglong Characteristics and optimisation strategies of spatial zoning of land in Fujian Province under the perspective of carbon neutrality. Journal of Applied Ecology 2022, 33, 500-508, doi:10.13287/j.1001-9332.202201.016.
50. Lai Li Carbon Emission Effects of Land Use in China. PhD, Nanjing University, 2011.
51. The Carbon Stock and Sequestration Rate in Tidal Flats From Coastal China Available online: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2020GB006772 (accessed on 2 December 2023).
52. Wang, Guibo; Nan, Ling Analysis of spatial and temporal differences in the carbon emission effects of land use in Shaanxi Province. Resources and Industries 2012, 14, 124-130, doi:10.13776/j.cnki.resourcesindustries.2012.01.023.
53. Xu, G.Q.; Liu, Z.Y.; Jiang, Z.H. Factor decomposition modelling and empirical analysis of carbon emissions in China: 1995-2004. China Population-Resources and Environment 2006, 158-161.
54. Construction of a Carbon Price Benchmark in China—Analysis of Eight Pilot Markets | Environmental Science and Pollution Research Available online: https://link.springer.com/article/10.1007/s11356-021-18137-3 (accessed on 8 December 2023).
55. Xie, G.; Zhang, C.; Zhen, L.; Zhang, L. Dynamic Changes in the Value of China's Ecosystem Services. *Ecosystem Services* **2017**, *26*, 146–154, doi:10.1016/j.ecoser.2017.06.010.
56. Xu, Li-Fen; Xu, Xue-Gong; Luo, Tao; Zhu, Gao-Ru; Ma, Zong-Wen A land use-based method for revising the equivalent value of ecosystem services - A case study of the Bohai Bay coast. Geography Research 2012, 31, 1775-1784.
57. Xie, Gao Di; Zhang, Caixia; Zhang, Leiming; Chen, Wenhui; Li, Shimei Improvement of ecosystem service valorisation method based on unit area value equivalent factor. Journal of Natural Resources 2015, 30, 1243-1254.
58. Wang, Dan; Jing, Yande; Han, Shanmei; Gao, Mingxiu A grid-based analysis of spatial and temporal relationships between land use carbon emissions and their ecosystem service values in the Nansihu Basin. Journal of Ecology 2022, 42, 9604-9614.
59. Wang Boyang Research on the spatial and temporal evolution of ecosystem service value and carbon emission based on LUCC. Master, Kunming University of Science and Technology, 2022.
60. Zhao, Xianchao; Tian, Yidou; Zhang, Xiaoxiang Analysis of spatial and temporal relationship between carbon emissions from land use and ecosystem service value in ChangZhuTan urban agglomeration. Journal of Soil and Water Conservation 2023, 37, 215-225, doi:10.13870/j.cnki.stbcxb.2023.05.026.
61. Ma T. Assessment of the current status of agricultural carbon sources and analysis of the potential for increasing carbon sinks in Shanghai. Agricultural Environment and Development 2011, 28, 38-41.

sustainability-2790824-peer-review-v1.pdf

ORIGINALITY REPORT

27%

SIMILARITY INDEX

PRIMARY SOURCES

1	www.mdpi.com Internet	488 words — 7%
2	mdpi-res.com Internet	200 words — 3%
3	open.uct.ac.za Internet	107 words — 1%
4	www.frontiersin.org Internet	96 words — 1%
5	royalsocietypublishing.org Internet	50 words — 1%
6	www.researchgate.net Internet	43 words — 1%
7	www.researchsquare.com Internet	41 words — 1%
8	link.springer.com Internet	36 words — < 1%
9	Can Cai, Min Fan, Jing Yao, Lele Zhou, Yuanzhe Wang, Xiaoying Liang, Zhaoqiang Liu, Shu Chen. "Spatial-temporal characteristics of carbon emissions corrected by socio-economic driving factors under land use changes in	33 words — < 1%

Sichuan Province, southwestern China", Ecological Informatics, 2023
Crossref

10	Xufeng Cui, Liuyi Huang. "Integrating ecosystem services and ecological risks for urban ecological zoning: a case study of Wuhan City, China", Human and Ecological Risk Assessment: An International Journal, 2023 Crossref	29 words — < 1%
11	agri.ckcest.cn Internet	26 words — < 1%
12	www.nature.com Internet	22 words — < 1%
13	Xin Yang, Guangyin Shang, Xiangzheng Deng. "Estimation, decomposition and reduction potential calculation of carbon emissions from urban construction land: evidence from 30 provinces in China during 2000–2018", Environment, Development and Sustainability, 2021 Crossref	21 words — < 1%
14	Yali Wang, Yangyang Liu, Zijun Wang, Yan Zhang et al. "Assessing the Spatio-Temporal Dynamics of Land Use Carbon Emissions and Multiple Driving Factors in the Guanzhong Area of Shaanxi Province", Sustainability, 2023 Crossref	20 words — < 1%
15	Xuejun Du, Zhonghua Huang. "Ecological and environmental effects of land use change in rapid urbanization: The case of hangzhou, China", Ecological Indicators, 2017 Crossref	19 words — < 1%

16 Qian Xu, Yu-xiang Dong, Ren Yang, Hong-ou Zhang, Chang-jian Wang, Zhi-wei Du. "Temporal and spatial differences in carbon emissions in the Pearl River Delta based on multi-resolution emission inventory modeling", Journal of Cleaner Production, 2019
Crossref
18 words — < 1%

17 Yangcheng Hu, Yi Liu, Zhongyue Yan. "Research Regarding the Coupling and Coordination Relationship between New Urbanization and Ecosystem Services in Nanchang", Sustainability, 2022
Crossref
18 words — < 1%

18 Yizhong Chen, Hongwei Lu, Jing Li, Jun Xia. "Effects of land use cover change on carbon emissions and ecosystem services in Chengyu urban agglomeration, China", Stochastic Environmental Research and Risk Assessment, 2020
Crossref
18 words — < 1%

19 ir.igsnrr.ac.cn
Internet
18 words — < 1%

20 Zhi-Jie Wang, Shu-Jun Liu, Jing-Hao Li, Chen Pan, Jin-Long Wu, Jun Ran, Yuan Su. "Remarkable improvement of ecosystem service values promoted by land use/land cover changes on the Yungui Plateau of China during 2001–2020", Ecological Indicators, 2022
Crossref
17 words — < 1%

21 journals.plos.org
Internet
16 words — < 1%

22 www.tandfonline.com
Internet
16 words — < 1%

23 Bohao Wei, Alimujiang Kasimu, Rukeya Reheman, Xueling Zhang, Yongyu Zhao, Yimuranzi Aizizi, Hongwu Liang. "Spatiotemporal characteristics and prediction of carbon emissions/absorption from land use change in the urban agglomeration on the northern slope of the Tianshan Mountains", Ecological Indicators, 2023 — 15 words — < 1%
Crossref

24 Quanxi Li, Biao Ma, Liwei Zhao, Zixuan Mao, Li Luo, Xuelu Liu. "Landscape Ecological Risk Evaluation Study under Multi-Scale Grids—A Case Study of Bailong River Basin in Gansu Province, China", Water, 2023 — 15 words — < 1%
Crossref

25 Shuming Ma, Jie Huang, Yingying Chai. "Proposing a GEE-Based Spatiotemporally Adjusted Value Transfer Method to Assess Land-Use Changes and Their Impacts on Ecosystem Service Values in the Shenyang Metropolitan Area", Sustainability, 2021 — 15 words — < 1%
Crossref

26 www.kerwa.ucr.ac.cr — 15 words — < 1%
Internet

27 Chaoxian Liu, Xueling Wu, Lei Wang. "Analysis on land ecological security change and affect factors using RS and GWR in the Danjiangkou Reservoir area, China", Applied Geography, 2019 — 14 words — < 1%
Crossref

28 Hejie Wei, Jiaxin Zheng, Dong Xue, Xiaobin Dong, Mengxue Liu, Yali Zhang. "Identifying the Relationship between Livelihoods and Land Ecosystem Services Using a Coupled Model: A Case Study in the “One River and Two Tributaries” Region of Tibet", Land, 2022 — 14 words — < 1%
Crossref

29 Pengyan Zhang, Jianjian He, Xin Hong, Wei Zhang, Chengzhe Qin, Bo Pang, Yanyan Li, Yu Liu. "Carbon sources/sinks analysis of land use changes in China based on data envelopment analysis", Journal of Cleaner Production, 2018 — 14 words — < 1%

Crossref

30 Kai Wang, Xiaobing Li, Xin Lyu, Dongliang Dang, Huashun Dou, Mengyuan Li, Siyu Liu, Wanyu Cao. "Optimizing the Land Use and Land Cover Pattern to Increase Its Contribution to Carbon Neutrality", Remote Sensing, 2022 — 13 words — < 1%

Crossref

31 "Research on ecological compensation in Anhui Province of China based on ecological footprint and ecosystem service value", The Frontiers of Society, Science and Technology, 2023 — 12 words — < 1%

Crossref

32 Hequ Huang, Jia Zhou. "Study on the Spatial and Temporal Differentiation Pattern of Carbon Emission and Carbon Compensation in China's Provincial Areas", Sustainability, 2022 — 12 words — < 1%

Crossref

33 Lintao Liu, Hengjia Zhang, Yao Zhang, Fuqiang Li, Xietian Chen, Yong Wang, Yingying Wang. "Spatiotemporal heterogeneity correction in land ecosystem services and its value assessment: a case study of the Loess Plateau of China", Environmental Science and Pollution Research, 2023 — 12 words — < 1%

Crossref

34 Nathalie Seddon, Alexandre Chausson, Pam Berry, Cécile A. J. Girardin, Alison Smith, Beth Turner. "Understanding the value and limits of nature-based solutions to climate change and other global challenges", — 12 words — < 1%

Philosophical Transactions of the Royal Society B: Biological Sciences, 2020
Crossref

35 Ping Zhang, Weiwei Li, Kaixu Zhao, Sidong Zhao. "Spatial Pattern and Driving Mechanism of Urban–Rural Income Gap in Gansu Province of China", Land, 2021 — 12 words — < 1%
Crossref

36 Shuo Yang, Xiaozheng Zheng. "Spatio-temporal relationship between carbon emission and ecosystem service value under land use change: a case study of the Guanzhong Plain Urban Agglomeration, China", Frontiers in Environmental Science, 2023 — 12 words — < 1%
Crossref

37 Yi-Ru Wang, Hui Zhang. "An Ecosystem Service Value Model to Quantify Eco-environment Cost", Applied Economics and Finance, 2020 — 12 words — < 1%
Crossref

38 Youguo Zhang. "Spillover and Feedback Effects in Low Carbon Development", Springer Science and Business Media LLC, 2021 — 12 words — < 1%
Crossref

39 "Nature-based Solutions for Resilient Ecosystems and Societies", Springer Science and Business Media LLC, 2020 — 11 words — < 1%
Crossref

40 sciforum.net — 11 words — < 1%
Internet

41 upcommons.upc.edu — 11 words — < 1%
Internet

42 Haixiao Long, Lei Yuan, Zhenglin Yin, Xiaowei Wu. "Spatiotemporal of ecosystem service values response to land use/cover change based on geo-informatic Tupu – A case study in Tianjin, China", Ecological Indicators, 2023 — 10 words — < 1%
Crossref

43 Ninghui Pan, Qingyu Guan, Qingzheng Wang, Yunfan Sun, Huichun Li, Yunrui Ma. "Spatial Differentiation and Driving Mechanisms in Ecosystem Service Value of Arid Region：A case study in the middle and lower reaches of Shule River Basin, NW China", Journal of Cleaner Production, 2021 — 10 words — < 1%
Crossref

44 Tiantian Chen, Li Peng, Qiang Wang, Shaoquan Liu. "Measuring the Coordinated Development of Ecological and Economic Systems in Hengduan Mountain Area", Sustainability, 2017 — 10 words — < 1%
Crossref

45 Xing Gao, Jie Wang, Chenxi Li, Weining Shen, Zhaoying Song, Chengjing Nie, Xueru Zhang. "Land use change simulation and spatial analysis of ecosystem service value in Shijiazhuang under multi-scenarios", Environmental Science and Pollution Research, 2021 — 10 words — < 1%
Crossref

46 Zhang, Xin Yu, and Pei Ji Shi. "Optimizing Land Use Structure for Low Carbon Target: A Case Study in Zhangye of Gansu Province", Applied Mechanics and Materials, 2014. — 10 words — < 1%
Crossref

47 Zhaoquan He, Xue Shang, Tonghui Zhang, Jianying Yun. "Coupled regulatory mechanisms and synergy/trade-off strategies of human activity and climate — 10 words — < 1%

change on ecosystem service value in the loess hilly fragile region of northern Shaanxi, China", Ecological Indicators, 2022
Crossref

48 en.cciced.net
Internet
10 words — < 1%

49 www.dlyj.ac.cn
Internet
10 words — < 1%

50 Chen Chen, ChaoFeng Shao, YanMin Shi. "Dynamic Evaluation of Ecological Service Function Value of Qilihai Wetland in Tianjin", International Journal of Environmental Research and Public Health, 2020
Crossref
9 words — < 1%

51 Wanxu Chen, Hongbo Zhao, Jiangfeng Li, Lijun Zhu, Zheye Wang, Jie Zeng. "Land use transitions and the associated impacts on ecosystem services in the Middle Reaches of the Yangtze River Economic Belt in China based on the geo-informatic Tupu method", Science of The Total Environment, 2020
Crossref
9 words — < 1%

52 Xiaoping Zhang, Delu Pan, Jianyu Chen, Yuanzeng Zhan, Zhihua Mao. "Using long time series of Landsat data to monitor impervious surface dynamics: a case study in the Zhoushan Islands", Journal of Applied Remote Sensing, 2013
Crossref
9 words — < 1%

53 Yalei Yang, Hong Wang, Xiaobing Li, Xizhi Huang, Xin Lyu, Haozhe Tian, Tengfei Qu. "How will ecosystem carbon sequestration contribute to the reduction of regional carbon emissions in the future? analysis based on the MOP-PLUS model framework", Ecological Indicators, 2023
Crossref
9 words — < 1%

54 Yang Li, Pengjun Zhang, Yaochen Qin. "Ecological Service Evaluation: An Empirical Study on the Central Loess Plateau, China", Polish Journal of Environmental Studies, 2020
Crossref
9 words — < 1%

55 Yingqing Su, Xiaohong Ma, Qi Feng, Wei Liu, Meng Zhu, Junjie Niu, Geng Liu, Lijiang Shi. "Patterns and controls of ecosystem service values under different land-use change scenarios in a mining-dominated basin of northern China", Ecological Indicators, 2023
Crossref
9 words — < 1%

56 Zhang Baolei. "Assessment and risk zonation of landslides in Panxi Area based on 3S Technology", Wuhan University Journal of Natural Sciences, 07/2006
Crossref
9 words — < 1%

57 downloads.hindawi.com
Internet
9 words — < 1%

58 ouci.dntb.gov.ua
Internet
9 words — < 1%

59 Changwen Wei, Jiaqin Zeng, Jiping Wang, Xuebing Jiang, Yongfa You, Luying Wang, Yiming Zhang, Zhihong Liao, Kai Su. "Assessing the Impact of Climate and Human Activities on Ecosystem Services in the Loess Plateau Ecological Screen, China", Remote Sensing, 2023
Crossref
8 words — < 1%

60 Guanshi Zhang, Duo Zheng, Long Xie, Xiu Zhang, Hongjuan Wu, Sen Li. "Mapping changes in the value of ecosystem services in the Yangtze River Middle Reaches Megalopolis, China", Ecosystem Services, 2021
Crossref
8 words — < 1%

61 Haoran Yang, Qun Wu. "Land Use Eco-Efficiency and Its Convergence Characteristics Under the Constraint of Carbon Emissions in China", International Journal of Environmental Research and Public Health, 2019
Crossref
8 words — < 1%

62 Jie Yang, Baopeng Xie, Shiying Wang, Degang Zhang, Changyu Liu, Erastus Mak-Mensah. "Temporal and spatial characteristics of grassland ecosystem service value and its topographic gradient effect in the Yellow River Basin", PLOS ONE, 2022
Crossref
8 words — < 1%

63 Mingyan Ni, Yindi Zhao, Caihong Ma, Xiaolin Hou, Yanmei Xie. "Exploring Relationships between Spatial Pattern Change in Steel Plants and Land Cover Change in Tangshan City", Sustainability, 2023
Crossref
8 words — < 1%

64 Shan Guo, Yang Wang. "Spatial-temporal changes of land-use mercury emissions in China", Ecological Indicators, 2023
Crossref
8 words — < 1%

65 Wei Liu, Jinyan Zhan, Fen Zhao, Haiming Yan, Fan Zhang, Xiaoqing Wei. "Impacts of urbanization-induced land-use changes on ecosystem services: A case study of the Pearl River Delta Metropolitan Region, China", Ecological Indicators, 2019
Crossref
8 words — < 1%

66 Yuling Wen, Hongbo Li, Xiaolin Zhang, Tingyun Li. "Ecosystem services in Jiangsu province: Changes in the supply and demand patterns and its influencing factors", Frontiers in Environmental Science, 2022
Crossref
8 words — < 1%

67	assets.researchsquare.com Internet	8 words — < 1%
68	digitalcommons.mtu.edu Internet	8 words — < 1%
69	livrepository.liverpool.ac.uk Internet	8 words — < 1%
70	"Effect of Anisotropy on the Resilient Behaviour of a Granular Material in Low Traffic Pavement", Materials, 2017 Crossref	7 words — < 1%
71	Chenxu Zhao, Yuling Liu, Zixuan Yan. "Effects of land-use change on carbon emission and its driving factors in Shaanxi Province from 2000 to 2020", Environmental Science and Pollution Research, 2023 Crossref	7 words — < 1%
72	Harry Morgan, Magdalena Lipka-Lloyd, Anna J. Warren, Naomi Hughes et al. " A 2.8 Å structure of zoliflodacin in a DNA-cleavage complex with DNA gyrase ", Cold Spring Harbor Laboratory, 2022 Crossref Posted Content	7 words — < 1%
73	Lili Pu, Chengpeng Lu, Xuedi Yang, Xingpeng Chen. "Spatio-Temporal Variation of the Ecosystem Service Value in Qilian Mountain National Park (Gansu Area) Based on Land Use", Land, 2023 Crossref	7 words — < 1%
74	Shouyi Ding, Shumi Liu, Mingxin Chang, Hanwei Lin, Tianyu Lv, Yujing Zhang, Chen Zeng. "Spatial Optimization of Land Use Pattern toward Carbon Mitigation Targets—A Study in Guangzhou", Land, 2023 Crossref	7 words — < 1%

75 Xia Li, Songtao Cheng, Yigui Wang, Guozhuang Zhang, Leyi Zhang, Chen Wu. "Future Land Use Spatial Conflicts and Habitat Quality Impacts Based on SSPs-RCPs Scenarios—Qin-Ba Mountain City", Land, 2023
Crossref
7 words — < 1%

76 Xuefu Pu, Qingping Cheng, Hongyue Chen. "Spatial–temporal dynamics of land use carbon emissions and drivers in 20 urban agglomerations in China from 1990 to 2019", Environmental Science and Pollution Research, 2023
Crossref
7 words — < 1%

77 Xun Zhang, Zhaoliang Gao, Yonghong Li, Guanfan Sun, Yunfeng Cen, Yongcai Lou, Yihang Yao, Wenbo Liu. "Eco-Environment Quality Response to Climate Change and Human Activities on the Loess Plateau, China", Land, 2023
Crossref
7 words — < 1%

78 Ying Wang, Hongwei Zhang, Chen Zhang, Cong Liu. "Is ecological protection and restoration of full-array ecosystems conducive to the carbon balance? A case study of Hubei Province, China", Technological Forecasting and Social Change, 2021
Crossref
7 words — < 1%

79 Zhipeng Lu, Bin Dong, Zhili Xu, Cheng Wang, Zezhu Wei, Xiao Liu. "Temporal and spatial evolution of ecosystem services value in Hefei city based on land use change, and multi-scenario prediction", Research Square Platform LLC, 2023
Crossref Posted Content
7 words — < 1%

80 Gouranga Biswas, Anuradha Sengupta, Faisal M. Alfaisal, Shamshad Alam, Raied S. Alharbi, Byong-Hun Jeon. "Evaluating the effects of landscape fragmentation
6 words — < 1%

on ecosystem services: A three-decade perspective", Ecological Informatics, 2023
Crossref

81 Hongjiao Qu, Chang You, Weiyin Wang, Luo Guo. "Exploring coordinated development and its driving factors between carbon emission and ecosystem health in the southern hilly and mountainous region of China", Frontiers in Environmental Science, 2023
Crossref
6 words — < 1%

82 Jiajia Liao, Chaoyue Yu, Zhe Feng, Huafu Zhao, Kening Wu, Xiaoyan Ma. "Spatial differentiation characteristics and driving factors of agricultural eco-efficiency in Chinese provinces from the perspective of ecosystem services", Journal of Cleaner Production, 2021
Crossref
6 words — < 1%

83 LIU Menghao, XI Jianchao. "Multi-Objective Optimization of the Spatial Structure and Layout of the Protected Area Based on Ecosystem Services: A Case Study of the Yellow River's Headwaters Region in the Three-River-Source National Park", Chinese Journal of Urban and Environmental Studies, 2021
Crossref
6 words — < 1%

84 Lisha Tang, Hualou Long, Daniel P. Aldrich. "Putting a Price on Nature: Ecosystem Service Value and Ecological Risk in the Dongting Lake Area, China", International Journal of Environmental Research and Public Health, 2023
Crossref
6 words — < 1%

85 Matteo Alpino, Luca Citino, Federica Zeni. "Costs and benefits of the green transitionenvisaged in the Italian NRRP - An evaluation using the social cost of carbon", Energy Policy, 2023
Crossref
6 words — < 1%

86 Quanfeng Li, Lu Wang, Guoming Du, Bonoua Faye, Yunkai Li, Jicheng Li, Wei Liu, Shijin Qu. "Dynamic Variation of Ecosystem Services Value under Land Use/Cover Change in the Black Soil Region of Northeastern China", International Journal of Environmental Research and Public Health, 2022 — 6 words — < 1%
Crossref

87 Ran Wu, Haifeng Lan, Yuxin Cao, Pingyi Li. "Optimization of low-carbon land use in Chengdu based on multi-objective linear programming and the future land use simulation model", Frontiers in Environmental Science, 2022 — 6 words — < 1%
Crossref

88 Xiaoping Li, Sai Hu, Lifu Jiang, Bing Han, Jie Li, Xuan Wei. "Spatiotemporal Patterns and the Development Path of Land-Use Carbon Emissions from a Low-Carbon Perspective: A Case Study of Guizhou Province", Land, 2023 — 6 words — < 1%
Crossref

89 Xinchen Gu, Aihua Long, Guihua Liu, Jiawen Yu, Hao Wang, Yongmin Yang, Pei Zhang. "Changes in Ecosystem Service Value in the 1 km Lakeshore Zone of Poyang Lake from 1980 to 2020", Land, 2021 — 6 words — < 1%
Crossref

EXCLUDE QUOTES	OFF	EXCLUDE SOURCES	OFF
EXCLUDE BIBLIOGRAPHY	ON	EXCLUDE MATCHES	OFF